Language, Syntax, and the Natural Sciences

Edited by Ángel J. Gallego
and Roger Martin

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Language, apart from its cultural and social dimension, has a scientific side that is connected not only to the study of "grammar" in a more or less traditional sense, but also to disciplines like mathematics, physics, chemistry, and biology. This book explores developments in linguistic theory, looking in particular at the theory of generative grammar from the perspective of the natural sciences. It highlights the complex and dynamic nature of language, suggesting that a comprehensive and full understanding of such a species-specific property will only be achieved through interdisciplinary work.

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To Juan Uriagereka for the significant contributions he has made, and continues to make, to the scientific study of language and mind, and for inspiring us to seek understanding by looking beyond the traditional domains of theoretical linguistics while at the same time resting firmly on those foundations.

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Acknowledgments

This book was originally conceived as a tribute to Juan Uriagereka. Juan has made tremendous efforts to develop highly interdisciplinary initiatives, creating bridges and stimulating interactions between linguistics and other sciences in order to reach a deeper and fuller understanding of human language and cognition as a natural object. Some of Juan's notable works in this regard are: *Rhyme and Reason: An Introduction to Minimalist Syntax* (1998), *Derivations: Exploring the Dynamics of Syntax* (2002), *Syntactic Anchors* (2008), and *Spell-Out and the Minimalist Program* (2012). Also significant is the long list of students he has supervised and whose own research strategies have been crucially influenced by his thinking, a list to which we humbly include our own names. Thus, first and foremost, we would like to acknowledge our tremendous intellectual and personal debt to Juan.

The inception of this volume goes back to 2012, when we started soliciting papers mostly from scholars who have worked closely with Juan over the years, or who share his vision of approaching the study of language from the perspective of the natural sciences. However, Juan, we would argue, is at the pinnacle of his career and thus may not yet be "ready" for a typical Festschrift. Furthermore, it was our strong intention from the outset that this volume should go beyond any special dedicatory function and serve as a highly focused survey of the current state of generative grammar, in particular the theory of syntax, with an emphasis on integrated scientific approaches to language. Although it has taken much longer than originally planned, because of several challenges faced along the way, this book never could have been realized if not for the tremendous support we received at every stage from Cambridge University Press, especially Andrew Winnard, Stephanie Taylor, Bethany Johnson, and Jacqueline French. Of course, we also express heartfelt thanks to the authors of the chapters for their cooperation, not to mention their endless patience and understanding of numerous delays.

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Hiroki Narita, Javier Ormazabal, Pablo Rico, and Bridget Samuels. Pablo Rico also deserves special mention for his invaluable assistance with the index. Indeed, there was no shortage of people willing to lend a hand to this project as a gesture of their respect for Juan. In addition, we would like to mention the following scholars who originally intended to contribute chapters to this book, but who were unable to do so in the end for various reasons despite their strong desire to participate in a project of this nature: Itziar Laka, Javier Ormazabal, Eduardo Raposo, and Itziar San Martin.

Introduction

Ángel J. Gallego and Roger Martin

Let us begin by recalling the old tale of the blind men and the elephant.[1] Six blind scientists set out to analyze an unfamiliar object that is both massive and complex – which turns out to be, in fact, an elephant. Each of the scientists examines it by touching a different part of the animal and draws a conclusion based on that experience alone. They compare their results only to discover that they are in complete disagreement, leading to an endless argument over whose interpretation is correct, whereas in reality their hypotheses are all completely off the mark. In some of the more optimistic versions of the tale, the scientists eventually realize their fallacy, at which point they begin to integrate their perspectives in a way that yields a more complete and unified description of an elephant-like creature. The moral of the story is simple: Insisting on a particular line of analysis or clinging to overly narrow scientific biases usually leads to a distorted picture of reality; more often than not, it is more productive to consider things from a variety of perspectives. Doing this is by no means easy. It requires the willingness to cooperate with others (within one's own field or not) in order to seek the understanding of the object of inquiry.

In the above fable, the blind scientists are merely exploring the external morphology of the elephant. Imagine if they had been trying to understand its internal morphology or, for that matter, how things work at the cellular or molecular levels, the structure of its protein folding, etc., all of which constitutes understanding what it means for something to be an elephant. The study of human language, which seems in many respects even more complex than an elephant, presents similar challenges. Research is commonly carried out from various disparate perspectives. For example, there are theoretical studies of the structure of language, biological studies of the genetic bases of language and language evolution, studies of brain function, not to mention computational studies, statistical studies, and the list could go on.

Of course, it is not necessarily the case that all imaginable perspectives should be viewed as equal, and in fact some may be irrelevant to the

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[1] An analogy of the sort we pursue here was presented earlier in the introduction to an unpublished monograph by Martin and Uriagereka (2013).

understanding of some particular phenomenon. For example, studies of certain cultural, political, or social aspects of language use may turn out to have very little relevance to the study of the human language faculty as a natural object. Furthermore, there may turn out to be situations where one approach has a sort of "methodological priority" over others; in order to make progress in understanding a particular natural phenomenon, it may sometimes be necessary to examine it from one perspective before further questions can even be seriously raised from another. As just one illustration, we point to Noam Chomsky's now famous remarks that although purely statistical approaches have led to little progress in our scientific understanding of human language, a number of rather successful studies exist that have integrated statistics or probabilities with notions from theoretical linguistics, such as the existence of particular grammatical constraints.[2] We think the same general point can be made about many other types of approaches as well – where language has been examined from the perspectives of biology, genetics, neurophysiology, computer science, or even physics or mathematics, the more such studies are based on a solid understanding of the results of theoretical linguistics, the more they tend to yield fruitful results, and as is typically the case, the integrated studies often lead to reworking their basic components, including of course (fundamental) ideas of theoretical linguistics.

It is in this light that we would like to present this book, the goal of which is to explore recent developments in linguistic theory as well as more integrated approaches to the study of language as a natural object. All of the studies in this volume essentially assume the theory of generative grammar (cf. Chomsky *et al*. 2017 for a summary, pointing out some challenges and open questions), in which language is taken to be a component of human cognition. On such a view, the study of language (or *I-language* in the sense of Chomsky 1986) would seem to fall squarely within the domain of biology. Indeed the so-called biolinguistics program (see, for example, Berwick and Chomsky 2011, Boeckx and Grohmann 2013, Boeckx *et al*. 2012, Di Sciullo and Boeckx 2011, Piattelli-Palmarini 1974, Piattelli-Palmarini *et al*. 2009, Uriagereka 1998, amongst many others) has gained much steam over the past couple of decades, fueled in part by the emergence of the minimalist program (Chomsky 1995 and ff.) with its emphasis on the reduction of language-specific, or first-factor, principles in favor of external factors, so-called third-factor principles, such as conditions imposed by performance systems and general principles of physics/mathematics determining the boundaries within which any biological system may develop.

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[2] The remarks, made at the *Brains, Minds, and Machines* symposium held at the Massachusetts Institute of Technology in 2011, gained some notoriety since they set off a high-profile debate between Chomsky and Google's Peter Norvig.

We do not expect, however, that we will be able to understand everything about human language by examining it through the lens of modern-day biological science alone. Research on the structure of language from the more abstract perspective of linguistic theory should, we believe, continue to shed a guiding light on biolinguistics endeavors, although the exponents of the former must also do more to embrace the results of the latter.[3] Moreover, additional perspectives from physics, mathematics, the theory of computation, and probability/statistical theory, at the very least, also seem to us to be crucial in order to reach a more complete picture of the beast (our "elephant") that we call human language, and should be actively and enthusiastically integrated into the natural scientific study of language in our view.

This volume is organized into three parts. Part I deals with the core first-factor principles of the computational component of language. Part II focuses on the nature of the interfaces, in particular between the computational component and the external systems (conceptual-intentional and sensory-motor) that utilize it, and also between linguistic experience and attained grammatical knowledge. Part III is concerned with the substantive integration of linguistics and other scientific disciplines, such as biology and physics, as well as placing of the study of language and mind within the larger context of the natural sciences.

In Part I, the nature of Merge is addressed in Tonia Bleam and Norbert Hornstein's chapter, which explores multiple-object constructions, providing an account where the direct object (DO) and indirect object (IO) form a small clause that adjoins to the verb phrase (VP). Francisco Ordóñez's contribution is devoted to the study of verbal complexes in Spanish, involving a series of verbal dependencies and a postverbal subject, which pose a series of puzzles to the analysis of control and subjects (and thus the status of Merge and Agree), as well as parametric concerns. Howard Lasnik focuses on asymmetries affecting A-bar displacement in defective clauses from the perspective of phase theory. Ricardo Etxepare and Myriam Uribe-Etxebarria discuss aspects of constituent-negation related to context-sensitive (transformational) processes of the focus type. Negation and its long-distance effects are also relevant to Esther Torrego's chapter, which considers Romance *because*-clauses under clausal negation, where mood marking reveals that the negative head can c-command into the embedded domain, thus revealing that it cannot be treated as an adjunct. Ian Roberts ties together many of the above issues, considering the nature of Agree as well as the structure of DPs, ultimately arguing for the

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[3] Here, we of course mean biolinguistics in the sense of trying to understand and explain linguistic phenomena using the ideas and tools of the biological sciences, in a real and serious sense, not just the labeling of theoretical linguistics (generative grammar or minimalism in particular) as a kind of abstract biology (see Martins and Boeckx 2016).

existence of φ-features based on a "no-choice parameter," which is a newly proposed type of parameter said to emerge from the interaction of Chomsky's (2005) three factors.

Jairo Nunes kicks off Part II by addressing the long-standing problem of the interpretation of chains at the interfaces, arguing that linearization plays a key role, not only for sensory-motor functions but also at the conceptual-intentional interface. Wolfram Hinzen tackles the question of why Case exists in grammar – problematic from a minimalist perspective in that it appears to be a purely grammar-internal device – and attempts to rationalize it in terms of the mapping of grammatical hierarchies to semantic hierarchies in which increased grammatical complexity corresponds to increased complexity in the ontology of meaning. Following a similar line, Pablo Bustos and Juan Romero argue that concepts are categorized according to hierarchies in structural complexity and, furthermore, that categorization is module independent, which leads them to propose a "porous modular" approach to cognition. Paul Pietroski also deals with the mapping to the semantic interface but offers an opinion that is rather different from the previous chapters, arguing for a highly limited semantic typology and an interface where semantic representations of human language do not have the kinds of rich recursive hierarchies that have been postulated for the syntactic component. In the following chapter, William Idsardi makes a proposal for the sensory-motor interface that is very similar in spirit to Pietroski's, arguing that phonology lacks recursion and is thus computationally simpler than syntax. Although not an interface in the technical sense that the word is typically used, the contribution by David Lightfoot takes up the mapping from external linguistic experiences (E-language) to attained internal grammars (I-language) in children as the only possible force driving language change as well as the acquisition of grammatical features specific to individual languages, hence not part of the initial state of Universal Grammar (UG). Carlos Otero's chapter, which also looks at the interface between grammar and experience, is concerned with the nature and acquisition of the lexicon and how one's lexical knowledge affects the externalization of language.

Part III closes off this volume. The first two chapters deal with approaches to language that are firmly grounded in biology. Sergio Balari, Antonio Benítez-Burraco, Marta Camps, Víctor Longa, and Guillermo Lorenzo deal with the evolution of language, arguing on theoretical and empirical grounds for an evolutionary connection between knotting ability and linguistic ability in humans. Cedric Boeckx and Constantina Theofanopoulou take on the so-called linking problem and argue that certain aspects of linguistic/cognitive structure can be explained as arising from basic neurophysiological processes such as brain oscillations. From a somewhat different perspective, Douglas Saddy tries to elucidate the basic operations of syntax by weaving together a number of threads from mathematics, physics, and cybernetics into a highly

dynamical model of language that crucially involves oscillations – between high-dimensional/non-metric and low-dimensional/metric spaces – adding a level of neurophysiological plausibility, as well as an interesting point of connection to the chapter by Boeckx and Theofanopoulou. Taking their inspirations mostly from physics and mathematics, David Medeiros and Massimo Piattelli-Palmarini propose a model of phrase structure in terms of matrices and, by rigorously analyzing characteristics such as eigenvalues, demonstrate that the X-bar schema uniquely exhibits special mathematical properties and thus may plausibly be emergent from third-factor principles. Noam Chomsky concludes Part III, and the volume, by providing a detailed and far-ranging reflection on the nature of the study of language and cognition from the perspective of the history and philosophy of science, both encouraging us to pursue inquiry into the mind with a broad scientific viewpoint and, at the same time, reminding us that some of the questions we raise may fall beyond the limits of human understanding.

A volume of this nature faces obvious issues in terms of scope, and in some respect we feel that we have only partially achieved our goals; and probably a similar feeling was that of the blind scientists analyzing different pieces of the elephant. Needless to say, there are many more valuable perspectives on the scientific study of language that are worthy of attention, including studies located outside of the theory of generative grammar, not to mention approaches based on statistical/probability theory, computational science, other modes of cognition, and so on. Still, we believe that the chapters that compose this volume provide the reader with a reasonably thorough overview of the current state-of-the-art when it comes to natural scientific approaches to the study of language and that the volume will encourage researchers from a variety of differing fields and perspectives to join together in the pursuit of understanding, so that someday we may come to better recognize the animal that stands in front of us.

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Part I

The Computational Component

1   Deriving Multiple "Object" Constructions

Tonia Bleam and Norbert Hornstein[1]

1   The Lay of the Land

There are several questions relating to predicates that occur with both a direct and an indirect object argument (henceforth: *multiple object constructions*, MOCs[2]) like those in (1) and (2). These examples illustrate the same predicate occurring in two different constructions: The prepositional dative (PP-dative) in (a) and the double object construction (DOC) in the (b) examples.[3]

(1) a. John gave/handed a book to Mary   PP-dative
     b. John gave/handed Mary a book   DOC
(2) a. John kicked/threw a ball to Mary   PP-dative
     b. John kicked/threw Mary a ball   DOC

One question is whether the (a)-sentences are derived from the same underlying form as the (b)-sentences. In other words, are (1a) and (2a) transformationally related to (1b) and (2b)? One common view is that these pairs of sentences are thematically identical and that this is best accounted for grammatically by deriving both from a common underlying structure plus some set (possibly null) of movement operations which maps them into their surface forms. A standard approach takes the (a)-forms to reflect the basic underlying thematic structure and the (b)-forms to be transformationally derived by a movement rule that moves the indirect object to some position higher up in the verb phrase.[4]

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[1] The authors are indebted to Juan Uriagereka for being an inspirational colleague and mentor, and for providing the foundational ideas of this work: (i) sidewards movement (Uriagereka 1998) and (ii) the idea that dative clitic constructions in Spanish correspond to English double object constructions (Uriagereka 1988). We would also like to thank Richard Larson, Jeff Lidz, Jairo Nunes, Javier Ormazabal, Paul Pietroski, and Omer Preminger for helpful discussions and comments.

[2] We are using the term "multiple object construction" instead of "ditransitive" because "ditransitive" evokes an analysis in which a single verb takes two complements. For us, the so-called indirect object ("IO") is always introduced via another predicate which itself is an adjunct to the main predicate (as will be discussed below).

[3] The analysis proposed below should extend to benefactive MOCs, though we won't discuss them explicitly here.

[4] See Larson (1988) and Baker (1997) for recent versions of a transformational analysis.

A second question relates to underlying structure: What is the hierarchical organization of a VP that contains both the direct and the indirect object? Following Larson (1988), the most common (and widely accepted) view is that these expressions form a VP shell structure, a kind of small clause complement to some higher verb-like head. More recently, the DO and IO are taken to flank an *applicative* head that is complement to a higher verb. They then have verbal structures like those in (3) (reflecting earlier shell accounts) or (4) (depicting more current applicative approaches):[5]

(3) a. John [$_{vP}$ v [$_{VP}$ a book [give to Mary]]]   PP-dative
     b. John [$_{vP}$ v [$_{VP}$ Mary [give a book]]]   DOC
(4) a. John [$_{vP}$ v [$_{VP}$ give [$_{ApplP}$ a book [Appl to Mary]]]]   PP-dative
     b. John [$_{vP}$ v [$_{VP}$ give [$_{ApplP}$ Mary [Appl a book]]]]   DOC

In the above, the verb (e.g. *give*) raises to form a unit with *v*, and, assuming the versions in (4) with the applicative heads, the *Appl* head also forms a unit with this verbal complex. (3) and (4) depict configurations in which the underlying forms are different in the PP-dative (a) cases from the DOC (b) cases. However, it is consistent with this kind of shell/applicative analysis that the two forms derive from a common underlying structure (as in Larson 1988) or that they are generated from different base configurations (e.g. Harley 1996). In the derivational analyses, the PP-dative form is typically taken to underlie the derived DOC form, which is constructed by moving the IO to a higher position and deleting the preposition through a process like incorporation (see Baker 1997, Larson 2014). Thus, the assumption that small clauses underlie PP-dative and DOC constructions is neutral with respect to the question of whether either is derived from the other.

There is one feature common to both approaches, however; the assumption that expanding the argument structure of the predicate via a shell structure involves adding a *clause-like complement* to the verb. This contrasts with earlier analyses in which the IO was treated as a prepositional adjunct, optionally added to VP, as in (5).

(5) John v [$_{VP/VP}$ [$_{VP}$ throw the ball] to Mary]

The contrast with this earlier analysis is easier to appreciate if one contrasts the less complex (5) and (6) with a more contemporary structure like (7):

(6) John v [$_{VP}$ throw the ball]

(7) a. John v [throw [$_{ApplP}$ the ball [Appl to Mary]]]
     b. John v [throw [$_{ApplP}$ Mary [Appl the ball]]]

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5 See Pylkkänen (2002).

In place of the nominal complement in (5) and (6), an applicative/shell analysis postulates a clause-like complement with the DO and IO being specifier and complement to a more abstract underlying head.[6]

This, of course, raises interesting semantic issues. For example, both sentences that correspond to the structures in (7) imply the one that corresponds to (6). A classical generative way of coding this kind of dependency is to make (6) a "subpart" of both of the sentences (7a,b). This is what we find in (5) but not in (7a,b). The latter two contain an ApplP that is absent in (6). Moreover, this ApplP is "clausal" in that it has an internal and external argument. This leaves it somewhat unclear how the arguments of the ApplP relate to the higher predicate *throw*. We clearly want both sentences in (7) to imply that John threw the ball, and this requires explaining how the ApplP semantically unpacks. However it does so, we are sure of one thing; it must unpack so that *the ball* is the semantic object of *throw* in both cases despite not being its complement, and in the case of (7a) not being a complement at all.

There are further complications in the context of UTAH,[7] which are made evident in comparing (5)–(7). Note that (5) retains the basic argument structure of (6), as the object is complement to the verb in each and the IO is added as an adjunct. In (7a), in contrast, the direct object is not any kind of object but a specifier, and is not syntactically related to the main verb *throw* at all, but to *Appl*, a more abstract head of the small clause. This raises UTAH puzzles if one takes a strict interpretation of these principles. In particular, it should not be possible for thematically identical DPs to project to different layers/levels of syntactic structure, as *the ball* seems to do in (6) versus (7).[8] Thus, it is unclear how a simple mapping principle, like, for example, themes are complements of the predicate that denotes the event they participate in, would generate both (6) and (7).

Consider, finally, one last property. Many MOCs can live easily and happily without IOs but are quite odd if their DOs are left unexpressed.

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[6] The main difference between transformational and base generation analyses revolves around whether the *Appl* head is the same in the two constructions. The former adopts the view that it is; the latter claims that they differ. We return to these concerns below.

[7] The Uniformity of Theta Assignment Hypothesis (Baker 1988): "Identical thematic relationships between items are represented by identical structural relationships between those items at the level of D-structure."

[8] UTAH has both a strict and a relativized interpretation. The problem is most severe for the strict interpretation, for it mandates that DPs with the same thematic powers always map to the same underlying positions in the syntax. This implies that *the ball* is complement to *throw* in both (6) and (7) if it is complement to *throw* in (6). Larson (1988) recognizes this and therefore adopts a relativized version of UTAH which loosens the mapping requirement. Relativized UTAH requires that the relative prominence of arguments in the syntax mirror their relative prominence in the thematic hierarchy. Baker (1997) reviews both interpretations and offers some interesting evidence in favor of the strict reading. What is clear is that this version runs into difficulties given the representations in (6) and (7). We return to these issues below.

(8)   a. John pushed *(the ball) (to Sue)
      b. John pushed (Sue) *(the ball)

This asymmetry between the "obligatory" nature of DOs and the "option-ality" of IOs makes sense on the classical analysis of these kinds of construc-tions, as the IO was typically analyzed as a kind of PP adjunct, namely (5). However, in the context of a shell/small clause analysis, why the IO is rela-tively optional while the DO is relatively obligatory remains obscure.[9]

The aim of this chapter is to provide an analysis of these MOC constructions that accommodates their observed properties. The analysis has two distinctive characteristics: First, though it incorporates a small clause approach, it proposes that the small clause is an adjunct rather than a complement. Thus, we partially return to earlier analyses of MOCs in assuming that MOCs add small clause structure, but via adjunction rather than complementation. The second assump-tion follows from the first: In building the clause, DPs *sidewards move* from the small clause to complement and specifier positions within the VP. We will show that given certain plausible structural properties of these small clauses, the "correct" DP will always move into the object position. The PP left in the small clause can remain in place (resulting in the PP-dative) or move to a position higher in the VP following the incorporation (resulting in the DOC). This analy-sis is consistent with either a transformational analysis of DOCs or a base gen-eration approach, although we present some evidence to suggest that the base generation (alternate underlying configuration) approach is to be preferred.

2   Deriving Structure

We propose the following derivation for PP-dative clauses:

(9)   a. John gave a book to Mary
      b. Numeration= {John, past, v, give, a, book, to, Mary, Appl}[10]
      c. E(xternal)-Merge *Appl* and *to Mary* → [Appl Mary]
      d. E-Merge *a book* and *[Appl to Mary]* → [$_{SC}$ a book [Appl to Mary]]
      e. I(nternal)-Merge *a book* and *give* → [$_{VP}$ give [**a book**]], [$_{SC}$ [**a book**] [appl to Mary]][11]
      f. E-Merge [$_{VP}$ give a book] and [$_{SC}$ a book [appl to Mary]] → [$_{VP/VP}$ [$_{VP}$ give [**a book**]] [$_{SC}$ [**a book**] [appl to Mary]]]

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[9] We say "relatively" for there are uses of these where the object need not be expressed either, e.g. *John's body kicked for half an hour.*

[10] We abstract here from the functional material needed to finish off the derivation, such as T, Agr, etc. We leave it to the reader to finish off the derivations.

[11] Note that we are bolding multiple instances of the same element just to make clear that these are indeed copies of the same element. Which copy is pronounced will be determined by spell-out principles of pronunciation. See Nunes (2004).

g. E-Merge *v* and *[$_{VP/VP}$ [$_{VP}$ give a book] [$_{SC}$ a book [appl to Mary]]]* →
   [v [$_{VP/VP}$ [$_{VP}$ give [**a book**]] [$_{SC}$ [**a book**] [appl to Mary]]]]

h. I-Merge *give* and *v* → [v+give [$_{VP/VP}$ [$_{VP}$ give [**a book**]] [$_{SC}$ [**a book**] [appl to Mary]]]][12]

i. E-Merge *John* and *[v+give [$_{VP/VP}$ [$_{VP}$ give a book] [$_{SC}$ a book [appl to Mary]]]* → [$_{vP}$ John [v+give [$_{VP/VP}$ [$_{VP}$ give [**a book**]] [$_{SC}$ [**a book**] [appl to Mary]]]]]

j. finish derivation as usual.

The interesting lines of the derivation are (9d,e,f). (9d) codes the assumption that there is a small clause structure consisting of the DO and IO. There is a natural semantics for this small clause. It should be read as depicting an event (state) in which Mary is a recipient of a book. This is not always how these small clauses are interpreted. In some cases, it denotes an event/state in which a book is located where Mary is. This will depend on the interpretation of *to*, which will in turn depend on that of the main predicate (see Rappaport-Hovav and Levin 2008 for discussion).[13] When the main verb is *give*, the recipient/possession reading dominates. When it is a verb like *throw*, *kick*, *send* … a location reading is also possible, e.g. *How far can you throw the ball? I can throw it to Bill, but not farther.* We will see below that there is another possible structure for *give*-sentences that uniquely codes possession structurally in the syntax. We return to this anon.

(9e) codes the assumption that the DP subject of the small clause gains an additional theta role by moving sidewards and merging with *give*. Note that it thereby receives the internal argument/DO role that *give* provides; *a book* is the givee, that which is given. Moreover, it gets this role in the standard way, by merging directly with the predicate that assigns it. As is standard in analyses that allow sidewards (SW) movement, the two sub-trees involved in the derivation are at this point unconnected.[14] Note one more important point. In this derivation, *a book* must move or remain unable to check case. The small clause has no case head within it. Thus in order to receive/check case the DP must move. This contrasts with *Mary*, which can be case marked/checked by

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[12] This is assuming that head movement applies in the syntax in these cases and it simplifies matters if it does. Combining *v* and *give* will involve sidewards (SW) movement so as not to violate Extension. We abstract from these issues here, but see Bobaljik and Brown (1997), Nunes (1995), and Uriagereka (1998) for discussion.

[13] Unlike Rappaport-Hovav and Levin, we do not think that *to* has different meanings which are then selected depending on the main predicate. Rather, *to* is underspecified or just has a weak meaning; it just assigns a theta role like "goal" which will then be interpreted differently depending on the meaning of the main predicate.

[14] Were they subparts of a larger tree, SW movement would violate Extension. Indeed, this is one of the main theoretical motivations in its favor (see Uriagereka 1998 for discussion).

to. So, the movement is required for case reasons and allowed if SW movement is permitted.[15]

(9f) codes the assumption that the small clause modifies V by adjoining to its maximal projection VP. It is, in short, a kind of adverbial clausal modifier. That the small clause is related to V rather than v is also assumed in the shell/applicative analyses. Recall that in these analyses the small clause is a complement of V. Here too it is involved with V, but as adjunct rather than complement.[16] There is some empirical support for this from examples like (10):

(10) a. John gave a book to Mary after eating a bagel
      b. *John gave a book after eating a bagel to Mary

The contrast in (10) emerges if we assume that the small clause housing the DO and IO adjoins lower down than the adverbial *after*-clause, which adjoins no lower than vP (see Hornstein 2001 for discussion).[17,18]

There is also a natural semantics for this adjunct structure: the small clause describes the terminus of the event V designates.[19] Thus, *John gave this book to Mary* would have a meaning roughly like that in (11). The small clause

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[15] This is actually the wrong way of phrasing matters for it suggests that an additional theoretical dispensation is required to permit SW movement. The truth is quite the opposite. SW movement follows immediately given two standard assumptions: that Merge is the sole operation for grammatical combination and grammatical operations are subject to Extension. These two suffice to license SW movement. *Preventing* it requires additional theoretical machinery. For discussion see Hornstein (2009).

[16] There is a further theoretical reason for thinking that it adjoins to VP, rather than vP say. If it moves and if move is subject to economy in the guise of Merge over Move, then if it adjoined to vP it would violate this injunction unless merged into SP v. In effect, *John gave a book to Bill* would mean John gave a book and thereby Bill was the recipient/possessor of **John**. This derivation is blocked if the small clause adjoins to and modifies VP and if we assume that after it is so adjoined further movement of the DP from the adjunct is blocked. See Hornstein (2001) for further discussion of the relation between adjunct height and possibility of movement from the adjunct.

[17] This is the same contrast we witness in (i):

  (i) a. John ate the bagel quickly, surprisingly
      b. *John ate the bagel, surprisingly, quickly

[18] One possible argument against this analysis involves sentences like (i):

  (i) Who did Mary send the book to?
      Here *to* is stranded inside an adjunct, possibly violating the CED. One possible reply to this is that movement out of PP adjuncts is more liberal than the CED leads us to expect. Thus, both (ii) and (iii) are acceptable despite stranding a temporal adjunct PP and an instrumental PP. We have nothing enlightening to say about why this is the case except to note that if this is generally grammatical, then the problem noted above may be part of a more general phenomenon. But, in any case, it is not an argument against treating the applicative phrase as an adjunct.

  (ii) Which act did Mary leave the opera after
  (iii) What did Mary open the bottle with

[19] In Spanish, the semantics is slightly different. Rather than necessarily designating the terminus of the event, the small clause/applicative can represent an initial state, resulting state, or simply

specifies a state that describes the terminus of the event. With verbs like *give*, the terminus is realized if the sentence is true (i.e. *John gave this book to Mary* is true iff John gives this book and Mary gets this book).

(11) ∃ e,e' [Agent (J,e) & Patient (this book,e) & Give (e) & Terminus (e',e) & Recipient (Mary,e') and Received (this book,e')]

An objection at this point might be that sentences of this form do not always entail the receiving of the object. John can kick the ball to Mary without Mary receiving the ball. Nonetheless the *terminus* of the event will still be Mary's getting the ball, or the ball getting to Mary: What kind of kicking of the ball event is it? One that depicts an event that in the regular course of affairs ends with Mary's getting it or it getting to Mary, i.e. a ball-to-Mary kicking event. This kind of modification is similar to what we find in other kinds of adverbials: e.g. *Baby pushed the ball to the wall, but too weakly for the ball to get there.*[20] In sum, the small clause classifies the event by providing a terminal state that modifies the event description and, depending on the verb/event, has certain realization requirements.

Before considering the virtues and vices of this kind of approach, let's consider a possible derivation of a DOC example. The derivation in (12) treats DOCs and PP-datives as emanating from the same underlying structure. However, we will show presently that this need not be assumed.

(12) a. John gave Mary a book
  b. Numeration= {John, give, past, Mary, to, a, book}
  c. The derivation is the same as (9) until step e: [$_{VP}$ give [**a book**]], [$_{SC}$ [**a book**] [Appl [to Mary]]]
  d. I-Merge *to Mary* and [$_{VP}$ give a book] → [$_{VP}$ to Mary [$_{V'}$ give [**a book**]]], [$_{SC}$ [**a book**] [Appl to Mary]]
  e. E-Merge [$_{VP}$ to Mary [$_{V'}$ give a book]], [$_{SC}$ a book [Appl to Mary]] → [$_{VP/VP}$ [$_{VP}$ to Mary [$_{V'}$ give [**a book**]]] [$_{SC}$ [**a book**] [Appl to Mary]]]
  f. E-Merge *v* and *[$_{VP/VP}$ [$_{VP}$ to Mary [$_{V'}$ give a book]] [$_{SC}$ a book [appl to Mary]]]* → v [$_{VP/VP}$ [$_{VP}$ to Mary [$_{V'}$ give [**a book**]]] [$_{SC}$ [**a book**] [Appl to Mary]]]
  g. I-Merge *v* and *give* → [v+give [$_{VP/VP}$ [$_{VP}$ to Mary [$_{V'}$ give [**a book**]]] [$_{SC}$ [**a book**] [Appl [to Mary]]]]]

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a static co-occurring state of possession. See Cuervo (2003). In this case, rather than "terminus" there will be an underspecified relation "R" relating the two events.

[20] For discussion see Pietroski (2005) and references therein. Pietroski (2005) makes the important point that the terminus modifies the event *description*, not the event itself. All events terminate, but only some event descriptions contain termini. Our discussion above is intended to be in line with this way of viewing the terminus.

  h. I-Merge *to* and *v+give* → [v+give+to [$_{VP/VP}$ [$_{VP}$ to Mary [$_{V'}$ give [**a book**]]]][$_{SC}$ [**a book**] [Appl [to Mary]]]]]]

  i. E-Merge *John* → John [v+give+to [$_{VP/VP}$ [$_{VP}$ to Mary [$_{V'}$ give a book]] [$_{SC}$ a book [Appl to Mary]]]]]

The interesting lines of this derivation are (12d,h). Note that like the derivation in (9), *a book* merges with *give* and thereby accretes the internal argument theta role. Thus, both MOCs have *give a book* as an underlying constituent, just as in (5) above. Things differ in the two derivations at (12d), where the *to*-PP SW moves to spec V prior to adjunction of the small clause to VP. This movement also ends up feeding the incorporation of *to* into the verbal complex, with deletion of the preposition as by-product (12h).[21,22]

Most of the derivational details in (12) are quite conventional. The main departure from standard analyses lies in the substitution of SW movement from the small clause for upwards movement from the small clause. The target of the PP's movement, the Spec V, remains the same. The DOC construction is more complex than that for the PP-dative form. Though both require SW movement of the small clause DP to the complement of V, only DOCs also SW move the PP out of the small clause. In addition, DOCs involve incorporation of the preposition after the PP has moved.

In contrast to most standard analyses, one feature of these derivations is noteworthy; neither structure directly reflects the underlying base form, as both require SW movement of the object to complement of V to get the required internal theta role. This contrasts with most analyses (in which the small clause is complement to V) where one or both of DO/IO and DOC pristinely reflect their base generated structures at the surface. Theories that postulate that these two constructions are derivationally related typically take the DO/IO form to represent the underlying form, the DOC deriving from this form via movement of the PP in roughly the way noted above (e.g. Larson 1989, Baker 1997). Theories that postulate separate thematic structures for the two constructions assume that each represents a different underlying form with no further movement required (e.g. Harley 2002). We propose that movement is *always* required, as this is how the internal argument of the main clause V is thematically saturated.[23]

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[21] We speculate that the PP movement is a type of VP-internal topicalization (see relevant work by Snyder 2003 and Jayaseelan 2002).

[22] We recognize that head incorporation of the P out of the specifier position might be a problematic move. One might appeal to morphological rebracketing (see, e.g., Marantz 1988, Halle and Marantz 1993, Harris 1996) or some other non-syntactic "movement" here. A possible alternative is that the P incorporates from its base position into the Appl head (which then might be followed by the Appl/P head sidewards moving to being incorporated with the main V). We leave full consideration of this issue for future work.

[23] Thus, both constructions are in effect instances of adjunct control, cf. Boeckx, Hornstein, and Nunes (2010) and Hornstein (2001, 2009) for elaborate discussion.

In sum, MOCs arise via SW movement from an adverbial small clause adjunct. In the PP-dative, a DP from the small clause sidewards moves into the object of the matrix V. In the DOC, the PP additionally SW moves from the small clause to Spec V after which P incorporation takes place. (We discuss the DOC derivation in more detail below.)

3   Virtues

This analysis has several empirical and theoretical virtues, which we enumerate here.

First, it allows for a strong non-relativized version of UTAH without additional complications. This is easily seen if we consider the trio of sentences in (13):

(13) a. John kicked the ball
      b. John kicked the ball to Mary
      c. John kicked Mary the ball

The internal argument (the *theme*, the *kickee*) in (13a–c) is *the ball*. The strong version of UTAH therefore requires that *the ball* be merged to the same structural position in each underlying phrase marker. If we take (13a) at face value, the relevant position is the complement of the V *kick*, as in (14):

(14) [$_V$ kick [the ball]]

This is indeed what the proposed analysis above does. In (13a) *the ball* is E-merged as complement; in (13b,c) it is I-merged there. In all cases, it realizes the structure in (14). We mention this because this is *not* typically the case in other approaches. Baker (1997), for example, proposes merging *the ball* in Spec V rather than complement of V in order to accord with the strong non-relativized version of UTAH (S(trong)-UTAH). He does this in order to assimilate the mapping in (13a) to what is taken to be required in (13b,c). Baker (1997) (following Larson 1989) adopts a complement small clause analysis of applicatives along the lines of (15):

(15) v [$_{VP}$ the ball [kick [to Mary]]]

Once one adopts (15), however, then given S-UTAH, *the ball* must be in Spec V in (13a) as well. This leads to the conclusion that sentences like (13a) actually have phonetically unrealized underlying syntactic indirect objects. This, however, seems problematic. For example, (13a) does not imply that John kicked the ball to someone the way, for example, *John ate* implies that he ate something. Thus, whereas it is fine to say *John kicked the ball, but he didn't kick it to anyone*, it is decidedly odd to assert *John ate, but he didn't eat anything.* If so, the unrealized IO argument underlying (13a) appears to be

thematically inert, which is a problem if one adopts any version of UTAH, let alone S-UTAH.

The problem posed by (13) can be resolved in several ways. One is to adopt a relativized version of UTAH that weakens the mapping requirement. Baker (1997) provides (to our minds) convincing arguments against this. Others may disagree. However, what seems clear is that methodologically speaking S-UTAH is the optimal mapping principle and proposals are better off respecting it than not.

A second option is to analyze *the ball* as complement to *kick* in (13b,c) but in an *extended* sense. For example, a contemporary applicative analysis would represent the underlying structure of (13b) as (16):

(16) v [$_{VP}$ kick [$_{ApplP}$ the ball [Appl [to Mary]]]]

To adhere to S-UTAH, it is proposed that *kick* and *Appl* form a complex predicate with *the ball* as an argument to the complex predicate. So (13b), though related to (13a), does not involve the identical predicates, so the fact that *the ball* is complement to *kick* in (13a) and Specifier to *Appl* in (13b) is not strictly a violation of S-UTAH.

This proposal is also problematic on several grounds. First, the proposal must provide semantic projection rules that guarantee that (13a) is a consequence of both (13b) and (13c). It requires, in other words, an additional theory of complex predicate formation that has as a consequence that the complex predicate *kick+Appl* as applied to the small clause arguments *the ball* and *Mary* implies that that *the ball* has the same meaning that it has when it is the internal argument of *kick*. This is no doubt doable, but, in contrast to the present proposal, it requires an extra piece of machinery. On our proposed approach this simply follows from the fact that *[kick [the ball]]* is a constituent of each of the sentences in (13). No theory of complex predicates is required. Further, given our proposal, the fact that (13b,c) both imply (13a) follows from conjunction reduction plus the standard account of adjuncts as conjunctive modifiers of the event. So no special account of the semantics of "Predicate+Appl" complexes is required.

In sum, our proposal eschews a theory of complex predicates, adheres to S-UTAH, and has a simple account for the consequence relations attested in (13).

Further evidence for the proposed analysis comes from considering some observations in Baker (1997). He observes that both PP-datives and DOCs behave as if, in sentences like (13), *the ball* is the internal argument of *kick* and the IO is a PP. The paper presents six arguments in all. Here we review three.[24]

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[24] The interested reader is referred to Baker (1997: 86–97).

The first argument is based on the generalization that objects in English can function as incremental themes, a standard test being the *in an hour/for an hour* alternation.

(17) a. John told stories #in an hour/for an hour
    b. John told the story in an hour/#for an hour[25]

If we take this as a diagnostic of objecthood, then the object in DOCs and PP-datives remains fixed:

(18) a. I told stories to Mary #in an hour/for an hour
    b. I told Mary stories #in an hour/for an hour
    c. I told the story to Mary in an hour/#for an hour
    d. I told Mary the story in an hour/#for an hour

In short, *stories/the story* acts like the object in both MOC constructions in that its status (whether bare plural or definite singular) affects the aspectual properties of the VP. On our proposed analysis, this is because it *is* the direct object merged as complement of *tell*. In other words, whatever projects a syntactic object into an incremental theme in cases like (17) will also do so in (18) without further ado.[26]

The second argument is based on the generalization that secondary predicates cannot modify PPs. As (19) indicates, *hot* cannot modify the more pragmatically reasonable *stove* and results only in a baked Alaska reading modifying *ice cream*.

(19) I put ice cream$_1$ on the stove$_2$ hot$_{1/*2}$

If IOs in MOCs are underlying PPs then secondary predicates should be unable to modify them, though they should be able to modify DOs. This appears to be correct.

(20) a. I gave the meat to Mary raw
    b. *I gave the meat to Mary$_1$ hungry$_1$
    c. I gave Mary the meat raw
    d. *I gave Mary$_1$ the meat hungry$_1$

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[25] (17b) is acceptable but only under the reading that the story was very long and never completed or it was repeated. This caveat applies to (18c,d) as well.

[26] We further predict that the IO should never function as incremental themes, as they are never underlying syntactic objects. This also appears to be correct, though the data is fuzzier than one might like. Baker (1997: 88: (16c,d)) reports the following judgments, with which we agree:

a. I have read the story to children ?for an hour/in an hour
b. I have read children the story ?for an hour/in an hour

Were *children* object-like in these cases we would expect (b) to be fine with the *for an hour* adverb, on a par with (18a).

On our analysis the IO *Mary* begins its derivational life as a PP, shedding this preposition during the course of the derivation. Thus, if the relation between secondary predicates and what they modify is determined in underlying syntax, the fact that *Mary* resists modification in (20b,d) and *the meat* allows it in (20a,c) follows apace.

The third argument is based on compounding. In compounds headed by an MOC verb, it is possible for the DO to appear inside the compound but not the IO.

(21) a. secret-telling (to spies), book reading (to children), ball kicking (to boys)
      b. *spy-telling (of secrets), *child-reading (of books), boy kicking (of balls)

This follows if the IO starts off as a preposition and the P blocks formation of the synthetic compound.[27] Note that the fact that DOs can form synthetic compounds follows if these are always internal arguments to the verbal head and directly theta-marked by them. Our proposed analysis incorporates both assumptions.

Another virtue of the present analysis regards the relative optionality of the IO in MOCs and the relative obligatory nature of the DO. The latter is a simple consequence of the fact that IOs are introduced by small clauses of which DOs are parts in conjunction with the assumption that the verb in simplex counterparts to MOCs requires objects. This leads to the conclusion that whenever there is an IO we must find a DO, and we need a DO even if we have no IO. The relative optionality of IOs follows from whatever makes adjuncts less "required" than complements, as IOs are introduced as parts of adjuncts in MOCs.

Consider finally one last bit of evidence in favor of the approach. Ellipsis phenomena are sensitive to adjunction structure. For example, VP ellipsis must elide arguments but only optionally removes adjuncts. With this in mind, consider a prepositional dative structure like (22):

(22) a. John gave a book to Bill after Harry did to Sam
      b. John gave a book to Bill after Harry did

The fact that *to Sam* can be retained or deleted under VP ellipsis follows if it resides in an adjunct. In fact, this is parallel to what we find in sentences like (23):

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[27] This could hold for a variety of reasons, including that only theta-marked dependents of the verb can so incorporate and IOs are theta-marked by Ps not Vs (Baker 1997: 94), or that these are formed by incorporation and Ps block this. The former proposal requires treating the P in MOCs as thematically active and this may go against the spirit of proposals that see the *to* as eliminable as semantically inert (e.g. Larson 1989).

(23) a. John ate the bagel quickly before Sam did slowly
      b. John ate the bagel quickly before Sam did

We further predict that in DOCs like (24) deletion will not allow the exclusion of the IO in VP ellipsis constructions, as neither the DO nor the IO remains in the adjunct, both SW-moving to the matrix VP.

(24) a. *John gave Bill a book before Harry did Sam
      b. *John gave Bill a book before Harry did a CD

In sum, the acceptability of ellipsis in (22a) fits nicely with our proposal that IOs reside in adjuncts in underlying structure and that they remain in the adjunct in the PP-dative construction.[28]

4   Some Complications: Alternate Underlying Configurations

The derivations in (9) and (11) start from the same underlying small clause. Thus, these two derivations correspond to a dative shift approach to the PP-dative/DOC alternation. However, nothing in the core proposal is committed to this assumption. Let's see why not.

Given the derivations in (9) and (11), the thematic structure of an MOC comes from two sources: the thematic information coded in the small clause and the thematic information derived via SW movement of the small clause DP to complement of V. As the semantic direct object is constant across PP-datives and DOCs, the thematic differences, such as they are, must reflect differences in thematic structure of the small clause adjuncts. Let's assume for the nonce that such differences exist. For concreteness, let's assume a theory like that in Harley (1996). Here DOCs have a different thematic structure from PP-datives. The PP-dative has a representation like that in (25) inside the small clause, while DOCs resemble (26). The a-entries represent the thematic interpretations, the b-entries the syntax. We here assume that small clauses in MOCs have applicative heads and that the location versus possession interpretation is related to whether the PP is the internal argument or the external argument of the applicative. These are simplifying assumptions, but they correspond to the intuition pursued in Harley (1996) which treats possessive *have* as the complex conjunction of the copula plus some prepositional structure.[29] For current

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[28] We owe these observations and their interpretation to Alex Drummond (p.c.).

[29] This is based on Freeze (1992) and Kayne (1984, 1993), which is in turn based on Benveniste (1966). The guiding intuition is that *have* is a complex expression consisting of the combination of *be+P*. Note that we do not necessarily adopt the view that MOC verbs are decomposed in order to adopt alternate underlying configurations. Thus, many of the arguments against "alternate projection" given by Rappaport-Hovav and Levin (2008) do not apply, since we do not require polysemous versions of the main verb in order to have different underlying configurations.

purposes the required assumption is that in PP-datives the location receives case within the small clause while for DOCs the possessor does. This is coded below in the b-entries by assuming that the location/possessor is a PP in the respective structures.

(25) a. [DP Loc PP]
     b. [a book Appl to Mary]
(26) a. [DP$_{\text{quirky case}}$ Have DP]
     b. [to Mary Appl a book]

Consider the derivations of the two MOCs given these assumptions. Consider first the PP-dative construction. It would have the derivation already outlined in (9). What of DOCs? It would look surprisingly similar to the derivation in (11), the only difference being the first two steps, which form the small clause. In place of (27a,b), we would have (28a,b):

(27) a. E-Merge *Appl* and *to Mary* → [Appl to Mary]
     b. E-Merge *a book* and *[Appl to Mary]* → [a book [Appl to Mary]]
(28) a. E-Merge *Appl* and *a book* → [Appl a book]
     b. E-Merge *to Mary* and *[Appl a book]* → [to Mary [Appl a book]]

All the other steps in the derivation would be the same after this point. In particular, in both cases *a book* would SW move to the complement of V, thereby receiving the internal theta role. Note that without this movement *a book* would fail to get/check case. Thus, if this DP does not SW move to the VP, the derivation does not converge. Note too that this DP is closer to V than is the one inside PP given the definition of distance in Hornstein (2009). In (29) the path from *a book* to *V* is {ApplP} while the path of *Mary* is {PP, ApplP}. As the former is a proper subset of the latter, it is closer to *V* and thus moving *Mary* (when *a book* is available) violates minimality and so is blocked.[30]

(29) a. give, [$_{\text{ApplP}}$ to Mary [$_{\text{Appl'}}$ Appl a book]]
     b. give, [$_{\text{ApplP}}$ a book [$_{\text{Appl'}}$ Appl to Mary]]

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[30] On the other hand, the PP is just as close to V as a book is. As such, it is unclear what prevents movement of the PP to complement of V and then raising the DP to spec V for case. Perhaps this PP cannot discharge the theta role of V, in which case there can be no movement to the theta position. This is similar to Parasitic Gap cases with SW movement discussed in Nunes (2004). Another open issue is that of how the object is assigned Case in DOCs. If we think that v assigns Case to the object as usual, then it is not clear why the IO can be moved to subject position when passivized and not the DO. It may be that incorporating the P to v/V forces the IO to get case from the v/V and then passivization occurs just as in pseudo-passive. However, this leaves open the question of how the DO gets Case if the IO is usurping accusative. This topic is beyond what we can address here, and we would just note that any analysis of DOCs must address this problem.

As this discussion hopefully indicates, the structure of the small clause makes little difference to the derivational profiles of the two kinds of MOCs within our approach.

What is critical is that the small clause is an adjunct rather than a complement and that the DO and IO form a small clause unit. Given these assumptions, the derivations follow easily. Thus, though our approach is consistent with either a transformational analysis of MOCs wherein DOCs are derived from PP-datives or a base generation analysis in which each MOC is associated with a different underlying small clause, it does not invidiously presuppose the accuracy of one rather than the other. Moreover, there is a reason for this that is worthy of brief attention. Here it is.

Both the transformational and base generation analysis share a common assumption: that the DO/IO surface configurations basically reflect underlying structure as regards word order and hierarchy. Where the analyses differ is on whether DOCs require movement to get the right surface form. Transformational accounts assume they do, base generation accounts assume they do not. However, the present proposal requires movement to derive surface form in both cases; DOs uniformly vacate the small clause via SW movement to merge with the V to attain the internal theta role. This makes it hard to conclude much regarding underlying order from surface form, given the present analysis.

This said, there are data that are potentially relevant for deciding whether MOCs are transformationally related or not. In our view the two strongest kinds of evidence in favor of alternate underlying configuration involve (i) binding (or prominence effects) and (ii) "possessor effects." The fact that these effects hold (and line up) cross-linguistically makes them especially strong arguments for alternate configuration. Let's quickly review these here.

4.1   Binding

The first kind of data that supports an alternate configuration approach comes from considering various binding properties of MOCs. Barss and Lasnik (1986) observe that there are binding asymmetries within MOCs.[31] These are illustrated in (30):

(30) a. The editor sent every book to its author   theme > goal PPD
     b. *The editor sent his book to every author   *theme < goal
     c. The editor sent every author his book   goal > theme DOC
     d. *The editor sent its author every book   *goal < theme

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[31] Barss and Lasnik considered general scope asymmetries including reflexive binding and polarity licensing. The logic is pretty much the same in all these cases. We restrict our attention to bound pronouns here.

These data present the following puzzle for derivational accounts: If one assumes that DOCs derive from DO/IOs via movement, then how is one to block derivations in which variables are bound in the DO/IO underlying structure (as in 30a) and then moved to form the DOC (as in 30d)? A derivation of (30d) would look like (31):

(31) a. [every book Appl to its author]
     b. [send every book] [every book Appl to its author]
     c. [to its author [send every book]] [every book Appl to its author]
     d. [[v+send+to [its author every book] [every book Appl to its author]]]

The binding would take place within the small clause prior to the subsequent movements. This binding can be effected in one of two ways; either variables/pronouns can be bound in the course of the derivation (see Belletti and Rizzi 1988) or it can take place under reconstruction (see Chomsky 1993, Hornstein 1995). If either is permitted, sentences like (30d) are predicted to be grammatical (with the relevant binding), contrary to fact.

To block these undesirables, both grammatical options must be prohibited. Nor are the relevant principles wanting. For example, Chomsky (1995) and Lasnik (1999) have argued that there is no A-chain reconstruction, i.e. that A-movement copies do not feed reconstruction.[32] Similarly it is the standard assumption that binding is licensed at the conceptual-intentional (CI) interface, not derivationally. These are common and not unreasonable assumptions. However, what is interesting is that these are *required* in the context of a transformational analysis, rather than just options.

Observe that these same assumptions will permit the derivation of (30c) despite its being derived from a structure like that underlying (30b). Though the underlying structure involves a small clause like (32) in which the pronoun is outside the c-command domain of the quantifier, the binding is licit if we assume that it applies after A-moving *every book* to Spec V and that binding from this position is licit.[33] This is not a particularly heroic assumption given that the postulated movement is A-movement and the position targeted (Spec V) c-commands the reflexive.

(32) a. [his book [Appl [to every author]]]
     b. [$_{vP/vP}$ [$_{vP}$ The editor [$_{v'}$ [v+send+to] [$_{VP}$ to every author [send his book]]]] [his book [Appl [to every author]]]]

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[32] This in turn plausibly follows from reconstruction being a product of turning chains into operator-variable structures. If A-chains are not mapped into such structures for CI purposes, they will fail to allow reconstruction.

[33] Observe, here we only need assume that the binding *can* apply at the interface not that it *need* apply there.

So in order to maintain the transformation approach, we have to assume that binding is not permitted in the course of the derivation and only holds at the interface.

Reconciling the data with the base generation approach is considerably less involved.[34] Under this hypothesis, the underlying structure of PP-datives involve small clauses where the DO is subject and IO predicate. The underlying structure of DOCs reverses things and the IO is subject and the DO predicate. The latter comes with a "possession" interpretation of the applicative. What is interesting for our purposes is that on this view licensing the relevant binding in (30) can be effected within the small clause. The relevant small clause structure for the four sentences is given in (33). As is easily observed, *were* binding established here then (35a,c) would be fine while (35b,d) would be out, as desired.

(33) a. [every book [Appl to its author]]
    b. [his book [Appl to every author]]
    c. [(to)-every author [Appl his book]]
    d. [(to)-its author [Appl every book]]

Note that for English, the surface order of DO and IO mimics its underlying form in both DOCs and PP-datives, so there is nothing to be gained in limiting binding to surface configuration.[35] However, this is not the case in every language, and these are worth a moment's consideration. Consider Spanish and the paradigm in (34).

(34) a. El editor envió [cada libro]$_i$ a su$_i$ autor.   DO > IO
      'the editor sent each book to its author'
    b. *El editor envió su$_i$ libro [a cada autor]$_i$.   *DO < IO
      'the editor sent his book to each author'
(35) a. El editor **le** envió [a cada autor]$_i$ su$_i$ libro.   IO > DO
      'the editor **CL** sent to each author his book'
    b. *El editor **le** envió a su$_i$ autor [cada libro]$_i$.   *IO < DO
      'the editor **CL** sent to its author each book'
    c. El editor **le** envió [cada libro]$_i$ a su$_i$ autor.   DO > IO
      'the editor **CL** sent each book to its author'

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[34] At least for the English data. We return to some interesting data from Spanish below.
[35] Note that if binding can apply in the derivation, one problem may still arise. In (30d) *every book* cannot bind *its* (in *its author*) as it does not c-command it. However, on the present account, in the course of the derivation, *every book* moves to become complement of *sent*, and this is a position from which it should (plausibly) be able to bind the reflexive still in the small clause. Were this to occur, then (30d) would be well-formed. Note that the same possibility would arise were reconstruction of the IO to the small clause subject permitted. We abstract away from this potential problem in what follows.

d. (?)El editor **le** envió su[i] libro [a cada autor][i].[36]   DO < IO
   'the editor **CL** sent his book to each author'

The examples split naturally into two parts, (34a,b) with no clitic versus (35a–d) where the clitic *le* doubles the IO. Bleam (2003) and Cuervo (2003), following Uriagereka (1988) and Demonte (1995), argue that the former pattern with English PP-dative constructions, the latter with English DOCs. If this is correct, then the binding data in (34–35) suggest that one must allow some binding to apply through the course of the derivation (at least in underlying base structure). If this is correct, then it argues against a transformational analysis and in favor of a dual base generation approach to MOCs. Consider the details.

The relevant example is (35d). Note that it is acceptable with the indicated bound pronoun interpretation. Note, however, that it differs from English examples in that in (35d) the bound pronoun *su* should not be bindable by *a cada autor*, as it is lower than the pronoun and on its left. Nonetheless, the sentence seems fine. This suggests that the binding is carried at some point earlier than the surface position. However, if DO always precedes IO (as a transformational analysis assumes), then there is no obvious point in the derivation where the binding could licitly occur. If, however, DOCs involve small clause configurations in which the IO c-commands the DO, then the binding in (35d) would be licensed prior to movement of the DO to the internal argument position of *envió/enviar*. The relevant underlying structure would be (36) with the binding taking place prior to movement of *su libro*.

(36) El editor le [envió su[i] libro] [[a cada autor][i] [Appl [su[1] libro]]]

It is not clear how this binding could be derived grammatically without allowing it to be licensed prior to movement of the DO, something that, as we saw above, a transformational analysis would be hard pressed to permit.[37]

We add data from Kannada to show that the generalization holds across language families and even in cases where the word order is quite free.[38] The cross-linguistic generalization is the following: If there is a dative alternation,

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[36] This judgment was originally reported as being semi-marginal in Bleam (2003). But the fact that backwards binding is possible in this sentence has been supported/reinforced by subsequent research (Bleam and Lidz, in prep., and Freynik 2012). Also, Lidz (2002) shows that the same binding judgments hold in Kannada: backwards binding of the IO into the DO is only possible with a particular benefactive marker on the verb that shows the properties of the DOC.

[37] (35c) indicates that binding should be allowed following movement as well. After the DO moves to the complement of V, it binds the pronoun inside the small clause. As the DP moving out of the small clause targets a theta-position and given that these are A-positions, then this would simply be a case in which A-movement feeds binding, as, e.g., in raising constructions in English.

[38] The data and generalizations about Kannada come from Lidz (2002) and Lidz and Williams (2005, 2006).

then, in the version which entails a possessor relation (i.e. the DOC),[39] the goal/possessor/IO will be prominent over (i.e. be able to c-command into) the theme no matter what the word order. The theme, on the other hand, can only c-command into the IO if it comes before the IO in the surface order. In the non-DOC version, the theme is the prominent element. Here, regardless of word order, the theme (or DO) can c-command into the IO, whereas the IO can only c-command into the DO if it comes first. (See Lidz 2002, Bleam and Lidz, in prep., Harley 2002.)

In Kannada, the DOC (i.e. the version that shows possession effects) has a benefactive morpheme attached to the verb. The English PP-dative is equivalent to the Kannada "No-BEN" version.

The data in (37) shows that when there is no benefactive marker, the theme (ACC) binds into goal (DAT), independently of word order (37a,b). The goal (DAT), on the other hand, can bind into the theme (ACC) only when it comes first (i.e. is higher in surface structure) (37c,d).

(37) a. sampaadaka pratiyondu lekhana-vannu adar-a lekhan-ige kaLis-id-a
        editor   every   article-ACC   it-GEN author-DAT send-PST-3SM
        'The editor sent every article to its author.'   (theme > goal)

    b. sampaadaka adar-a lekhan-ige pratiyondu lekhana-vannu kaLis-id-a
        editor   it-GEN author-DAT every   article-ACC   send-PST-3SM
        'The editor sent every article to its author.'   (goal < theme)

    c. sampaadaka pratiyobba lekhan-ige avaL-a lekhana-vannu kaLis-id-a
        editor   every   author-DAT she-GEN article-ACC   send-PST-3SM
        'The editor sent every author her article.'   (goal > theme)

    d. *sampaadaka avaL-a lekhana-vannu pratiyobba lekhan-ige kaLis-id-a
        editor   she-GEN article-ACC every   author-DAT send-PST-3SM
        'The editor sent every author her article.'   (*theme < goal)

We take the fact that the theme (DO) is always prominent when there is no benefactive marker to indicate that in the underlying structure, the DO c-commands the IO, and that additional c-command configurations can arise due to subsequent (A-) movement.

The examples in (38) show that when the benefactive marker is present, the dative can bind into the accusative independent of word order; but, the accusative can bind into dative only when it comes first:

(38) a. sampaadaka pratiyondu lekhana-vannu adar-a lekhan-ige kaLis-i-**koTT**-a
        editor   every   article-ACC   it-GEN author-DAT send-PP-BEN.PST-3SM
        'The editor sent every article to its author.'   (theme > goal)

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[39] One can recognize the DOC independently because it will show possessor effects. See the argument in section 4.2 below.

b. *sampaadaka adar-a lekhan-ige pratiyondu lekhana-vannu kaLis-i-**koTT**-a
   editor   it-GEN author-DAT every   article-ACC   send-PP-BEN.PST-3SM
   'The editor sent every article to its author.'   (*goal < theme)

c. sampaadaka pratiyobba lekhan-ige avaL-a lekhana-vannu kaLis-i-**koTT**-a
   editor   every   author-DAT she-GEN article-ACC   send-PP-BEN.PST-3SM
   'The editor sent every author her article.'   (goal > theme)

d. sampaadaka avaL-a   lekhana-vannu pratiyobba lekhan-ige kaLis-i-**koTT**-a
   editor   she-GEN article-ACC   every   author-DAT send-PP-BEN.PST-3SM
   'The editor sent every author her article.'   (theme < goal)

Here, the persistent prominence of the IO indicates that it c-commands the DO in the base structure.

4.2   *Possessor Effects*

The second kind of evidence for alternate underlying configurations is the existence of a possessor restriction that we find between the elements in the DOC. The generalization (from Harley 2002) is that an IO and a DO can appear in the DOC only if the IO can be interpreted as possessing the DO. A test for this is whether the IO can appear as the subject of "have" or "receive" where the DO is the thing that is had or received. There is no such restriction for the PP-dative. Here the IO is just interpreted as a location. For example, since a street is not a felicitous possessor of a book, the DOC is not acceptable with "Main Street" as goal/recipient and "the book" as theme (or possessed element). This is illustrated in (39), and (40) shows that a similar example is bad with the clitic, which is the signal for the DOC in Spanish.

(39) a. #Mary sent **Main Street** the book.   DOC
     b. #**Main Street** has/received the book.
(40) a. Mari (*le) envió el libro **a calle Dato**.[40]
        Mari (*CL) sent the book to Dato Street.
     b. #Calle Dato tiene/recibió el libro.
        Dato Street has the book.

There are several points about the generalization that we wish to make clear. One thing to note is that this is not an animacy restriction per se. It is true that possessors are often animate; however, as long as the individuals can be interpreted as being in a possession relation (such as a house having a roof, a table having a leg, tea having sugar, etc.), then the DOC will show no anomaly, as in the following examples.[41]

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[40] Thanks to Javier Ormazabal for this particular example and the idea to use a street name, rather than a city name, to make the anomaly more clear.

[41] In Spanish, the effect is more obvious because verbs like "put" (which do not entail possession) allow the use of the DOC (the dative clitic). In English, verbs like "put" require a prepositional

(41) a. Mari **le** puso un techo nuevo a **la casa**.
    Mari CL put a new roof on the house (lit. "to the house").
  b. **La casa** tiene un techo nuevo.
    The house has a new roof.
(42) a. Mary gave **the house** a new coat of paint.
  b. **The house** has/got/received a new coat of paint.

The second point to be clear about is that this does not mean the effect will not arise in the PP-dative as well. The effect will arise any time possession is entailed. Sometimes possession is entailed purely by having the DOC (i.e. the P-HAVE small clause). In the case of *send* or *throw*, the verb itself does not entail possession and so the meaning can only be added by the meaning of the small clause. However, the verb *give* already entails transfer of possession, with or without the DOC. Thus, we see possession effects in the PP-dative with *give* but not with *send*.

(43) a. #Mary gave the book to Main Street.
  b. Mary sent the book to Main Street.

The generalization holds in Kannada as well. When there is no benefactive marker, there is no possessor restriction, regardless of the word order, as shown in (44):

(44) a. nannu   banglor-ige   pustaka-vannu   kaLis-id-e
    I   Bangalore-DAT   book-ACC   send-PST-1s
    'I sent the book to Bangalore.'
  b. nannu   pustaka-vannu   banglor-ige   kaLis-id-e
    I   book-ACC   Bangalore-DAT   send-PST-1s
    'I sent the book to Bangalore.'

But when the benefactive marker is present, the IO must be interpreted as a possessor of the DO. Since it is weird to interpret the city of Bangalore as a possessor of a book, the sentences in (45) are anomalous.

(45) a. #nannu   banglor-ige   pustaka-vannu   kaLis-i-**koTT**-e
    I   Bangalore-DAT   book-ACC   send-PP-BEN.PST-1s
    'I sent the book to Bangalore.'
  b. #nannu   pustaka-vannu   banglor-ige   kaLis-i-**koTT**-e
    I   book-ACC   Bangalore-DAT   send-PP-BEN.PST-1s
    'I sent the book to Bangalore.'

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phrase and no DOC is available. Thus, we must use "give" in order to get an inanimate IO that allows for possession, and, as we note above, "give" will exhibit the possessor restriction regardless of the alternation.

The strength of the argument for alternate underlying structures comes from the fact that the binding effects line up with the possessor effects and that these correlations hold cross-linguistically.

We have tried to show two things in this section. First, that our proposal is consistent with either a transformational or a base generation analysis of MOCs. Second, that there is evidence from binding and possessor effects in favor of a dual analysis.[42]

5   Conclusion

This chapter has argued the virtues of returning to an earlier analysis of MOCs. In the earliest days of Generative Grammar, indirect objects were treated as adjuncts. Based on Larson's important work, these constructions were later reanalyzed as deriving from underlying small clause complements. This chapter has argued that it is possible to retain the insights of the earlier adjunct analysis while also adopting a small clause structure if one allows for sidewards movement, a possibility that contemporary minimalist conceptions of structure building make possible, as Juan Uriagereka was among the first to observe.

We further noted that this approach to MOCs leaves open the question of whether DOCs and PP-datives are transformationally related or are independently base generated. We believe that the current evidence favors the second approach; however, the issues, though often related, are on the proposed analysis logically independent.

Last of all, it seems to us that a small clause adjunct analysis like the one proposed here might also reasonably apply to the analysis of further constructions including benefactives, resultatives, and *spray/load* alternations. We leave justification of this conjecture to further work.

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[42] But see Larson (2014) and Ormazabal and Romero (2010) for some strong arguments in favor of a transformational analysis.

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2   Verbal Complex Formation and Overt Subjects in Infinitivals in Spanish

Francisco Ordóñez[1]

1   Introduction

The study of the distribution of postverbal subjects has been the topic of much discussion in recent years in the literature on Romance. Of particular interest is the syntactic variation that one can find in the Romance languages and how those different distributions can illuminate the discussion of theoretical issues related to control, case, and focus. I will concern myself with recent proposals on how to analyze overt subjects in infinitival structures involving control. One possible analysis of the overt realization of subjects in these control constructions has been the backward control analysis proposed by Polinsky and Potsdam (2002). These are instances in which the *controlled* subject in the infinitival verb is overtly pronounced as opposed to the *controller*, which is an argument of the main clause.

   This chapter brings to light a new analysis to the facts and proposes an alternative to backward control for Spanish. I will propose that overt subjects in these infinitival clauses of the control type are not overt realizations of the subject of the infinitival; instead they involve the main clause subject. This subject ends up in this position because massive remnant movement of verbal projections to the left has taken place. This remnant movement masks the fact that the subject is in reality the main subject. This alternative has important advantages of drawing parallelism between these Spanish constructions and the formation of verbal complexes in the Germanic languages (Hinterhölzl 2005), Hungarian and Dutch (Koopman & Szabolsci 2000), and causatives in French (Homer, Ishizuka & Sportiche 2009). One important advantage of this proposal is that it accounts for the following generalization: those languages that allow VSO order are also the ones that permit a wider distribution of subjects in apparent backward control contexts. We conclude that this wider distribution is a

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consequence of the fact that Spanish has a higher Spec position for the landing site of its subjects.[2]

2 On the Position of Postverbal Subjects in Infinitival Clauses: A Comparison of Catalan and Spanish

In order to better understand the exact position subjects occupy in infinitival clauses in Spanish, I will make a comparison with Catalan. Catalan allows postverbal subjects with infinitives, but its distribution is different in many crucial respects. We will start with contexts in which nominative case is available with infinitives. This is the case, for instance, for subjects in adverbial clauses with *before*. When the verb is transitive and the object is overt, the subject can appear either before or after the direct object. The preverbal position is generally ungrammatical in most dialects.[3]

(1) Antes   de (*Luis)   comprar   (Luis) manzanas   (Luis)[4]
    Before   of (*Luis)   buy-ying-INF   (Luis) the apples   (Luis)
    'Before Luis buying apples'

This pattern in Spanish contrasts with Catalan, which does not allow the possibility of having the subject between the object and the complement. Subjects usually follow complements:

(2) Abans de   comprar (*en Lluís)   pomes   (en Lluís)
    Before of   buy-INF (*Lluís)   apples   (Lluís)
    'Before Luis buying apples'

The same pattern exists with infinitival clauses involving control. These examples are particularly interesting because there is no obvious source for case of the subject in the infinitival clause. According to standard assumptions, these control structures involve a PRO with null case or an empty category product of movement, as in Hornstein (1999). (4a) in Spanish shows that a subject might appear in different positions: either before the infinitive, or after the infinitive before the complement, or after the complement. Again Catalan (in 4b) clearly contrasts with Spanish in the possibilities allowed. See also Ordóñez (2007).[5]

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[2] For an interesting alternative to backward control, and to the one I am proposing here, see Ortega-Santos (2016). For a higher subject position, see Ordóñez (2007).

[3] Caribbean Spanish dialects do allow this pre-infinitival position subject more easily. This is more common with pronouns. I leave aside this important question.

[4] There might be a slight preference for having the subject after the complement for some speakers. However, the two possibilities exist.

[5] Again speakers might vary in their preference for where to put the subject, and the judgments might require special intonation depending on whether the subject is the focus or not. I leave for future research the study of the interaction of intonation and distribution of postverbal subjects in Spanish.

(3) V (S) INF (S) XP (S)

(4) a. Hoy   no querían   (los estudiantes)   leer   (los estudiantes)
         Today not wanted   (the students)   read-INF (the students)
         las novelas   (los estudiantes)
         the novels   (the students)
         'Today the students didn't want to read the novels.'

     b. Avui no volien   (?*els estudiants) llegir   (?*els estudiants)
         Today not wanted   (the students)   read-INF (the students)
         les novel.les   (els estudiants)   (Catalan)
         the novels   (the students)
         'Today the students didn't want to read the novels.'

These differences in the distribution of subjects in infinitival constructions
are clearly related to the fact that subjects in Spanish have a wider distribution
in general with respect to other complements in finite as well as infinitival
clauses. It is well known that V (S) XP (S) orders are more readily available in
Spanish than in Catalan, which allows only V XP S (Gallego 2012, Rosselló
2002, Solà 1992, Vallduví 2002), as shown below:

(5) V (S) XP (S)

(6) a. Hoy   comprará   (Juan) comida   (Juan)   (Spanish)
         Today   will buy   (Juan) a meal   (Juan)

     b. Avui   comprarà   (*en Joan)   menjar (en Joan) (Catalan)
         Today   will buy   (en Joan)   lunch (en Joan)
         'Today Juan will buy a meal.'

     c. En Irak   fue   (usted)   herido (usted)   (Spanish)
         In Iraq   were-Past (you)   injured (you)

     d. A l'Irak   hi va ser   (*vostè)   ferit (vostè)   (Catalan)
         In Iraq   loc-be-Past (you)   injured (you)
         'In Iraq, you were injured.'

The different distributions of postverbal subjects in infinitival verbs with
nominative case, control infinitival, and finite subjects are equivalent. This
suggests that a common analysis is needed. This is possible if we propose a
common source for all postverbal subjects. We will propose exactly an analysis
that makes that connection possible in this chapter.

3   The V S INF XP and V INF S XP and Control

3.1   *The V S INF XP Order*

We can start with the subject control examples as in (3). As we saw, the V S INF
XP and V INF S XP orders are both possible. The V S NF XP order poses no
problems for most theories if the subject in this example is the main subject and

if Spanish S stays in a position below the final position of the verb (Alexiadou & Anagnostopoulou 2001, Cardinaletti 2001, Costa 1997, Motapayane 1995, Ordóñez 1998).

(7) [V [$_{VP}$ S [INF XP]]]

However, the order V INF S XP raises various questions. Since these are control examples, the subject could be either the controller subject of the finite verb or the controllee. If it is the controller, the question is how the main subject can end up in this postverbal position.

Under the standard GB proposal, the controllee subject is a phonetically empty PRO. That PRO obtains its reference by being co-indexed by the subject argument in a local domain:

(8) Juan$_i$ quiso   [PRO$_i$ comprar   el libro]
     Juan   wanted   PRO   buy-INF   the book
     'Juan wanted to buy the book.'

However, in recent years Hornstein (1999) has proposed that control structures do not involve PRO. Instead control is reduced to an instance of movement from the theta subject position of the infinitival verb to the subject theta position of the main clause. After movement of the subject from its infinitival clause to the main subject position, the lower copy is deleted:

(9) Juan$_i$ quiso   [~~Juan$_i$~~   comprar   el libro]
     Juan   wanted   ~~Juan~~   buy-INF   the book
     'Juan wanted to buy the book.'

Polinsky and Potsdam (2006) follow Hornstein's (1999) approach and claim that a more thorough picture emerges when the different alternatives of deletion are considered. The distribution of the subject depends on the locus of pronunciation after movement: if the higher copy is pronounced, forward control (FC) is obtained, as in the standard examples of control in GB; if the lower copy is pronounced, backward control (BC) is obtained; and finally examples in which both copies are pronounced are cases of resumption:

(10) Typology of control and raising according to Polinsky and Potsdam (2006)

Higher copy pronounced	Lower copy pronounced	Structure
√	*	FC
*	√	BC
√	√	Resumption

Given this typology, a new analysis for the V INF (S) XP order emerges. This could be taken to be an instance of BC in which the lower copy is pronounced.

As we saw with the adjunct infinitivals with overt subjects, infinitival verbs must necessarily move above the position of the overt subject. This movement corresponds to the two scenarios proposed: FC and BC.

(11) Juan$_i$ quiso   [comprar$_i$ ~~Juan$_i$~~ el libro] **FC = S INF XP**
     Juan   wanted   [buy-INF   ~~Juan~~   the book]
(12) ~~Juan$_i$~~ quiso   [comprar   Juan$_i$ el libro] **BC = INF S XP**
     ~~Juan~~   wanted   [buy-INF   Juan   the book]
     'Juan wanted to buy the book.'

Thus, there are two subject positions: one in the higher clause and one in the lower one, and there is a movement chain that unites these two positions. Thus, the analysis captures in an elegant way the second possibility attested in Spanish. Of course, many questions arise as to what are the conditions necessary for a language like Spanish to manifest these examples of BC, and not Catalan, as we saw in the introduction. We pose some more questions in the next section.

3.2   Some Objections to Backward Control Analysis
         for the V INF S XP Orders

We will start with adoption of backward control analysis in languages like Greek by Alexiadou, Anagnostopoulou, Iordachioia, and Marchis (2010) and compare the analysis in Greek with a possible counterpart as above for Spanish. Greek, contrary to Spanish, does not show infinitives for control structures in general. However, it has been convincingly argued that the subjunctive mood involves obligatory control. Alexiadou et al. (2010) claim that instances in which the subject is overt in the embedded subjunctive clause is an instance of BC, in which the subject's lower copy is pronounced.

(13) (O Janis)   emathe   (o Janis)   na pezi   (o Janis)
     John-nom   learned-3sg   John-nom   subj play-3sg John-nom
     kithara (o Janis)
     guitar   John-nom
     'Janis learned to play the guitar.'

The argument that this is an instance of backward control is given by the fact that the embedded subject is itself licensed in that position and that it differs from the properties of the main subject. In order to do that, they go through a series of tests. The first is licensing of negative polarity items (NPIs). Greek is a negative concord language like Spanish. Postverbal negation requires a negation in preverbal position in order to license it. When the negative quantifier appears in the main clause with the embedded negation in the subjunctive, the sentence is ungrammatical since it gives a reading of double negation, as in (14a).

However, when the negative word *kanis* appears embedded in the subjunctive, the embedded negation is able to license it (14b):

(14) a. *Kanis   tolmise   na   min   fai   to   tiri
       Nobody   dared-3sg   subj   not   eat   the   cheese
     b. %[6]tolmise na   min   fai   **Kanis**   to tiri (Greek)
       dared-3sg subj   not   eat-subj nobody   the cheese

We can try the same tests for Spanish. The crucial test is whether an embedded negation will license the subject negative quantifier *nadie*. Starting with a clause like (15), the embedded subject **Juan** might be embedded under the scope of the negation. The sentence implies that Juan picked his nose despite the prohibition made by someone to not do so:[7]

(15) a. **Juan**   olvidó   no   tocarse   la nariz
       Juan   forgot   not   to pick   his nose
     b. [8]Ayer   olvidó   no   tocarse   **Juan** la nariz
       Yesterday   forgot   not   to pick   Juan   his nose
       'Yesterday Juan forgot not to pick his nose.'

When a negative quantifier *nadie* is inserted, the paradigm gets more complicated. With *nadie* preverbally, a double negation arises. Namely (16a) implies that everybody remembered to not pick their nose. That reading is maintained in (16b) with *nadie* in the embedded clause and with the negation in the main clause. The first negation is required because of negative concord. This shows that *nadie* is licensed by the higher negation and not the lower one. However, when the main negation is deleted, the lower negation is incapable of licensing *nadie* on its own as shown in (16c). This indicates that the subject *nadie* belongs to the main clause and not the embedded infinitive clause.

(16) a. Nadie   olvidó no   tocarse   la nariz (everybody remembered)
       Nobody   forgot not to touch   his/her nose
       'Nobody forgot not to touch their nose.'
     b. **No** olvidó no tocarse **nadie**   la nariz (everybody remembered)
       Not forgot not to touch nobody   his/her nose
       'Nobody forgot not to touch their nose.'
     c. *?Ayer   olvidó no   tocarse   nadie   la nariz
       Yesterday   forgot not to touch   nobody   his/her nose
       'Nobody forgot not to touch their nose.'

---

[6] This indicates the sentence is grammatical but discursively odd.

[7] Recall that these sentences must always be read with an appropriate focal intonation and in a particular discourse environment without which they sound a bit unnatural for most speakers. This comment applies to the rest of the examples with postverbal subjects. It is possible that for some speakers the most natural examples are the ones involving infinitivals assigning nominative case.

[8] In the examples with postverbal subjects, I am introducing an adverbial phrase in order to make it more natural. Topic phrases at the beginning make it more easy for subjects to appear postverbally.

The examples above contrast with similar examples with raising verbs. For raising verbs like *parecer* ('to seem'), the embedded subject *nadie* ('nobody') can appear with the infinitival with the embedded negation licensing it. The same occurs with verbs like *empezar* ('begin') which are ambiguous between raising and control in Greek and Spanish. This asymmetry is not surprising if *nadie* ('nobody') starts out in the infinitive clauses according to the raising analysis:

(17) Ya   que parece **no**   tocarse   **nadie**   la nariz
     Since   it seems   not   to pick   nobody   the nose
     'Since nobody seems to pick their nose.'

(18) Ya   que empezó a   **no**   distinguir   **nadie**   los colores
     since   that started to   not   distinguish nobody   the colors
     'Since nobody started to distinguish the colors.'

The second puzzle for a backward control analysis is the fact that backward control (BC) is sensitive to locality in a way that forward control (FC) is not. This is unexpected if both involve the same movement, but they are distinguished with respect to where the copy is pronounced. This is clearly shown in examples involving infinitival wh-islands, as discussed by Torrego (1996). While the upper copy is available, the lower one is ungrammatical.

Wh-islands:

(19) *?~~Juan~~   no sabe   si   contestar   Juan   las cartas (BC)
     ~~Juan~~   not know   whether   to answer   Juan   the letters
     'Juan does not know whether to answer the letters.'

(20) Juan   no sabe   si   contestar   ~~Juan~~   las cartas (FC)
     Juan   not know   whether   to answer   ~~Juan~~   the letters
     'Juan does not know whether to answer the letters.'

An interesting puzzle related to these contrasts is the fact that pronominals do not show the same effects, as pointed out again by Torrego (1996). See also Belletti (2007) for similar effects in Italian:[9]

(21) Los estudiantes$_i$ no saben   si   contestar   **ellos**$_i$ la carta
     The students   not know   whether   to answer   they   the letter
     'The students didn't know whether to answer the letter.'

Another reason against a simple spell-out solution for the embedded subject in these infinitival examples is the different intervention effects of different arguments between main verb and embedded infinitive. Thus, under a movement approach, to control a verb like *prometer* ('to promise') can have the

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[9] See also Piera (1987). He points out that this phenomenon must be related to the fact that overt pronouns can be doubling a preverbal subject.

(i) tus hermanos me acusaron ellos despiadadamente.
    your siblings accused me they without pity.

upper copy pronounced as (22a), yielding the expected FC result, or the lower copy is pronounced yielding the BC result in (22b).

(22) a. El jurado   prometió   [darles   ~~el jurado~~   la libertad
        The jury   promised   to give-cl   ~~the jury~~   the liberty
        a los prisioneros] (FC)
        to the prisoners
     b. ~~El jurado~~   prometió   [darles   el jurado   la libertad
        ~~The jury~~   promised   to give-cl   the jury   the liberty
        a los prisioneros] (BC)
        to the prisoners
        'The jury promised the prisoners to give them the liberty.'

However, when the indirect object of *promise* appears between the main verb and the embedded infinitive, the lower copy cannot be spelled out. This can be seen in the following contrasts:

(23) a. El jurado   les prometió   a los familiares   [darles   ~~el jurado~~
        The jury   promised   to the family   to give-cl   ~~the jury~~
        la libertad   a los prisioneros] (FC)
        the liberty   to the prisoners
        'The jury promised the family to give the prisoners the liberty.'
     b. ~~El jurado~~   les prometió   a los familiares   [darles   el jurado
        ~~The jury~~   promised   to the family   to give-cl   the jury
        la libertad   a los prisioneros] (BC)
        the liberty   to the prisoners
        'The jury promised the family to give the prisoners the liberty.'

The point in question is that if control involves movement of the subject, and there is a free choice of which copy can be pronounced, then both backward and forward control should be equally available. However, this is not what we see.

The next point is not an immediate criticism of the backward analysis, but it raises issues related to how best to characterize such analysis. We should consider not only forward and backward control but also middle control. Take, for instance, example (24).[10] Example (24a) would be backward control; (24b) would be forward control; and (24c) could be considered then middle control:

(24) a. En todo caso debería   Juan poder   ~~Juan~~ devolverte   ~~Juan~~   el
        In any case   should   Juan be able   ~~Juan~~ to return   ~~Juan~~   the
        dinero (FC)
        money
        'In any case Juan should not be able to return the money.'

---

[10] Romance languages, contrary to English, do not show a difference in morphological behavior between modal verbs and typical control verbs. Many authors assume they involve the same syntactic structure with PRO. See Rizzi (1976).

b. En todo caso debería ~~Juan~~ poder ~~Juan~~ devolverte Juan el
   In any case   should   ~~Juan~~ be able ~~Juan~~ to return   Juan the
   dinero (BC)
   money

c. En todo caso debería ~~Juan~~ poder Juan devolverte ~~Juan~~ el
   In any case   should   ~~Juan~~ be able Juan to return   ~~Juan~~ the
   dinero (MC)
   money

   'In any case, Juan should be able to return the money.'

But the crucial argument against a backward analysis of these control structures is that it fails to capture the fact that similar patterns are found in structures that standardly are not considered to involve control. This is, for instance, the example of causative and perception verb constructions. In (25) and (26) the subject might appear overtly in the post-infinitival position:

(25) Ayer   nos hizo   leer   Juan   el libro
     Yesterday to us make   to read   Juan   the book
     'Yesterday Juan made us read the book.'

(26) Ayer   oyó   cantar   Pedro   *La Traviata*
     Yesterday heard   to sing   Pedro   *La Traviata*
     'Yesterday Pedro heard the singing of *La Traviata*.'

If no movement chains are involved in this construction, then we need to derive the postverbal subject position in a different fashion. Another generalization not captured is that object control verbs show the same pattern with main subjects. Here the controller element in the infinitive is the object clitic *me*, and the subject is able to appear after the infinitive. No chain is involved but the subject appears in the post-infinitival position:

(27) Ayer   me recomendó   leer   Juan   este libro
     Yesterday cl-recommended   to read   Juan   this book
     'Yesterday Juan recommended me to read this book.'

(28) Ayer   nos prohibió   leer   Juan   este libro
     Yesterday cl-prohibited   to read   Juan   this book
     'Yesterday Juan prohibited us from reading this book.'

The same locality issues mentioned with *promise*-type verbs are found in causatives, perception verbs, and object control verbs. No intermediate object argument in the middle of the sentence can intervene between the verb and infinitive with postverbal subject as in (29a), (30a). On the contrary, if the intermediate object argument appears at the end of the sentence, it is rendered grammatical as in (29b), (30b):

(29) a. ??Ayer   nos prohibió   a nosotros   leer   Juan   este libro
        Yesterday cl-prohibited   to us   to read   Juan   this book

	b. Ayer	nos prohibió	leer	Juan	este libro	a nosotros
		Yesterday	cl-prohibited	to read	Juan	this book	to us

'Yesterday Juan prohibited us from reading this book.'

(30) a. ??Ayer   nos hizo   a nosotros   leer   Juan   este libro
         Yesterday   made   to us   to read   Juan   this book

   b. Ayer   nos hizo   leer   Juan   este libro   a nosotros
      Yesterday   made   to read   Juan   this book   to us

   'Juan made us read this book.'

Finally, not only main subjects are permitted after the infinitive as assumed by backward control, but also the direct object of a main verb might be inserted in this post infinitival position in object control verbs. This is shown in the order V DO INF XP and V INF DO XP in (31). This example shows that main subject and main object controllers can be equally embedded and appear after the infinitival verb:

(31) a. Obligaron   a Bush   a firmar   los acuerdos de paz
         Obliged-3pp   to Bush   to sign   the peace agreements

   b. Obligaron   a firmar   a Bush   los acuerdos de paz
      Obliged-3pp   to sign   to Bush   the peace agreements

   'They obliged Bush to sign the peace agreements.'

To summarize the arguments so far, a backwards control analysis for infinitival verbs in Spanish faces two problems: there is not enough evidence to show that the lower copy of the control structure is based generated there; and it is not sufficiently general to cover all the similarities we found between these infinitival subjects in these control structures and other non-control structures like causatives and perception verbs. In those last structures, there is no control involved. If we eliminate the possibility of assuming that subjects in (4a) are instances of backward control, we are led to propose that the post-infinitival subject found in these structures is the main subject verb. The question is how we derive the following general schema without backward control:[11]

(32) V_1 [V-INF$_2$ SUBJ$_1$ OBJ$_2$]

We can entertain various proposals. The first one is to assume a head movement analysis. Guasti (1993) proposes that there is head movement of the infinitive to adjoin to the main verb as proposed for causative constructions in Romance languages. However, this implies a right adjunction of the infinitive to the main verb, not a welcome result if right adjunction is generally not permitted as proposed in Kayne's (1994) proposals.

(33) V-VINF$_2$ SUBJ [$_1$ t OBJ$_2$]

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[11] The sub-index shows that 1 indicates main verb, main object, 2 embedded verb or embedded object.

Cinque's (2006) restructuring proposal provides an alternative possibility. According to Cinque, restructuring involves monoclausal structures and each modal verb that takes infinitives projects into the functional field. Under this approach infinitival verbs must move past the position of the postverbal subject just as past participles move past the position of the subject *in situ* in auxiliary constructions to an agreement head (Belletti 1990). The comparison between auxiliary and modals is shown below:

(34) Auxiliary   > Vpp$_1$ > > [$_{VP}$SUBJ   t$_1$ OBJ]
       habia (functional)   comido (vpp)   Juan   las manzanas
       has   eaten   Juan   apples
(35) Modal (functional)   > INF$_1$ > > [$_{VP}$SUBJ   t$_1$ OBJ]
       wanted   to eat   Juan   the apples

To understand the optionality of movement of the infinitive, one can adopt a modification of Cinque's (2006) proposal by Cardinaletti and Shlonsky (2004) and assume that modal optionally projects into the functional field. The possibility of having a post-infinitival subject would have to be tied to whether modals project functional verb as opposed to lexical VPs. When modals are like auxiliaries, then subjects can appear after the infinitive (35). When modals are like lexical verbs, then the subject must appear before the infinitive as in (36):

(36) [$_{VP}$ Modal lexical   > SUBJ   INF$_1$ > > [$_{VP}$ t$_1$ OBJ]]
        wanted   Juan   to eat   the apples

Both hypotheses need to answer why the process of restructuring goes beyond the typical modal, causative, and perception verbs. As we saw in examples (27) to (29), postverbal subjects might appear after certain object control verbs, which are not modal and are not taken to project into any functional field in Cinque's typology.

Moreover, some examples of V$_1$ [V-INF$_2$ SUBJ$_1$ OBJ$_2$] involve more than pure verbal infinitival heads; some infinitivals come with a preposition or complementizer. When complementizers and prepositions come into play, a functional analysis is not enough, since it requires a new position for the preposition to merge in the functional structure:[12]

(37) a. Ayer   olvidó **de** tomar   Juan   el desayuno
          Yesterday   forgot of   to have   Juan   breakfast
          'Yesterday, Juan forgot to have his breakfast.'
       b. Ayer   tuvo   **que** tomar   Juan   el desayuno
          Yesterday   had   that   to have Juan   breakfast
          'Yesterday, Juan had to have his breakfast.'

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[12] Additionally, it is unclear why some functional restructuring verbs require the preposition and some others don't.

In conclusion, we need other alternatives to the backward control, the head movement, or functional analysis. I will propose an alternative in which subjects end up in postverbal position in these examples when finite verb and infinitive form a verbal complex. In forming the verbal complex, subjects can appear in a post-infinitival position. This is captured in the following generalization:

(38) Generalization: All the Infinitival elements to the left of the SUBJECT in the form V_1 INF_2 $SUBJ_1$ OBJ_2 must form verbal complexes in order to be licensed.

Here we will implement the term verbal complexes by taking a phrasal movement approach to verbal complexes. In this sense we want to follow the path started with Dutch and Hungarian by Koopman and Szabolsci (2000), Dutch and German by Hinterhölzl (2005), and for causatives for French by Homer et al. (2009).

4   Towards a Phrasal Movement Analysis of Postverbal Subjects with Infinitives in Spanish

The advantage of phrasal movement analysis as opposed to a head movement or functional analysis of verbal complexes is that, in a phrasal movement analysis, verbal XP projections might contain or not other particles, prepositions, and certain predicates. This has already been argued by Hinterhölzl (2005) and Koopman and Szabolsci (2000) for the examples of verb raising in Dutch, in which the insertion of particles is perfectly plausible as in the following case of Dutch verb raising:

(39) Toen   Jasmijn   de lamp   wou   **beginnen op   te   poetsen**
     When   Jasmijn   the lamp   wanted   begin   up   to   polish
     'When Jasmijn wanted to begin to clean up the lamp.'

However, as pointed out by Hinterhölzl (2005), the intervention of a temporary adverb like *yesterday* interferes with the verbal complex and the judgment degrades:

(40) a. Dat   jan   de   schuur   **rood**   wil   schilderen
        That   Jan   the   door   red   wants   to paint
        'That Jan wants to paint the door red.'
     b. ??Dat jan   de schuur   **rood**   gisteren   wil   schilderen
        That jan   the door   red   yesterday   wants   to paint
        'That Jan wants to paint the door red yesterday.'

Spanish also seems to show certain parallelism to this case. It is possible for the verb and a predicate adjective *red* to form a verbal complex in Spanish with the subject following the complex as in (41a) and (42a). However, the

insertion of the adverb between *paint* and *red* makes the sentence degraded somehow:

(41) a. Por   querer   **pintar**   **rojo**   Juan   el corral
         For   to want   to paint   red   Juan   the barn
         'For Juan not wanting to paint the barn red.'
     b. ??Por querer   **pintar**   **ayer**   **rojo**   Juan   el corral
         For   to want   to paint   yesterday   red   Juan   the barn
         'For Juan not wanting to paint the barn red yesterday.'
(42) a. Por   querer   **comer**   **cruda**   Juan   la carne
         For   to want   to eat   raw   Juan   the meat

         'For Juan not wanting to eat the meat raw.'
     b. ??Por   querer   **comer**   **ayer**   **cruda**   Juan   la carne
         For   to want   to eat   yesterday   raw   Juan   the meat
         'For Juan not wanting to eat the meat raw yesterday.'

   Another important advantage is that verb raising in Dutch might be formed with a large variety of infinitivals, beyond the typical modal examples. They might involve what is considered object control cases. This is what we observed for Spanish examples (25) and (28). For all the reasons above, it seems that the parallelisms between these Dutch verb raising analyses and Spanish require similar structures.

   In the analysis of VR by Hinterhölzl (2005), adjacent verbs are really the output of successive phrasal verbal movements. The end result of verb raising in Dutch is the following sentence with the final verbal complex in bold:

(43) a. dat   Jan   boek   vaak   lang   **wil**   **lezen**
         that   Jan   book   often   long   wants   to read
         'that Jan wants to read books often'

   The derivation starts in (44a). In Step 1 the object moves out of the Aspectual Phrase (AspP) where past participles are. This is a licensing movement for objects and it is followed by Step 2 where remnant movement of AspP moves to its Spec of CP. Spec CP is the landing site for AspP in order to create a complex predicate (also Koopman & Szabolsci 2000). In Step 3 the remnant TP moves to Spec of Pred P to form a complex predicate with the matrix verb. In Step 4 subject and object scramble out to the main clause and render the final order. This last step is optional:

(44) a. [dat vaak   [$_{VP}$ Jan   wil   [$_{CP.}$ [lang [PRO lezen het boek]]]]]
         that often   Jan   wants   long   read the book
       Step 1: Movement of the object out of AspP:
     b. [dat vaak   [$_{VP}$ Jan   wil   [$_{CP}$ [$_{TP}$ **het boek$_i$** [lang [PRO [$_{AspP}$ lezen t$_i$]]]]]]]
         that often   Jan wants   the book   long   read

Step 2: Movement of AspP into Spec CP, in the embedded clause:

c. [dat vaak   Jan   wil   [$_{CP}$ [$_{AspP}$ **lezen**] [$_{TP}$ het boek [lang [PRO t$_{AspP}$]]]]]
    that often Jan   wants   read   the book   long

Step 3: Movement of TP into the spec of PredP in the matrix clause:

d. [dat vaak   Jan [$_{PredP}$ [$_{TP}$ **het boek**   [lang [PRO t$_{AspP}$]]]   wil
    that often Jan   the book   long   wants

[$_{CP}$ [$_{AspP}$ lezen **t$_{TP}$**]]]
to read

Step 4: Scrambling of the matrix subject and the embedded object:

e. [dat **Jan$_i$** **het boek$_j$** vaak t$_i$ [$_{PredP}$ [$_{TP}$t$_j$ [lang [PRO t$_{AspP}$]]   wil
    that Jan   the book   often   long   wants

[$_{CP}$ [$_{AspP}$ **lezen**]]]
to read

A proposal along the same lines has been given to derive causative construction in French by Homer et al. (2009). The final output of causative verb complexes in French is in step (45e) in the following derivation:

(45) a. [$_{VP}$ faire   [$_{TP}$ [$_{VP}$ Max   lire   le livre]]]
        to   make   Max   to read   the book

Step 1: Movement of the TP above *faire*:[13]

b. [$_{TP}$ [$_{VP}$ Max   lire   le livre]$_i$ [$_{VP}$ faire t$_i$]]
        Max   to read   the book   to make

Step 2: Movement of the subject and object out of the TP:

c. [**Le livre$_1$**   **a Max$_2$** [$_{TP}$ [$_{VP}$ t$_1$ [$_{VP}$ lire t$_2$]$_i$][$_{VP}$ faire   ]]
    the book   to Max   read   to make

Step 3: Movement of the VP *lire* above the licensing position of subject and object:

d. [$_{VP}$ **lire t$_2$**]$_i$ [le livre$_1$ a Max$_2$ [$_{TP}$ [$_{VP}$ t$_1$][$_{VP}$ faire   ]]]
    to read   the book   to Max   to make

Step 4: Movement of the VP *faire* above CP which is a phase head and Spell Out is triggered:

e. [$_{VP}$ **faire**   ][$_{VP}$ lire t$_2$]$_i$ [le livre$_1$ a Max$_2$ [$_{TP}$ [$_{VP}$ t$_1$]]]
    to make   to read   the book   to Max

Both the derivation of verb raising in Dutch and the derivation of causative constructions in French involve remnant XP movement of the projection containing the verbal element. The XP arguments – subjects and objects – must vacate the projection that contains the verbal elements that form the output of the verbal complex. Applying the same logic to all the verbal

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[13] Homer et al. (2009) do not indicate the nature of the projection the TP is moving to. They assume there is an EPP feature that triggers such movement.

complexes in Spanish, the following derivation with some variations will be proposed. Starting with (46a) in step 1 the modal verb moves to TP first where it will get its finite traits, thus this would probably be head movement. Then the infinitival verb with its object moves above, as in step 2, in similar fashion in which AspP moves to Spec CP in Dutch. This would be similar to movement to PredP. In step 3 the object and the main subject both in the TP must move out. This is a moving condition on verbal complex formation according to Koopman and Szabolsci (2000).[14] In step 4 the infinitival verb containing the infinitival moves above the licensing position of the subject. Finally in step 5 the verb *querer* moves to its final position and leads to the desired order:[15]

(46) a. [$_{VP}$ Juan   [querer   [$_{CP}$ [$_{TP}$ comprar   el libro]]]
            Juan   to want   to buy   the book

   Step 1: Movement of the verb *quiso* to T:
   b. [$_{TP}$ quiso   [Juan   V$_i$ [$_{TP}$ [$_{TP}$ comprar   el libro]]]
            wanted   Juan   to buy   the book

   Step 2: Movement of the TP *comprar el libro* above *quiso*:
   c. [$_{TP}$ [$_{TP}$ comprar el libro] [$_{TP}$ quiso$_i$ [$_{VP}$ Juan t$_{TP}$]]]
            to buy the book   wanted   Juan

   Step 3: Scrambling of the object out of TP + movement of the main subject *Juan* to its licensing position above the scrambled object:
   d. [$_{TP}$ Juan$_i$ el libro$_j$ [$_{TP}$ comprar t$_i$]   [$_{TP}$ quiso   t$_j$ [$_{VP}$ t$_{TP}$]]]
            Juan   the book   to buy   wanted

   Step 4: Movement of the TP containing *to buy* above the licensing position of subject and object:
   e. [$_{TP}$ comprar] [$_{TP}$ Juan   el libro   [$_{TP}$ quiso   [$_{VP}$ t$_{TP}$]]]
       to buy   Juan   the book   wanted

   Step 5: Movement of TP *quiso* to Spec CP and final Spell Out:
   f. [$_{TP}$ quiso   [$_{VP}$ t$_{TP}$]]] [$_{TP}$ comprar] [$_{TP}$ Juan   el libro
       wanted   to buy   Juan   the book

Crucial properties of the XP analysis followed with remnant movement are the following. First, importantly the XPs that follow the subject in the V INF S XP have been scrambled out of its TP and do not form a constituent with the infinitive. This is steps 2 and 3 for Homer et al. (2009) and step 3 for (46).

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[14] According to this proposal, all arguments must vacate before remnant movement due to this filter.

[15] One can envision an alternative derivation in which subject and object vacate the structure in the order *subject-object* in step 1, in the same line of Homer et al.'s (2009) derivation of causative constructions in French. I will leave this as a possible alternative.

This movement of the object XP in these languages has been masked by subsequent remnant movements of the TP. Also this step crucially implies that subjects have a licensing position above the position of the scrambled XP object in Spanish. Thus, this analysis makes crucial this higher subject position above the object. This has important consequences as we will see in the next section. It also assumes that infinitives in these structures end up as TP projections voided of any arguments. This treatment is similar to the VP for Homer et al. (2009) and AspP for Hinterhölzl (2005) and Koopman and Szabolsci (2000).

Another important result of this analysis is that movement of the XP that follows the subject in the V INF S XP is a product of short movement. Thus XP moves out of TP (46d) because the TP is infinitival. Scrambling is a local movement and cannot cross over finite clauses, so this is a welcome consequence of this analysis of short distance scrambling. Neither Spanish, French, nor Dutch have long distance scrambling; therefore, we predict NO verbal complexes formation with embedded indicative or subjunctive verbs. Those examples would require long distance movement of the object across a finite TP. Thus we predict the contrast below between subjunctive and infinitival complements:

(47) a. *?Ayer **les hizo que comprasen** Juan el libro
Yesterday cl made that buy-subj-3pp Juan the book
'Yesterday, Juan made them buy the book.'
    b. Ayer **les hizo$_i$ comprar** Juan$_i$ el libro
Yesterday cl made to buy Juan the book
'Yesterday, Juan made them buy the book.'

More evidence of the movement of the scrambling of the XP in V INF S XP is that CPs filled with wh-words block such movements as we saw previously and repeat below. We conclude that Spec CP is an escape hatch for short movement of the postverbal subject only when it is not filled by a wh-element:

(48) *?No sabe si contestar Juan las cartas (from Torrego 1996)
Not know whether to answer Juan the letters
'Juan doesn't know whether to answer the letters.'
(49) *?No sabe a quién regalar tu hermana este libro
Not know to who to give your sister this book
'Your sister doesn't know to whom to give this book.'

This scrambling movement also explains why there is degradation when the subject is followed with a determinerless DP; determiner DPs are harder to be scrambled than definite DPs. The same occurs with bare predicates:

(50) a. Nos propuso leer Juan las novelas.
cl proposed to read Juan the novels
'Juan proposed to read the novels to us.'

    b. ??Nos   propuso   leer   Juan   novelas.
       cl   proposed   to read   Juan   novels
       'Juan proposed to read novels to us.'

(51) a. No   quiso   Juan   comerla   cruda
       not   wanted   Juan   to eat it   raw
       'Juan did not want to eat it raw.'
    b. *?No   quiso   comerla   Juan   cruda
       not   wanted   to eat it   Juan   raw
       'Juan did not want to eat it raw.'

The XP that follows the subject might be a whole CP or a TP with a string of infinitives. Under this analysis, the kind of XP that might appear after the subject must be similar to what in Germanic constitutes the extraposed elements after the verb.

(52) Dijo   Juan   [$_{CP}$ que   iba   a llegar tarde]
     said   Juan   that   go-3ps   to arrive late
     'Juan said that he will arrive late.'

(53) Debería   Juan   poder   salir   de su casa
     should-3ps   Juan   to be able   to leave his house
     'Juan should be able to leave his house.'

For some speakers intermediate cases might be degraded. This means that a TP with a string of infinitives pied pipes all the other infinitives for extraposition. A subpart of string of infinitives might lead to degradation for these speakers:

(54) ?Debería   poder   Juan   salir   de su casa
     should-3ps   be able   Juan   to leave   of his home
     'Juan should be able to leave his house.'

Since the infinitive that follows the subject in V S INF XP does not form a unit with V, then we expect that clitic climbing is degraded, which is the correct prediction:

(55) a. ?*Me lo   debería   Juan   poder   decir (Clitic climbing)
       to me it   should   Juan   be able   to say
       'Juan should be able to tell it to me.'
    b. Debería   Juan   poder   decírmelo (No clitic climbing)
       should   Juan   be able   to tell me/to me

(56) a. ?*?Te lo   quiere   Juan   comprar (Clitic climbing)
       to you it-   wants   Juan   to buy
       'Juan wants to buy it for you.'
    b. Quiere   Juan   comprártelo (No clitic climbing)
       wants   Juan   to buy-it-to you
       'Juan wants to buy it for you.'

One crucial aspect of this analysis is that subjects have a licensing position above the position of the scrambled object in Spanish. Recall that in step 3 of the derivation the subject moved higher than the scrambled object. An important claim in this approach is that postverbal subjects are moved to a higher Spec position before the TP containing the infinitive moves even higher. This evidence was provided in Ordóñez (2007), and I repeat some of the arguments in the following sections. This will be crucial in order to understand the parametric differences that distinguish Catalan from Spanish and the locality question we discussed above.

5   On the High Position of Subject in VSO Structures and V INF S O

5.1   Leftward Movement of Quantifiers and the Position of the Subject

The first argument that postverbal subjects are high up comes from the behavior of non-focalized quantifiers like *todo*. As argued for French, quantifiers move leftward to the past participle position overtly as in (57). Spanish apparently does not show such overt movement of the quantifier over the past participle as in (58):

(57) Jean   a   [tout]   mangé [*tout] (Kayne 1975)
     Jean   has   all   eaten [*all]
     'Jean has eaten everything.'
(58) Juan   se   lo   había   (*todo)   comido   todo
     Juan   CL   CL   had   all   eaten   all
     'Jean has eaten everything.'

One possible conclusion is that non-focalized quantifier *tout* moves overtly in French but not in Spanish. Rizzi (1996) and Nicolis (2001) analyzed the syntactic distribution of the equivalent quantifier in Italian *tutto* in Italian, which behaves like Spanish in (58), with the only difference that there is no clitic involved. They claim that the quantifier *tutto/todo* moves in both languages, but past participles in Italian and Spanish move further to the left than French. In reality, the movement of the quantifier *tutto/todo* gets masked by further movement of the past participle in Spanish as shown below in the English glosses.

(59) [have   [all$_j$ [$_{VPP}$ eaten   t$_j$]]] (French)

(60) [have   eaten$_i$ [all$_j$ [$_{VPP}$ t$_1$ t$_j$]]] (Spanish)
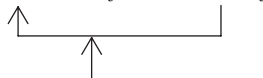
(61) Juan   se   lo   había   comido   todo
     Juan   to him it   had   eaten   everything
     'Juan had eaten everything.'

Further tests that show that quantifier *todo* is moved to the left shows us the position of these quantifiers with respect to manner adverbs that mark the left edge of the VP such as *bien (well)*, *mal (badly)*, *claro (clear)*. Recall that in these judgments *todo* is not focalized. As expected *todo* must necessarily appear to the left of the adverbs that mark the left edge of the VP as shown below:

(62) Leftward movement of *todo* in Spanish:

    […… *Todo* … .. [[*bien/mal* .[VP……]]]]

(63) Por   no   hacerlo   todo   bien   ÉL …
     For   not   to do   all   well   HE
     'For him not doing everything well.'

The alternative order is also possible, but it requires focus on *todo*:

(64) Pedro   lo   hace   bien   TODO
     Pedro   it   makes   well   EVERYTHING
     'Pedro makes everything well.'

A final interesting point in this respect is that object quantifier *todo* must follow the floating subject quantifier *ambos* (both). This provides clear empirical evidence that postverbal subjects are higher than the Spec VP position.

(65) a. Mis compañeros   lo   hacen   ambos   todo   bien
         My classmates   it   do   both   everything well
         'My classmates both do everything well.'
      b. *?Mis compañeros lo   hacen   todo   ambos   bien
         My classmates   it   do   everything   both   well
         'My classmates both do everything well.'
      c. ??Mis compañeros lo   hacen   ambos   bien   TODO
         My classmates   it   do   both   well   EVERYTHING
         'My classmates do everything well.'

A similar behavior is obtained with non-quantifier subjects in this postverbal position:

(66) a. Ayer   lo hizo/encontró   Juan   todo   bien
         Yesterday it did   Juan   all   well
      b. *?Ayer   lo hizo/encontró   todo   Juan   bien
         Yesterday it did/found   all   Juan   well
         'Yesterday Juan did/found everything well.'

Catalan, contrary to Spanish, does not allow this high subject position. Therefore there is a link between this high subject position in Spanish and the wider distribution of subjects in Spanish versus Catalan as we saw in section 2:

(67) *Ahir   ho va fer   en Joan/ell tot bé
     Yesterday   it did   Juan/él   all well

5.2   *The Special Behavior of Pronominal Elements and the Auxiliary Have Plus Past Participle*
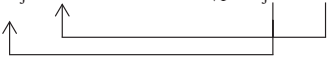
Another argument in favor of subjects in a high position above VPs comes from their distribution with auxiliary *have*. As is well known, Spanish generally disallows subjects to appear between the auxiliary verb and the past participle:

(68) *Ayer   no nos   había   tu hermana   dicho   la verdad
     Yesterday   not to us   had   your sister said   the truth

In that respect, Spanish clearly differs from Icelandic (TEC), which allows the subject to precisely appear in this intermediate position:

(69) Það   hafa   jólasveinar borðað   búðing
     There have   many trolls eaten   pudding

According to the analysis by Bobaljick and Jonas (1996), postverbal subjects in Icelandic are moved out of the VP to a higher projection. Spanish masks that movement by the movement of the past participle and the output obtained as in (70b). However, as we argued with the cases of quantifier *todo* in object position, we can assume that the difference in behavior in the distribution of subject in both languages is just a question of whether the past participle is capable of moving. In Icelandic it does not move and yields the output in (70a). However, Spanish shows that it can move and that leads to the order in (70b):

(70) a. [*Have* [subject$_i$[$_{VP}$ Past participle   t$_i$]]] (Icelandic)

     b. [*Have* [Past participle$_j$ [subject$_i$ [$_{VP}$ t$_j$ t$_i$ t]]]] (Spanish)

Crucially, pronominal subjects like *usted* (polite 2ps) and other pronominal elements might be able to behave like Icelandic and allow the pre-past participle position:

(71) Había usted dicho que lo lograría (from Sánchez López 1993: 281)
     Have   you   said   that it accomplish
     'You had said that you would accomplish it.'

(72) Ya   les había   yo   dicho   a   estos   que ...
     already   had   I   said   to   these people that
     'I had already said to these people that ...'

This recalls the well-known examples of object shift. Pronouns can move further to the left than DPs. The kind of pronoun that allows this position are weak pronouns, as shown by the fact that it cannot be modified or coordinated in this position (74):

(73) [*Have*   *Usted*$_j$ [Past participle$_i$ [t$_j$ [$_{VP}$ t$_i$]]]]

(74) a. *Ayer   no habían usted *y*   él   dicho que lo lograría
         Yesterday not had   you   and   he   said   that he would make it
         'Yesterday he and you had said that he would accomplish it.'
     b. *Ayer   no había   sólo   usted dicho   que lo lograría
         Yesterday not had   only   you   said   that he would make it

Catalan, as expected, does not allow any of the possibilities above; no pronominal subject can be allowed between auxiliary *have* and the past participle:

(75) *Ahir   no havia vostè   dit   que   ho aconseguiria
     Yesterday had   you   said   that   you will make it
     'You had said that you will make it.'

Again the distribution of postverbal subjects in Spanish shows that they have access to higher positions in the VP contrary to Catalan. Thus, the analysis of verbal complexes needs to crucially take into account this higher position for subjects in Spanish.

6   The Problem of Locality in These Verbal Complexes

Given the proposal made so far, we can address the locality issues raised in section 3.2. We noticed that no argument can intervene between finite verbs and infinitives with postverbal subjects. The intervening elements with causative (76), object control (77), and subject control (78) infinitive are in italics:

(76) *?Ayer   nos hizo   *a nosotros* leer   el maestro este libro
     Yesterday to us-made to us   to read the teacher the book
     'Yesterday the teacher made us read the book to us.'
(77) *?Ayer   nos prohibió *a nosotros* leer   el maestro   este libro
     Yesterday prohibited   to us   to read   the teacher   this book
     'Yesterday the teacher prohibited us from reading this book.'
(78) *?les prometió *a los familiares* dar   el jurado la libertad
     cl-promised   to the family   to give the jury   liberty
     'The jury promised the family to give liberty.'

Those sentences immediately improve if the argument is in post-infinitival position. So there is a contrast with the examples above:

(79) Ayer   **nos hizo   leer**   el maestro   el libro   *a nosotros*
     Yesterday   cl-made   to read   the teacher   the book   to us
     'Yesterday the teacher made us read the book to us.'
(80) Ayer   **nos prohibió   leer**   el maestro   este libro   *a nosotros*
     Yesterday   cl-prohibited   to read   the teacher   this book   to us
     'Yesterday the teacher prohibited us from reading this book.'
(81) **les prometió   dar**   el jurado   la libertad   *a los familiares*
     cl-promised   to give   the jury   liberty   to the family
     'The jury promised the family to give liberty.'

According to the analysis I proposed above, the issue with the ungrammatical examples in (76)–(78) is due to how the verbal complex is built. One of the conditions of the formation of verbal complex is that all arguments must vacate the VP (for Homer et al. 2009) and AspP (for Hinterhölzl 2005, Koopman & Szabolsci 2000). The intervention of arguments between infinitive and finite verbs in (76)–(78) indicates that the VP has not raised to steps 2 and 3 in (46) which requires its movement in the derivation. Observe that when that infinitive movement to form the verbal complex fails, the sentences are grammatical as long as the subject is always higher than the complement that follows. When the main subject appears below the causer or the overt DO/IO of the main clause, the sentences are degraded as in (82b) and (83b).

(82) a. Ayer   nos hizo   **Juan**   a nosotros   leer   el libro
         Yesterday   cl-made   Juan   to us   to read   the book
         'Juan made us read the book to us.'
     b. *?Ayer   nos hizo   a nosotros   **Juan**   leer   el libro
         Yesterday   cl-made   to us   Juan   to read   the book
         'Yesterday Juan made us read the book to us.'
(83) a. Ayer   nos prohibió   **Juan**   a nosotros   leer   este libro
         Yesterday   cl-prohibited   Juan   to us   to read   this book
         'Yesterday Juan prohibited us from reading this book.'
     b. *?Ayer   nos prohibió   a nosotros   **Juan**   leer   este libro
         Yesterday   cl-prohibited   to us   Juan   to read   this book
         'Yesterday Juan prohibited us from reading this book.'

This implies that main subjects end up licensed in a higher position than the other arguments.

The above generalizations require further investigation, but they shed some light on the problems of locality in examples (76–78). They have orders in which the causer or DO/IO argument is below the subject in these intermediate positions. But as we saw in (82b) to (83b), that input is impossible because DO/IO cannot move above the postverbal subject position * V IO SUB INF.

I am proposing that the problem with (76) to (78) is the same problem we find in (82b) and (83b). The locality issue is reduced to the fact that the verbal complex violates the condition that requires main subjects to be in a higher projection than the embedded objects. Finally, by relating the possibility of post-infinitival subjects in (3) to this higher projection in Spanish, we account for why Catalan does not allow this distribution of subjects in (4).

7   Conclusions

While many details remain to be fulfilled, I have shown that there exists a striking parallelism between Spanish and Dutch, French, and Hungarian verbal complexes. I entertained an approach with XP movement of predicates in order to form verbal complexes. This alternative overcomes many of the problems of the backwards control approach. XP movement of the verb and subsequent movement of the subject and object lead to the post-infinitival positions in Spanish. One very important assumption of this analysis is that postverbal subjects in the V S XP and V INF S XP order are always moved; they must always end in a position higher than the final position of the object. Consequently, this approach provides a clear link between V S XP order and V INF S XP; languages like Catalan or Italian do not have this higher position and therefore do not allow V INF S XP.

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3   Two Families of Questions

Howard Lasnik[1]

1   Wh-Island Escape and Related Matters

Locality has been an important part of transformational generative grammar since the dawn of the approach. For one thing, it has been assumed, often with no explicit discussion, that various relations are blocked by clause boundaries. For example, Chomsky (1955) argues for a transformational process making "John" the matrix object in sentences like (1) in order to allow a passive like (2), obviously under the assumption that the positions involved in passive must be clause-mates.

(1) They consider John a fool.
(2) John is considered a fool by them.

Numerous other cases are also discussed or hinted at. Another related case was later discussed by Chomsky (1964), who observed that embedded questions disallow extraction from them, as seen in (3).

(3) *What did he wonder where John put?

Chomsky formulated a constraint that had the effect of excluding such cases. In the realm of what came to be called Ā-movement, Chomsky (1955) pointed out the unacceptability of (4).

(4) *Whom did your interest in __ seem to me rather strange?

Surprisingly from a modern perspective, Chomsky did not seek any generalization here. (For example, a ban on extraction out of a subject, one of many constraints proposed in Chomsky 1973.) Rather, he suggested incorporating

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the constraint into the transformation itself. Unsurprisingly, he did not suggest just how this could be done; such a modification would have dramatically complicated what was quite a simple and straightforward statement: Move a wh-expression to the front of the sentence.

It was only in Chomsky (1964) that we find the idea of formulating general constraints on the operation of Ā-movement. In that work, we find a relatively modern-looking wh-movement transformation, which is both simple and quite general:

(5) Y – *Wh* + X – Z ⇒ *Wh* + X – Y – Z   [Find a wh-expression, preceded by anything at all and followed by anything at all. Then move the wh-expression to the beginning of the sentence.]

As Chomsky notes, this generality raises potential problems of overgeneration – the production of ungrammatical sentences. Some of these problems are addressed by constraints on movement:

although several Noun Phrases in a sentence may have *Wh* attached to them, the operation [(5)] must be limited to a single application to each underlying terminal string. Thus we can have "who saw what?", "you met the man who saw what?", "you read the book that who saw?", "you saw the book which was next to what?", etc., but not "who what saw?", "you saw the book which was next to" (as a declarative), and so on, as could arise from multiple applications of this rule. These examples show that [(5)] cannot apply twice to a given string.

(Chomsky 1964: 43)

Chomsky provides several additional arguments that this constraint is necessary, most notably the following, an instance of what came to be called the wh-island Condition, which bans movement out of an embedded question:

(6) *What did Mary wonder [where John put __ __]?
     (cf. Mary wondered [where John put something __]).

In a foreshadowing of modern concerns, Chomsky raises questions about the nature of the constraint:

The constraint that [(5)] may not reapply to a given string is thus necessary if the grammar is to achieve descriptive adequacy. Once again, to achieve the level of explanatory adequacy, we must find a principled basis, a general condition on the structure of any grammar, that will require that in the case of English the rule [(5)] must be so constrained. Various suggestions come to mind, but I am unable to formulate a general condition that seems to me entirely satisfying.

(1964: 45)

In later developments, Subjacency, Superiority, and Relativized Minimality were proposed as more general constraints from which these specific cases follow. I will be particularly concerned with the first of these.

Ross (1967), *the* classic work on the locality of Ā-movement, explicitly rejected this constraint of Chomsky's. Ross's first objection is that the condition is "somewhat too strong" (p. 19), ruling out acceptable sentences. Ross first gives the following, which also sound fine to me:

(7) He told me about a book which I can't figure out
$\begin{cases} \text{whether to buy or not.} \\ \text{how to read.} \\ \text{where to obtain.} \\ \text{what to do about.} \end{cases}$

While Ross acknowledges that Chomsky's original example, (3) above, is bad, he indicates that Chomsky's condition "is too strong as it stands, although examples like Chomsky's make it clear that it is partially true. This all indicates that much more work needs to be done on this condition, so that a weaker version of it may be found" (p. 21). I will return to this question and to some of Ross's other examples.

In Chomsky (1973), Chomsky for the first time explored constraints on the operation of transformations in detail. Most significantly for the present discussion, he proposed Subjacency as a general constraint intended to unify some locality conditions on movement.

(8) "If X is superior to Y in a phrase marker P [roughly, if X asymmetrically c-commands Y], then Y is '**subjacent**' to X if there is at most one cyclic category C $\neq Y$ such that C contains Y and C does not contain X. Thus, if Y is subjacent to X, either X and Y are contained in all the same cyclic categories or they are in adjacent cycles."

(9) "No [movement] rule can involve X, Y, X superior to Y, if Y is not subjacent to X" (p. 247).

Chomsky took the cyclic categories to be NP and clause. I return immediately below to the precise characterization of the latter. Subjacency had the major brand-new consequence that apparent unbounded movement was actually constituted of a series of short movements, via Comp (what later became CP, Spec) for wh-movement. Just like what had already been standardly assumed for NP-movement (though without much discussion), wh-movement must be successive cyclic.

Subjacency did very little work in Chomsky (1973). Essentially, it captured Ross's Complex NP Constraint (10), and also a new observation: that extraction of something out of an NP that is inside another NP is degraded.

(10) Complex NP Constraint (modified version of a constraint attributed by Ross to Ed Klima)

No element contained in a sentence dominated by a noun phrase with a lexical head noun may be moved out of that noun phrase by a transformation.

(11) a. *The man who I read a statement which was about is sick.
    b. The man who I read a statement about is sick.
(12) *What do you receive requests for articles about __?

Interestingly, what eventually became two major cases of Subjacency, island-hood of subjects and embedded questions, did not fall under Chomsky's (1973) formulation. First, consider the fact that the islandhood of subjects did not fall under Subjacency and thus demanded a separate new constraint.

(13) *[Who did [[$_{NP}$ stories about __] terrify John]]?

This was because, for Chomsky (1973), the higher clause node $\bar{S}$ (later CP) was the bounding/cyclic node, not the lower one S (later IP). There was much confusion about this in the literature, for the following reason. At the time, the higher clause label was rather standardly $\bar{S}$, and the lower one S, due to Bresnan (1970):

(14) $\bar{S} \rightarrow$ Comp S

But, mysteriously, Chomsky reversed this:

(15) S $\rightarrow$ Comp $\bar{S}$

So when he asserted that S was the relevant bounding/cyclic node, he actually meant the *higher* clausal node (though at the time most everyone mistakenly assumed he meant the lower one). Thus, contrary to initial appearances, (13) is completely consistent with Subjacency. There is only one "cyclic category," NP, separating *Who* from its launching point. From now on, I will use Bresnan's standard convention.

For essentially the same reason that Subjacency in Chomsky (1973) didn't cover Subject Condition effects, it also didn't cover wh-island effects.

(16) *[$_{\bar{S}}$ What$_i$ did [$_S$ Mary wonder [$_{\bar{S}}$ where$_j$ [$_S$ John put t_i t_j]]]]?

The movement of *What* crosses two instances of S (Chomsky's $\bar{S}$), but only one instance of $\bar{S}$ (Chomsky's S). So instead of Subjacency, Chomsky used his Tensed Sentence Condition and Specified Subject Condition (the joint ancestors of Condition A of the LGB Binding Theory) to prevent movement out of an embedded question. This assumed, ultimately incorrectly, that wh-movement obeys exactly the same constraints as passive or raising.

The reason for Chomsky's choice of $\bar{S}$ (his S) as the relevant clausal node was that while subjects are islands, objects are not:

(17) Who did [$_S$ you read [$_{NP}$ stories about __]]?

If S, the smaller clausal node, were the relevant bounding node, this extraction would be barred, incorrectly. It was so tempting, though, to subsume the Subject Condition and the wh-island Condition into Subjacency that Chomsky (1977) suggested a reversal in course making the *smaller* clausal node, Bresnan's S, the clausal bounding node. (16) is then excluded because, given that *where* has already moved into the embedded clause wh-position, movement of *What* from the t_1 position must be in one fell swoop, thus crossing two S nodes in one jump. This, of course, left (17) as a problem, which Chomsky (1977) attempted to solve in what seem to be unsatisfying ways. Rizzi (1980), in one of the most influential footnotes in the history of transformational syntax, suggested that S and S̄ are *both* correct, but with some languages parametrically choosing S and others S̄. English is of the former language type, given the unacceptability of extraction out of embedded questions and out of subjects. Italian is of the latter type, as Rizzi presents evidence that both such extractions are possible in that language. (According to Rizzi there is an interfering factor with questions, so his examples involve relativization, which, as Ross [1967] showed, obeys all the same constraints as wh-interrogation.) Some of Rizzi's examples:

(18) a. Il solo incarico che non sapevi a chi avrebbero affidato è poi finito proprio a te.
'The only charge that you didn't know to whom they would entrust has been entrusted exactly to you.'
b. Tuo fratello, a cui mi domando che storie abbiano raccontato, era molto preoccupato.
'Your brother, to whom I wonder which stories they told, was very troubled.'
c. La nuova idea di Giorgio, di cui immagino che cosa pensi, diverrà presto di pubblico dominio.
'Giorgio's new idea, of which I imagine what you think, will soon become known to everybody.'

All of these are degraded in English, leading to Rizzi's speculation that while S is the relevant clausal bounding node in English, thus excluding movement out of any embedded question, S̄ is the relevant one in Italian, thus allowing movement out of a simple embedded question.

Sportiche (1981) argues that French is like Italian in this regard, providing acceptable instances of extraction out of embedded questions:

(19) a. C'est à mon cousin que je sais lequel offrir.
'It is to my cousin that I know which one to offer.'
b. Voilà une liste des gens à qui on n'a pas encore trouvé quoi envoyer.
'Here is a list of the people to whom we have not yet found what to send.'

So there seems to be good reason to believe that S versus S̄ for Subjacency is a syntactic parameter. This is important, and somewhat problematic, in light of the next development in Subjacency, the Barriers framework of Chomsky (1986). Chomsky (1986) was a bold attempt at a new principled theory of bounding nodes. Oversimplifying somewhat, the core idea is that ALL XPs are potentially barriers, but that an XP that is the complement of a lexical head (V, N, A, maybe P) is not a barrier. This gives the subject-object asymmetry discussed by Chomsky (1973), since object is complement of V, while subject is not a complement at all:

(20) Who did [you read [stories about t]]?

This new "Barriers" theory also accounts for the observation of Huang (1982) that extraction out of adjuncts (including adverbial modifiers) is barred:

(21) *Who did you go home [because Mary mentioned t]?

An obvious initial problem is that extraction of anything out of VP ought to be blocked, since VP is usually not the complement of a lexical head. Hence, Chomsky, developing an idea of May (1985), proposes that an item can escape from a barrier by adjoining to it. Metaphorically, adjoining to a category gets a moving item part way out, the "segmentation" theory of adjunction. Ah, but now, why are there *any* Subjacency effects? Adjunction should void all barriers. To address this, Chomsky proposes a set of constraints on adjunction (ultimately, in effect, only allowing adjunction to VP). Finally, Chomsky proposes that IP is generally not a barrier on its own, even when, as usual, it is the complement of C (which is not a lexical head). But CP can "inherit" barrierhood from IP. This becomes the source of wh-island effects.

The resulting theory is an intriguing blend of very complicated and very principled. There is no obvious place in it for Rizzi's S/S̄ parameter. Chomsky briefly discusses this. He gives infinitival examples reminiscent of Sportiche's (and, in fact, Ross's), and observes (as, in fact, Ross had) that ones like (22c,d) are more acceptable than standard finite ones (22a,b). (From here on, S becomes IP and S̄ becomes CP, as proposed in some detail by Chomsky 1986.)

(22) a. $What_i$ did you wonder [$_{CP}$ [to whom]$_j$ John gave t_i t_j]
     b. [To whom]$_j$ did you wonder [what$_i$ John gave t_i t_j]
     c. $What_i$ did you wonder [$_{CP}$ [to whom]$_j$ to give t_i t_j]
     d. [To whom]$_j$ did you wonder [what$_i$ to give t_i t_j]

Given this fact, Chomsky (1986: 37) suggests the following:

Suppose, then, that tensed IP is an inherent barrier (possibly weak) to wh-movement, over and above the system just outlined ... Then examples [(22a,b)] will involve the crossing of a second barrier beyond CP, yielding degraded sentences. This assumption yields the major facts that have been discussed concerning such languages as English and French, at least in terms of judgments of relative acceptability.

There is clearly something to this notion that boundaries of finite clauses are somehow stronger than those of non-finite clauses. Chomsky's idea is that, at least under some circumstances, finite clauses are strengthened. An alternative is that non-finite clauses are weakened. Fukui and Speas (1986) propose that the PRO subject of an infinitival clause can remain in Spec of VP and need not raise to Spec of IP. Thus, such a clause generally will lack a Spec entirely. Given this, on their theory of phrase structure, that clause will not be a full XP. Then, as they observe, given Chomsky's theory of barriers, an infinitival clause with PRO subject will not constitute a barrier. The IP won't (basically by a stipulation in Chomsky's theory) and the CP above it won't, as barrierhood can only be inherited from an XP.

There are many other instances of island configurations with the abstract patterning of (22). For instance, clausal complements to nouns create islands, one instance of Ross's Complex NP Constraint.

(23) *Who$_i$ does he have [$_{NP}$ a plan [$_{CP}$ that [$_{IP}$ the department will hire t_i]]]?

But notice that if the clausal complement is non-finite, extraction is much improved, in fact fully acceptable for many speakers.

(24) Who$_i$ does he have [$_{NP}$ a plan [$_{CP}$ [$_{IP}$ to hire t_i]]]?

One rather ironic example occurs in the Chomsky (1972) discussion of repair of island violations via ellipsis. Chomsky's sole example is (25).

(25) He has plans to send some of his children to college, but I don't know which ones.

And while Chomsky calls the non-elliptical source bad, it is, at worst, very slightly degraded.

(26) (?)I don't know which children he has plans to send to college.

Adjunct islands (one instance of the Condition on Extraction Domain of Huang (1982)) show a similar pattern. Extraction out of a clause in an adjunct is typically quite degraded:

(27) *Who$_i$ did Mary go to the meeting [in order that her company could evaluate t_i]?

But if the clause is infinitival, with null subject, the result is much improved:

(28) ?Who$_i$ did Mary go to the meeting [(in order) to evaluate t_i]?

Similarly, gerundives are better than finite clauses:

(29) a. *Who$_i$ did John go home [after Mary talked to t_i]?
      b. ?Who$_i$ did Mary go home [after talking to t_i]?

Possibly some version of the Fukui and Speas (1986) proposal could extend to these cases as well, but exploration of this would take us too far afield here. I will note in passing that parasitic gaps inside adjuncts also show somewhat similar behavior. Based on the observation that parasitic gaps often occur inside adjuncts, Chomsky (1982) developed a theory of them involving no movement, hence no Subjacency effects at all. A standard example is (30).

(30) Which article$_i$ did you file t_i [after reading *p.g.*]?

Kayne (1983), however, observed that we actually do find the full range of island effects internal to the adjunct, leading Chomsky (1986) to argue that parasitic gaps are actually traces of null operators that move, in the cases at hand, to the top of the adjunct, but no further. In light of what we saw just above about extraction out of adjuncts, this might be reconsidered. When the adjunct is a gerund or an infinitive, the parasitic gap is good, but when it is finite, the result is degraded. (30) contrasts rather sharply with (31).

(31) ??Which article$_i$ did you file t_i [after the boss read *p.g.*]?

The following pair exhibit a parallel contrast:

(32) Who$_i$ did Mary interview t_i [(in order) to evaluate *p.g.*]?

(33) ??Who$_i$ did Mary interview t_i [in order that her company could evaluate *p.g.*]?

The facts here are so similar to what we have seen with simple extraction from adjuncts that reexamination of the nature and derivation of parasitic gaps might well be in order. In both cases, weakness of non-finite clauses vis-à-vis finite ones is surely at work.

Sportiche's French facts have been handled without recourse to an S/$\bar{\text{S}}$ parameter, and the way they have been handled extends to Ross's examples in (7), which led Ross to reject Chomsky's early version of the wh-island constraint. But what about Rizzi's Italian facts? For these, Chomsky (1986: 37) adds another suggestion.

Suppose that the parameter involved in Rizzi's material relates to the choice of IP vs. CP: that is, in the variety of English under consideration the "extra barrier" is tensed IP, and in Italian it is tensed CP ... Choice of tensed CP rather than tensed IP as the value of the parameter adds no barrier in [(22)] since the lowest CP is already a barrier by inheritance.

The addition of this parameter adds a layer of complication, and, as implied above, such parameters are not a very natural fit in the framework Chomsky was developing. Uriagereka (1988) hints at another more interesting possibility, extending the proposal of Fukui and Speas (1986). It was around 1986

that Juan Uriagereka, then my student, first observed to me that Rizzi's Italian examples shared an interesting property: The embedded questions all had null subjects. The suggestion of Uriagereka (1988) is that not just null subjects of infinitivals (PRO) remain in situ, but even null subjects of finite clauses (pro) do as well. (See Lasnik and Uriagereka 2005 for more recent discussion.) Then, by the logic of Fukui and Speas (1986), such a finite IP will not be a full XP, hence the CP immediately dominating it will not inherit barrierhood from it. I have not yet had the opportunity to check whether examples like Rizzi's but with overt subjects are degraded. But Juan Uriagereka (personal communication) informs me that in Spanish, which is relevantly like Italian with respect to Rizzi's examples, overt subjects of embedded questions do, indeed, result in lower acceptability when something is extracted out of the embedded question.

I turn now to some additional examples that Ross presented in rejecting Chomsky's early wh-island constraint. Above, we saw Ross's examples with infinitival embedded questions. Along with Sportiche's French examples, they fall naturally into some version of the Fukui and Speas (1986) theory, or the Uriagereka (1988) extension of it (for Rizzi's examples). But the rest of Ross's examples cannot be so analyzed.

(34) Which books did he tell you $\left\{ \begin{array}{l} \text{why} \\ \text{?whether} \\ \text{??when} \end{array} \right\}$ he wanted to read.

The annotations are Ross's. To my ear all three of these are virtually perfect, and, as Ross notes, far better than Chomsky's example (35), in which I assume coreference is not intended as that would be an independent violation.

(35) *What did he wonder where John put?

I suggest that it is significant that the most salient readings, by far, of the examples in (34) have the subjects of the embedded question coreferential with the subject of the matrix clause. That is, the embedded subject is a bound pronoun. The pronominal status of the matrix subject seems irrelevant, as can be seen in (36).

(36) Which books did Bill_i tell you $\left\{ \begin{array}{l} \text{why} \\ \text{whether} \\ \text{when} \end{array} \right\}$ he_i wanted to read.

In fact, Chomsky's (35) is dramatically improved if we reverse the name and pronoun, and make the latter bound:

(37) What did John_i wonder where $\text{he}_{?i/*k}$ put?

The adjunct islands briefly considered above, for which we saw improvement when the adjunct had a null subject, also show some improvement when the subject of the adjunct is a bound pronoun:

(38) ?Who$_i$ did Mary$_j$ go to the meeting [in order that she$_j$ could evaluate t_i]?
(39) ?Who$_i$ did John$_j$ go home [after he$_j$ talked to t_i]?

And roughly the same seems to be true for the parasitic gap cases:

(40) a. ?Which article$_i$ did you file t_i [after you read *p.g.*]?
      b. ?Which article$_i$ did the boss$_j$ file t_i [after he$_j$ read *p.g.*]?

Thus, along with the apparent null subject exemption for locality, there also seems to be some sort of bound pronoun exemption (or at least weakening) as well. The latter clearly cannot be reduced to the former – patently, overt pronouns are not null subjects. Can the former be reduced to the latter? That is slightly more promising. Ross's wh-island counter-examples in (7) all have a bound subject, PRO, as do Sportiche's examples in (19). However, Rizzi's original examples, (18) repeated here, the ones that led to all the investigation of bounding node parameters, do not have bound subjects of the embedded questions: null, yes – bound, no. Hence, there is evidently no way to reduce one of the exemptions to the other.

(41) a. Il solo incarico che non sapevi a chi avrebbero affidato è poi finito proprio a te.
          'The only charge that you didn't know to whom they would entrust has been entrusted exactly to you.'
      b. Tuo fratello, a cui mi domando che storie abbiano raccontato, era molto preoccupato.
          'Your brother, to whom I wonder which stories they told, was very troubled.'
      c. La nuova idea di Giorgio, di cui immagino che cosa pensi, diverrà presto di pubblico dominio.
          'Giorgio's new idea, of which I imagine what you think, will soon become known to everybody.'

We have seen a direction toward an account of the null subject exemption. What could be behind the bound pronoun exemption? One possibility is hinted at by Lasnik and Uriagereka (2005). There, it is suggested that an anaphoric dependency keeps a domain open, and not immediately spelled out. That is, Transfer is postponed. If a bound pronoun is, or even can be, regarded as partaking in this sort of dependency, this might provide a direction toward an answer. Grano and Lasnik (in press), based on a proposal of Kratzer (2009), suggest the following:

(42) Valuation-based binding: Bound pronouns enter the derivation with Φ-features that are not valued until the antecedent is merged in.

If we then assume that the relevant locality has to do with phasehood, we come close to deducing the facts with (43).

(43) Convergence-based phasehood: Phases are constituents with no unvalued features. (Cf. Felser 2004.)

However, as Lasnik and Grano (in press) observe, without further constraint this creates too large a loophole. For example, while a bound pronoun as subject allows escape, a bound pronoun **inside** a subject does not:

(44) ?*Which books did Bill$_i$ tell you $\left\{\begin{array}{l} \text{why} \\ \text{whether} \\ \text{when} \end{array}\right\}$ his$_i$ mother wanted to read?

The examples in (44) contrast noticeably with those in (36). Further, though this time the difference seems more subtle, bound objects contrast with bound subjects, with the latter making the embedded question more permeable:

(45) a. ?*Which books did John$_i$ ask when Mary gave him$_i$ t?
     b. ??Which books did John$_i$ ask when he$_i$ received t from Mary?
(46) a. *What did John$_i$ write a report after Mary gave t to him$_i$?
     b. ?What did John$_i$ write a report after he$_i$ received t from Mary?

Hisa Kitahara (personal communication) provides a very promising direction for a solution to these problems. He suggests that under the assumption that a bound pronoun starts with defective Φ-features, it naturally follows that those defective Φ-features won't be able to value "fully" the unvalued Φ-features on T. If so, when such a bound pronoun appears in Spec-T, the T too bears defective Φ-features. Suppose, then, that it is the defective Φ on T that is responsible for the postponement of the application of Transfer. As Kitahara observes, this minor modification immediately solves the problem posed by examples like (44). In (44), the bound pronoun *his* is embedded inside the subject NP *his mother*, and this subject NP can value the Φ-features of the relevant T. As a result, there is no T bearing defective Φ-features; hence, given the suggestion above, there is no postponement of the application of Transfer – the desired result. The same line of reasoning can extend to the fact that bound objects don't have the ameliorating effect of bound subjects, as in (45) and (46) just above. As in (44), there will be no postponement of the application of Transfer, since *Mary* can value the Φ-features on T; hence, Transfer does apply to the complement of the phase-head; there is no postponement or transparency effect, as desired.

   David Pesetsky (personal communication) raises an important question. Since Huang (1982) and Lasnik and Saito (1984), it has been a standard observation that a configuration triggering any Subjacency effects at all with a moved argument triggers extreme violations with moved adjuncts, characterized in

those works as empty category principle (ECP) effects. But, as Pesetsky notes, if the loopholes discussed here mean that there are no Subjacency effects at all, especially in the case of control complements, a priori we would expect no ECP effects either. But this expectation is not fulfilled. Extraction of an adjunct out of even the most porous kind of embedded question yields strong unacceptability. Consider the following contrast:

(47) What problem$_i$ did you figure out [how$_j$ [PRO to solve t_i t_j]]?
(48) *How$_j$ did you figure out [what problem$_i$ [PRO to solve t_i t_j]]?

Thus, either the standard generalization is incorrect, and ECP effects involve different barriers/phases from Subjacency effects. Or else somehow barrierhood/phasehood is preserved in otherwise exempt configurations when an adjunct is extracted. I will have to put this question aside for future investigation.

2   Family of Questions Readings: A Constraint and a Loophole

May (1985) presents interesting and important discussion of examples like (49).

(49) What did everyone buy for Max?

May's particular concern is that (49) has a reading "as a "distributed" question, asking of each individual what it is that that person bought for Max" (p. 38). May dubs these "family of questions" interpretations. There are, as May discusses, certain constraints on when these readings are possible. Earlier, May (1977) had observed one such constraint (and one not discussed by May 1985). May had observed that (50) lacks what he later called a family of questions reading.

(50) Who did everyone say that Bill saw?

notice that in [(50)], the wh-quantifier takes wider scope than "every" (since this question is an inquiry into the identity of a specific person, of whom everyone said that Bill saw him).

(p. 141)

May pointed out that (50) contrasts with (51) and (52), which do have the family of questions reading.

(51) What did each senator say?
(52) Where did everyone go?

According to May (and I concur), these examples, unlike (50), are ambiguous. May proposed that wh-phrases optionally can undergo QR. This results in two possible LFs for (51). (I have corrected an obvious typo in [(53)].)

(53) [$_{\bar{S}}$ [$_{COMP}$ What] [$_S$ [each senator]$_\alpha$ [$_S$ did α say t]]]?
(54) [$_{\bar{S}}$ [$_{COMP}$ t]$_t$ [$_S$ [each senator]$_\alpha$ [what [$_S$ did α say t]]]]?

[(53)] represents the reading in which the wh-phrase has wider scope; an appropriate reply to [(53)] under this reading would be "That he would vote for the Canal treaty". [(54)], on the other hand, represents a reading in which the wh-phrase has narrower scope. An appropriate reply here would be "Proxmire said that he would vote for the treaty, Goldwater said he wouldn't ..." [This latter is a "family of questions" reading.]

The family of questions reading arises when ∀ c-commands WH (and the two are close to each other – for May [1985], if they govern each other), subject to an additional constraint that I will not be concerned with here distinguishing (55) from (56). (See May 1985, Lasnik and Saito 1992, and Chierchia 1993, among others.)

(55) Who did everyone see?   [Family of questions reading possible]
(56) Who saw everyone?   [Family of questions reading not possible]

Now consider (57).

(57) Who do you think [everyone saw *t* at the rally]?

As May (1985) says, this one does allow a family of questions reading; he captures this roughly as before, with a couple of technical differences:

(58) WH does not undergo QR, but just wh-movement.
(59) Rather, if ∀ and WH are close together, either can scope over the other. (In this model, unlike the 1977 model, LFs are not disambiguated.)

This new analysis also immediately carries over to the original simple examples (51) and (52).

There are two apparent problems with this account of (57). First, it fails to distinguish (57) from (50). Second, as observed by Williams (1986), on May's account, nominative *everyone* must scope out of the embedded finite clause, but this is normally not possible, as illustrated in (60), which only allows embedded scope for ∀.

(60) Someone thinks everyone saw you at the rally.

As Williams (1986: 298) says, "The scope of *every* as a quantifier seems to be limited to the S that immediately dominates it."

May (1988) responds to this argument sharply disagreeing with Williams, calling the claimed lack of broad scope for *everyone* in (60) a "spurious datum," and reporting as a "standard observation" that a universal quantifier in this position can be understood as having broad scope. He goes on to state that "there does not seem to be any grammatical principle that can limit extraction from the complement subject position" (p. 128). I don't believe that this is a

standard observation. Rather, Williams's claim reflects a pretty broad consensus, one that, interestingly enough, very quickly included May himself:

> whereas quantified subjects can be given scope out of infinitives, this is not generally possible with tensed complements ... whereas [(61a)] permits a wide-scope reading for *everyone* vis-à-vis *someone* and *believe*, according to which for each person x there is someone who believes x is a genius, [(61b)] permits only a narrow-scope reading for *everyone*, according to which there is some person who believes genius to be a universal characteristic.
>
> (Larson and May 1990: 108)

(61) a. Someone believes everyone to be a genius.
      b. Someone believes (that) everyone is a genius.

Sloan and Uriagereka (1988) and Sloan (1991) also raise a challenge to the May (1985) analysis of WH-Q interactions based on the over-prediction of ambiguity, observing, contra May's prediction, that (62) does not have a family of questions reading.

(62) Who does everyone think you saw?

Agüero-Bautista (2007: 414) presents a somewhat similar structural account of the possibility of family of questions readings:

> the pair-list interpretation of a question with a universal quantifier requires syntactic reconstruction of the wh-phrase below the quantifier ... such readings arise when the quantifier binds a null variable in one of the copies left behind by wh-movement.

This allows family of questions readings in (at least) all the circumstances that May's account does. Agüero-Bautista acknowledges that the possibility of a family of questions reading for (63), which I will argue is the crucial kind of case, was questioned by a reviewer (who apparently even questioned the possibility for cases like (57)).

(63) Which book did every professor say that Pete read?

Agüero-Bautista indicates, however, that his factual claim "is widely corroborated in the literature," citing May (1985), Williams (1986), Williams (1988), Chierchia (1993), and Aoun and Li (1993).

   But with the one exception of May (1985), *none* of these works give an example like (63), or make any claim about such an example. And while May (1985) did indeed call such an example ambiguous, this contradicts May's (1977) assertion that such an example is *un*ambiguous. (See (50) above.) For Agüero-Bautista, the two situations are not distinguished. His theory treats them both the same, allowing the family of questions reading in both. And they fall under the same description: Long-distance wh-movement from a

position below the Q to a position above it. May's (1985) analysis has the same consequence.

As noted, May's analyses are based on structural interaction between the Q and the surface position of the WH. Not long after May (1985) appeared, three alternatives appeared, all based on structural interaction between the Q and the trace of WH (in particular, the initial trace), and all in somewhat different ways: Sloan (1991), Lasnik and Saito (1992) and Chierchia (1993). For Sloan (1991) and Lasnik and Saito (1992), what is crucial is that the WH originates in the same clause as the Q (and lower than the Q, a fact discussed in great detail by May 1985 and Chierchia 1993).

Lasnik and Saito propose that (part of) the initial trace of wh-movement is actually an existential quantifier, an old idea, found, for example, in Chomsky (1964). Family of questions readings, then, are the result of a ∀ scoping over this ∃ (as opposed to the approach of May (1985) in which they arise from ∀ scoping over WH). On the Lasnik and Saito account, the WH part of the wh-phrase marks (only) the domain of interrogation. The quantificational work is performed by the ∃ trace of the moved wh-phrase, which then potentially interacts with the ∀. This kind of scope interaction is usually clause bound. This obviously accommodates the standard simple cases like (52), as well as the long-distance wh-movement cases like (57), where ∀ and the ∃ wh-trace are in the same clause. Further, cases like (50) will be excluded (correctly, I believe, and just as claimed by May 1977 and Sloan 1991), since the ∀ and the ∃ wh-trace are not in the same clause.

But there is a complication. Sloan (1991) reported that in response to her claim that examples like her (64) lack the family of questions reading, Robert May gave her structurally similar examples like (65), which do have this reading.

(64) a. Who does everyone think Mary saw *t*?
      b. Who does everyone expect Mary to see *t*?
(65) a. Who does everyone$_i$ think he$_i$ saw *t*?
      b. Who does everyone$_i$ expect PRO$_i$ to see *t*?

(65b) is, on the face of it, not particularly surprising, since it has been known at least since Postal (1974) and Rizzi (1978) that subject control constructions behave in many respects as if they constitute a single clause (though it is not clear that *expect* is actually of the restructuring class that Rizzi explored). And *claim* is not a restructuring verb by usual criteria, yet we still find the possibility of family of questions when *claim* substitutes for *expect*:

(66) Who does everyone$_i$ claim PRO$_i$ to have seen *t*?

But regardless, these cases are strongly suggestive of Uriagereka's generalization discussed above.

(65a) is surprising, since no one has ever proposed restructuring for finite complements yet, unlike (64a), the former allows a family of questions reading. If clause-mateness is, indeed, relevant in licensing family of questions readings, sentences like (65a) are striking exceptions, and ones not evidently rescuable by restructuring under any circumstances. The salient difference between (64a), disallowing family of questions, and (65a), allowing it, is that the latter, like a control construction, has a bound subject. The **bound** aspect is crucial. If *he* is understood as independently referential in (65a), the family of questions reading becomes just as inaccessible as it is in (64a). But that, interestingly enough, seems to fall under exactly the same generalization explored above with respect to certain island exemptions.

Significantly, Kayne (1998) observes almost precisely the same pattern with cross-clausal Q/Q interaction that I have argued for with respect to Q/WH-*t* interaction. He gives the following examples:

(67) At least one student has asked to see each of these new books.

(68) At least one student has tried to fool every professor/each of the professors.

(69) At least one man$_i$/some man$_i$ thinks he$_i$'s in love with each of these women.
      each/every > at least one possible …

(70) At least one man/some man thinks Bill's in love with each of these women.
      each > at least one not possible

(70) illustrates the usual (finite) clause-boundedness of quantifier scope, while (69) displays the now familiar bound subject exemption.

One small clarification is in order. In (70), the ban is on the downstairs object scoping over the upstairs subject. But in the blocked family of questions cases like (64), the ban must be on the downstairs object scoping **under** the upstairs subject:

(71) $\forall x \exists y | x$ thinks Mary saw y. [Where the existential quantifier is the "trace" of wh-movement, which then undergoes QR (or whatever process is responsible for scope interpretation).]

Now it is occasionally and slightly misleadingly said (not by Kayne) that, in a sentence like (70), the downstairs object can scope under the upstairs subject: *at least one > each*. And similarly for (72).

(72) Someone thinks Bill is in love with everyone.

Where $\exists > \forall$ is sometimes given, implying that we can have:

(73) $\exists x | \forall y$ x thinks Bill is in love with y.

But I am convinced that all we actually have for (72) is:

(74) ∃x|x thinks ∀y Bill is in love with y.

Similarly, the narrow scope reading reported by Larson and May for (61) above is not (75), but rather (76):

(75) ∃x|∀y x thinks (that) y is a genius.
(76) ∃x|x thinks (that) ∀y y is a genius.

And this is actually the expected state of affairs, all else equal. If a quantifier is generally barred from scoping out of a finite clause, neither ∀∃ ... **nor** ∃∀ ... should be possible when ∃ originates in a finite clause that excludes ∀. Given this, the facts that Kayne reports fall under just the same generalization as the one observed by Sloan for family of questions readings. In both instances, a quantifier is normally unable to scope out of the minimal finite clause containing it. And, strikingly, the bound subject exemption from that constraint similarly shows up in both cases. The obvious next step should be to investigate family of questions readings (and, indeed, scope interactions more generally) in null subject languages to see if the null subject exemption also holds.

3   In Lieu of a Conclusion

In this chapter we have seen some classes of locality effects involving (finite) clause-mates. In current minimalist theorizing, it is tempting to attribute these effects to phases and Transfer. What is particularly interesting about the phenomena examined here is that they all share the same exemption: The ordinarily local domain remains open if its subject is a bound pronoun. I hope that this work, along with Grano and Lasnik (in press), constitutes at least a step toward the correct characterization of phases, and possibly of locality more generally, two areas of inquiry in which Juan Uriagereka has played such an important role.

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4   Context-Sensitive Aspects
of Constituent Negation

Ricardo Etxepare and Myriam Uribe-Etxebarria

1   Sequences of *Neg+Quantifier Phrase* in Spanish

The examples in (1a–b) illustrate two of the syntactic configurations where negation can be found in Spanish in sentences involving a quantifier phrase (QP).[1] In (1a) negation surfaces separated from the QP *pocos programas* ("few programs") and serves to negate the proposition; it thus constitutes a typical case of *sentential negation* (SN) (see Acquaviva 1997, Herburger 2000). In contrast, in (1b) negation surfaces immediately preceding the QP, and it does not negate the proposition; rather, it only affects the quantificational expression it is adjacent to, yielding what is known as *constituent negation* (CN) (Klima 1964, Horn 1989, Sánchez López 1999).

(1) a. Pocos   programas innatos   no   implican cuestiones relativas
          few.pl programs innate.pl neg   raise   issues   concerning
          a   los derechos   humanos
          to   the rights   human.pl
          "Few innate programs don't raise issues related to human rights."

     b. No   pocos   programas innatos   implican cuestiones relativas
          not few.pl programs innate.pl   raise   issues   concerning
          a   los derechos   humanos
          to   the rights   human.pl
          "Many (lit: not few) innate programs raise issues related to human rights." (From CREA, Sept. 2015)

There are several tests that show that the scope of negation in cases like (1b) is not sentential.

First, sequences where NEG immediately precedes the QP are compatible with positive polarity items, which are banned in the scope of negation. Consider in this regard the paradigm in (2–3). The negative examples in (2a–b) involve a pseudo-focal quantifier and an approximative quantifier, respectively. All these sentences sound odd, as those elements are positive polarity items and cannot occur in the scope of negation (see González 2008 for Spanish). Notice, however, that, as illustrated in (3a–b), their constituent negation counterparts are good; this is precisely what we expect if the scope of negation in structures involving CN is not sentential, and only affects the QP it precedes.

(2) a. *Muchos lingüistas no   han   publicado al menos 3 artículos
        many   linguists neg have published at least 3 papers
        *Many linguists haven't published at least 3 papers."

    b. *Muchos lingüistas no   han   publicado casi   100 artículos
        many   linguists neg have published almost 100 papers
        "*Many linguists haven't published almost 100 papers."

(3) a. No   muchos lingüistas han   publicado al menos 3 artículos
        neg many   linguists have published at least 3 papers
        "Not many linguists have published at least 3 papers."

    b. No muchos lingüistas han publicado casi   100 papers, como tú
        not many   linguists have published almost 100 papers, like you
        "Not many linguists have published nearly 100 papers, like you."

The scopal properties of CN may also provide an explanation of why certain quantifiers are just impossible with this type of negation. Thus, there is no sequence like *no algún/alguien* or *no un/-a, unos/-as* in Spanish:

(4) a. *No   algún   estudiante   ha   venido
        neg   some   student   has   come
        "No students have come." (lit: "Not some student has come.")

    b. *No   un   estudiante   ha   venido
        neg   a   student   has   come
        "Not a single student has come." (lit: "Not a student has come.")

Quantifiers like *algún/alguien* and indefinite determiners such as *un/-a* and their plurals behave as positive polarity items in negative contexts and, consequently, are not licensed within the scope of negation. Furthermore, notice that the reverse pattern arises if we insert strong polarity items of the minimizer sort: they are licensed by SN, but not by *NEG+QP* sequences.

(5) a. *No   pocos   moverán   un   dedo   por   ti[2]
         neg   few.pl   move.fut   a   finger   for   you
         "*Many (lit: not few) will lift a finger to help you."
     b. Pocos   no   moverán   un   dedo   por   ti
         few.pl   neg   move.fut   a   finger   for   you
         "A few people will not lift a finger to help you."

Again, this strongly suggests that the scope of the negation particle in those
cases does not extend beyond the QP.

   A final argument can be provided on the basis of structures involving Clitic
Left Dislocation (CLLD). As illustrated in (6), instances of CN (sequences
involving *NEG+QP*) can occur in CLLD; in those cases, the clitic resumes the
compositional meaning of the dislocated constituent.

(6) Y   a   no   pocos, los   estimuló el anhelo de ganar un   sitial
     and   to   not few.pl, CL.acc.pl   pushed   the wish   of earn a   place
     glorioso en la   historia
     glorious in the history
     "And many (lit: not few) were led by the wish to earn a glorious place in
     history." (From CREA, X-2015)

What is interesting for our discussion, however, is that the availability of this
type of construction depends directly on the compositional meaning of the
NEG+QP sequence. Consider the following contrast, in a context where some-
one is commenting on people's reactions to a recent movie:

(7) a. A   no   pocos, parece que   les   han   gustado sobre todo los
         to neg few.pl seems   that CL.dat.pl have liked   above all   the
         efectos especiales
         effects special
         "And many (lit: not few) seemed to have liked the special effects."
     b. *A no   muchos, parece que   les   han   gustado sobre todo los
         to neg many.pl seems that CL.pl   have liked   above all   the
         efectos especiales
         effects special
         "Not many seemed to have liked the special effects."

Whereas a sequence involving negation and the quantifier *pocos* "few" can
be clitic left dislocated, a sequence with negation and the quantifier *muchos*
"many" cannot. This is strikingly the reverse of what we find with the bare
quantifiers *muchos* and *pocos*: *pocos* by itself cannot be left dislocated (witness
the oddness of (8b)), whereas *muchos* can (8a).

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[2] The sentence, although impossible out of context, would be grammatical under the non-idiomatic
     meaning of *mover un dedo* (lit: "move a finger").

(8) a. A   muchos, parece que les   han gustado los efectos   especiales
        to   many.pl seems that CL.pl have liked   the effect.pl special.pl
        "Many seemed to have liked the special effects."

   b. *A   pocos,   parece que les   han gustado los efectos   especiales
        to   few.pl, seems that CL.pl have liked   the effects special.pl
        "Few seemed to have liked the special effects."

Following standard assumptions, we will assume that the contrast in (8a,b) is
due to the different ability of *muchos* and *pocos* to introduce a discourse ref-
erent. If that is a semantic effect, and the compositional meaning of negation
and *muchos* conceptually yields something like *pocos* "few," then the contrast
in (7a,b) also follows.[3]

   A wide range of quantifiers can form part of these *NEG+QP* sequences in
Spanish. Among them we find quantifier expressions akin to *muchos* and *pocos*,
like the degree quantifier of excess *demasiado* "too many/much," and compar-
atives of degree such as *más/menos de* "not more than/less than." Universal
quantifiers, such as *todos* "all," or *todo el mundo* "all the world/everyone," can
also be immediately preceded by negation. Given that sequences of *NEG+QP*
seem to be widely available, it would then be tempting to assume that a similar
"constituent negation" analysis may be unproblematically extended to all the
attested cases. This is precisely the position defended by some authors, who
suggest a unified treatment of such sequences (cf. Sánchez López 1999, Kim &
Sag 2002). As we will show in the next section, however, in Spanish *NEG+QP*
sequences do not behave uniformly with respect to the syntactic and semantic
properties they display.

2   Asymmetries in the Behavior of *NEG+QP* Sequences

2.1   Word Order: Relative Order between Negation
              and Case Markers/Prepositions

The first domain where we spot an asymmetric behavior between different
types of quantifiers is in the word order exhibited by sequences formed by
negation and a QP when this QP is case marked or embedded within a prepo-
sitional phrase (PP). Two different word orders seem to be available a priori:
(i) the word order where negation precedes the case marker (CM) or the prep-
osition, *NEG+CM/P+QP*, and (ii) the word order where the CM/preposition
precedes negation, *CM/P+NEG+QP.*

NEG+CM/P+QP   The relative order in which negation precedes the CM/P
seems to be available to all the quantifiers that can combine with negation

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[3] On the difficulty of topicalizing bare quantifiers like *few*, see Cinque (1990: 83), Rizzi (1997: 290), Kiss (2002: 25), and references therein.

(all the examples below are taken from CREA [Sept. 2015], except for (9f,g), which we have borrowed from Google, and (9h)):

(9) a. este tipo de deporte que *no a   mucha gente*   le   gusta
         this type of sport   that not to many   people CL.dat likes
         jugar
         play.inf
         "this type of sport, which not many people like playing"

     b. hecho que molestó *no a   pocos de   los periodistas* cansados por
         thing that bothered neg to few.pl of   the journalists   tired   by
         actos a medias
         performances half.hearted
         "a thing that bothered many of the journalists who were fed up with half-hearted performances"

     c. *No a   todo   el   mundo*   le   sientan igual   las
         neg to all.sg. the.sg. world.masc.sg. CL.dat affect   equally the
         bromas
         jokes
         "Not everyone is equally affected by jokes."

     d. *No   a   todos* les   interesa llegar tan   lejos
         neg to   all.pl   CL.dat   interests get.inf that far
         "Not everybody is interested in getting that far."

     e. *No a   cualquiera* hubiera   enviado el   Superior a   hablar
         not to anyone   would.have sent   the superior to speak.inf
         con el   joven
         with the young
         "The headmaster wouldn't have sent just anyone to speak to the young man."

     f. Si bien *no   a cada uno le*   resulta   fácil establecerse   para
         if   well neg to each one CL.dat turns.out easy establish.inf.refl to
         hacer   hitbodebut durante   la noche …
         do.inf hitbodebut during   the night …
         "Even if not everyone finds it easy to set out to do hitbodebut during the night …"

     g. Hay   casos extremos, *no a   todo dios le*   sienta igual
         there are cases extreme,   not to all   god CL.dat affects equally
         todo
         all
         "There are extreme cases, not everybody is equally affected by everything."

     h. No   por   todos los montes   crecen flores
         not   through all   the mountains   grow   flowers
         "Flowers don't grow on every mountain."/"Not on every mountain do flowers grow."

CM/P+NEG +QP   However, the word order where Neg follows the CM/P is more restricted and, as we will show next, does not seem to be available to all quantifiers.

   As the examples in (10) and (11) show, this word order is possible in sequences involving quantifiers like *muchos/-as* "many" or *pocos/-as* "few."

(10) Muchos ("many")

… recuerdo	que	a	no	muchos	les	gustó	ese	traje
… remember-I	that	to	not	many.pl	CL.dat.pl	liked	that	suit

"I remember that not many liked that suit." (http://blogdesuperheroes
.es/cine-el-misterioso-personaje-de-escuadron-suicida-es-deadshot-ni-
nadie-solo-un-espontaneo-que-se-colo-en-el-set)

(11) Pocos ("few")

a. *En realidad son varios los interrogantes que preocupan a*

in	reality	are	several	the	questions	that	concern	to

no pocos   trabajadores sociales …

neg	few.pl	workers	social.pl

"To be honest, there are several issues that concern many (lit: not few) social workers ..." (https://books.google.es/books?id=LtUiDWWyapgC)

b. En   no   pocas   ocasiones,   Luis   ha   sido   muy generoso

in	no	few.pl	occasions.pl	Luis	has	been	very	generous

"On many occasions (lit: on not few occasions) Luis has been very generous."

Despite the fact that not all speakers seem to like them, similar examples can be reproduced with other quantifiers. Thus, the sequence *CM/P+NEG+QP* is also possible for some speakers when the quantifier involved is *todos/-as* ("all"), or even *todo el mundo* (lit: "all the world" = "everyone").[4]

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[4] Examples involving *todos* ("all") come not only from the internet (Google search, for instance) but also from monitored corpora such as the *Corpus de Referencia del Español Actual* (*CREA*) ("Reference Corpus of Contemporary Spanish," Royal Academy of the Spanish Language), as in the case of (11) in the text. Examples involving *todo el mundo* (lit. "all the world"), on the other hand, are only found in non-monitored corpora (13).

   With regard to the frequency of each sequence, a quick Google search for a sequence like *a no todos* ("to not all CL$_{dat.pl}$") shows 52,300 instances of that sequence, while the search for the sequence with the lineal order *no a todos* ("not to all") yields 315,000 cases. Although not all examples might be real cases of these sequences and many of them might have to be filtered out, what is significant is that the order where negation is external to the case-marked DP/PP is six times more frequent than the other sequence. Similar results obtain for the case of the QP *todo el mundo* ("all the world/everyone"): the sequence *no a todo el mundo* ("not to all the world/everyone") results in 230,000 cases, while the sequence *a no todo el mundo*, with negation following the case marker/preposition, yields 57,300 examples; the first one is thus four times more frequent than the second one. One of the authors of the chapter does not accept sequences of *CM-Neg-Universal Quantifier*. Other speakers we have consulted share the same judgment.

(12) Todos/-as ("all")

 a. Es un evento que a no todos les   parece claro
   is an event that to not all CL.dat.pl seems clear
   "It is an event that not everyone considers (to be) clear." (From CREA, Sept. 2015)

 b. *En no todos los niños* surge efecto
   in not all   the children have   effect
   "It doesn't work with all children."

 c. Por   no todos los montes   crecen flores
   through not all   the mountains grow   flowers
   "Flowers don't grow on every mountain."

(13) Todo el mundo (lit: "all the world" = "everyone")

 Sin embargo, *a no todo el mundo* le   gusta un medio tan abierto
 however   to neg all the world CL.dat likes a media so open
 "However, not everyone likes such open(-minded) media."
 (es.bab.la › Diccionario bab.la › Español-Alemán)

Finally, this combination seems to be highly restricted for quantifiers like *cualquiera* "anyone." We did not find a single example in monitored corpora, but we did find a few on the internet:[5]

(14) Cualquiera ("anyone")

 a. Con el tiempo aprendí que *a no cualquiera* se   le   llama
   with the time, learnt.I that to neg anyone CL.imp CL.dat calls
   amigo
   friend
   "As time went by, I learnt that you cannot call just anybody a friend."
   (https://twitter.com/.../ status/309346974564495360)

 b. A no cualquiera le   sale   rico
   to not anyone   CL.dat comes.out tasty
   "Not everyone knows how to make it so tasty."
   (http://bobadillayasociados.blogspot.com.es/2013/11/hola-hay-que-trabajar-con-el.html)

But there are two quantifiers that do not admit such a configuration. We have not found a single instance either on the Internet or elsewhere of sequences like *a no cada uno* ("to not each one"), or *a no todo dios* ("to not everyone"). The examples would have looked as follows:

(15) a. *∗A no todo dios* le   gusta eso
   to not all   god CL.dat likes that
   "Not everyone likes that."

---

[5] 41,700 entries for the sequence *no a cualquiera le* ("not to any CL$_{DAT}$") and 2,830 entries for the sequence *a no cualquiera le* ("to not any CL$_{DAT}$"), in a quick Google survey. Notice that when compared with the cases analyzed in the previous note, the ratio between the two sequences is as big as 14'7.

b. *A   *no*   *cada estudiante*   le   gusta   eso
to   neg   each   student   CL.dat likes   that
"*Not each student likes that."

2.2   *Scales and Constituent Negation*

What is the property that distinguishes *todo dios* (lit. "all god" = "everybody") from those quantifiers which can prima facie merge directly with negation? One could in principle approach the restriction from more than one angle.

Hypothesis #1 (to be rejected): distributivity   Since QPs like *todo dios* ("each god = everyone") and *cada uno/-a* ("each on") are distributive, the first possibility that comes to mind is that the occurrence restrictions under analysis are related to the distributive nature of these quantifiers. However, we do not think that distributivity is directly at issue here. Evidence for this comes from the fact that other quantificational expressions which have the same distributive properties as *todo dios* and show identical internal syntactic configuration (lacking morphological number) can be combined with negation within the scope of a CM/P, even if they have a distributive interpretation:

(16) a. *A*   *no*   *toda figura del*   *plano*   se   le   puede asignar
to   neg   all   figure of.the plane CL.imp CL.dat can   assign
un *área*
an area
"You cannot assign an area to every figure on the plane."
(rinconmatematico.com/foros/index.php?topic=1883.0;wap2)

   b. *A*   *no*   *toda persona* le   *funciona* *igual*
to   neg   all   person CL.dat works   equally
"It doesn't work the same way for everybody."
(www.nfcol.net/tratamientos.html)

Since distributivity does not seem to be enough to account for the ungrammaticality of the relevant examples, we will follow another lead, to be supported later by independent evidence, which links the illformedness of the sequences under analysis to the inability exhibited by *cada uno* ("each one") and *todo dios* (lit: "every god" = "everyone") to license a scalar interpretation.

Hypothesis #2: scales   The impossibility to merge negation and the quantifier *each* directly had already been observed by Beghelli and Stowell (1997: 99) (hereafter, B&S; see also Baunaz 2011 for French): "whereas *not* can combine

with a variety of proportional quantifiers, including *more/less (than) n*, *many*, or with *every* and *all*, it cannot combine with *each*."[6,7]

(17) a. Not more than ten boys ate an ice-cream cone.
      b. ? Not ten boys ate an ice-cream cone.
      c. Not many boys ate an ice-cream cone.
      d. Not all the boys ate an ice-cream cone.
      e. Not every boy ate an ice-cream cone.
      f. *Not each boy ate an ice-cream cone. (B&S: 99)

Beghelli and Stowell mention a difference between *each* and other universal quantifiers like *every* and *all* that we believe may play a role in accounting for the ungrammaticality of the *CM/P+NEG+QP* sequences under analysis: "a difference between *each* and *every* concerns modification by *almost*. This particle can qualify any quantifier or numeral designating a fixed quantity that is understood as the end point of a scale, including universal Qs like *every* and *all,* but it **cannot combine with *each***." This is shown in (18) (from B&S: 99).

(18) a. One boy has eaten almost 20 apples.
      b. One boy has eaten almost nothing.
      c. One boy ate almost all the apples.
      d. One boy ate almost every apple.
      e. *One boy ate almost each apple.

Following these authors, "this suggests that *all* and *every* – but not *each* – can designate the end point of a scale, here the full set of apples. Note that the

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[6] B&S (99) acknowledge that it is not obvious what property of the quantifiers distinguishes the good from the bad examples: "the marginal status of the bare numeral example in (35) [= (17b) in the text] suggests that a proportional function of the quantifier may be relevant here, but (35) [= (17a) in the text] seems to have a non-proportional construal."

[7] B&S also discuss in detail why certain combinations involving *each* and sentential negation are impossible. These authors argue that *each* is a strong distributive quantifier, and contend that there are two ways in which a distributed share can be provided to set up distribution: "The first one involves an overt indefinite GQP [a Group-Denoting QP] functioning as a distributed share for another QP; the second involves a covert existential quantifier over events functioning as a distributed share, on a distributive (non-collective) event construal" (p. 89). It thus follows that *each* needs to distribute over either an indefinite GQP or an event variable. When these conditions are not met, the sentences will be ungrammatical, as shown in (i) and (ii) below. (These authors note that focus can affect the grammaticality of these sentences; see B&S: 95.)

  (i) *Each boy didn't leave
  (ii) *John didn't read each book

Since in these examples there is no overt indefinite GQP available that can serve as a distributive share, the only available option for *each boy* in (i) and *each book* in (ii) is to bind the event variable, so that they can distribute. But there is a competitor to bind the event variable: negation. If negation binds the event variable, then *each boy* and *each book* cannot bind any variable in these sentences; alternatively, if these quantifiers bind the event variable, then negation does not have a variable to bind, so in any case we would have a case of vacuous quantification.

ungrammaticality of (34e) [= (18e) in the text] cannot be due to a failure of distributivity, since the D(istributive)QP should be free to distribute over the indefinite subject" (B&S: 99).

We contend that this is a feature that *each/cada* also shares with *todo dios* (lit: "all god" = "everyone"). More specifically, with respect to *todo dios* we will argue that the absence of a true descriptive nominal restriction affects the possibility of licensing a conceptual domain for scalar reasoning (see Israel 2012: 54–57).

If our hypothesis is correct, we will also have a reason why PP-internal or case-marked DP-internal merge of negation is most natural in the case of degree quantifiers.

In order to support our hypothesis, we will provide some more evidence that scalar interpretation plays a role in explaining the ungrammaticality of the linear order under analysis.

With that goal in mind, we next analyze in some detail the interpretation of other quantificational expressions when embedded in sequences involving negation.

2.2.1   Towards an Explanation

2.2.1.1   *Cualquiera*   Let us start with the quantifier *cualquiera* "anyone," which can be interpreted as either a universal quantifier or an existential one. Consider in this regard the following contrast (adapted from Sánchez López 1999):

(19) a. Cualquier acusado   tiene derecho a   un juicio justo
        any   defendant has   right   to a   fair   trial
        "Every defendant has the right to a fair trial."
     b. Primero hay siempre un   lunch,   y   luego   cualquier
        first there.is always a   lunch   and   then   any
        académico   lee   un   discurso de   bienvenida
        academician reads a   speech   of   welcome
        "First there is always a cold buffet, and then some academic reads a
        welcome speech."

Cualquier in the first sentence stands for all defendants. It is the total number of defendants who are liable to a fair trial (*universal* interpretation). In the second sentence, the only plausible reading of *cualquier académico* is the existential one: one academic, no matter which, will read a welcome speech. Implicit in the latter case is the idea that even the least prominent academic in the set can actually do the job. In other words, (19b) implies a scale of scholars (*scalar* interpretation).

The scalar and non-scalar construals seem to correlate with their relative position vis-à-vis the case marker/preposition. Negated *cualquiera* in the scope

of the case marker is always scalar. (20) provides an illustrative example from Google with the case marker/preposition preceding the quantifier:

(20) Has   de pagerle   todo lo demás para que esté
     have.you of paying.CL$_{dat}$ all the rest   for   that be$_{SUBJUNCT}$
     a   la   altura de sus   compañeros
     at the level of his/her friends
     "You have to buy him/her everything so that (s)he can keep up appearances."
     la ropa   de marca, las excursiones a no cualquier sitio …
     the clothing of design, the trips   to not any   place
     "the designer clothing, the trips to not just anywhere …"

In cases where negation precedes the case marker/preposition, one can find clear cases of non-scalar quantification (quantification over a non-ordered domain):

(21) Esta politica de privacidad se   aplica solo a   la   página
     this policy of privacy   CL.imp applies only to the   page
     web en la que aparece, y   no a cualquier otro sitio web
     web in which it.appears and not to any   other place web
     o   servicio
     or service
     "This privacy policy applies only to the web page on which it appears and not to other websites or services."

It seems clear that the warning discards not just one other service or website, but in fact all other websites or services to which a privacy policy could in principle apply.

   If the generalization holds true, we can advance the following tentative hypothesis: CM/P-internal merge for negation is only possible if the QP complement is one that denotes a scale. Let us consider what happens if both a scalar reading and a non-scalar universal reading are impossible, either because of restrictions imposed by the predicate or because the nominal restriction of the quantifier does not license a conceptual scale. Assuming that each of those readings corresponds to the two positions available to negation (external and internal to the case marker/preposition), our prediction is that a sequence of *NEG+QP* should be impossible. This prediction is borne out. Consider (22), for instance:

(22) Cualquier día   de estos me   suicido
     any   day of these CL.reflex commit.suicide(I)
     "One of these days I just might kill myself."

Because of the once-only semantic status of the predicate, the universal reading is not possible in (22) (since it would assert that I may commit suicide every day, while what the sentence means is that I may commit suicide one of these days (an undentified day)). Note, further, that the restriction of the quantifier in (22) is such that it does not allow establishing a scale. The reason is that the partitive *de estos* ("of these") defines a set of similar-in-kind days that explicitly disavow any scalar arrangement of the relevant occasions. As we expect, in this context a sequence of *NEG+QP* is simply not possible:

(23) *No   cualquier   día   de   estos   me   suicido
     neg   any   day   of   these   CL.reflex   commit.suicide(I)
     "I won't kill myself one of these days."

Note, crucially, that there is nothing in the sequence *no cualquier día* which precludes constituent negation, as shown by the grammaticality of (24b):

(24) a. Cualquier   día   es   bueno   para   suicidarse
        any   day   is   good   for   committing suicide
        "Any day is a good one to commit suicide."
     b. No   cualquier   día   es   bueno   para   suicidarse
        not any   day   is   good   to   commit suicide
        "Not just any day is a good one to commit suicide."

(24a), with a universal reading of the QP, allows subclausal negation (24b).

2.2.1.2 Predicate Negation   That the scalar dimension is crucial to the possibility of combining directly negation and a QP is also shown by constructions which have nothing to do with D-quantification. Predicate negation is a case in point. Consider the examples in (25). The only difference between (25a) and (25b) is that (25b) has an overt degree modifier: *muy* "very."

(25) a. Rodolfo   está   bien
        Rodolfo   is   well
        "Rodolfo is alright."
     b. Rodolfo   está   muy   bien
        Rodolfo   is   very   well
        "Rudolfo is very well."

As shown in (26)–(27), predicate negation (postverbal negation) is only possible under the presence of this adverbial degree modifier:

(26) a. Rodolfo   no   está   bien
        Rodolfo   neg   is   well
        "Rodolfo isn't well."
     b. *Rodolfo   está   no   bien
        Rodolfo   is   not   well
        "Rodolfo is unwell."

(27) a. Rodolfo   no   está   muy   bien
       Rodolfo   neg   is   very   well
       "Rodolfo isn't very well."
    b. Rodolfo   está   no   muy   bien
       Rodolfo   is   not   very   well
       "Rodolfo is not very well."

One could think that the underlying reason why (26b) is bad is that there already exists a lexical item that covers the same conceptual space as *no bien* "not well," namely *mal* "bad/unwell." But this explanation cannot be right, in general. Consider hair colors, for instance, which can be more than one: *moreno* "dark-haired," *castaño* "brunette," *rubio* "blond," *pelirrojo* "redhead," etc. One cannot say (28a), despite the fact that there is no word covering the same conceptual space, but (28b), where *moreno* is modified by a degree adverbial, is possible:

(28) a. *Rodolfo   es   no   moreno
       Rodolfo   is   neg   brunette
       "Rodolfo is not brunette."
    b. Rodolfo   es   no   muy   moreno
       Rodolfo   is   neg   very   brunette
       "Rodolfo's hair isn't very brown."

Let us assume, with Corver (1997), that degree modifiers merge to a degree phrase. With this assumption we can define a type of subclausal negation, which we will call *constituent negation* (CN) as negation over degrees. This relation is syntactically realized in terms of direct merge of a negative head to a degree phrase:

(29) [$_{\text{NegP}}$ no [$_{\text{DegreeP}}$ muy...]]

For the case of quantifiers, we will assume that degree quantifiers are headed by a degree denoting head:

(30) [$_{\text{NegP}}$ no [$_{\text{DegreeP}}$ muchos/pocos/cualquiera...]]

2.2.1.3 Todo Dios   What can we say about *todo dios* (lit: "all god" = "everyone")? As we saw above, its resistance to combine directly with negation cannot be due to its distributive character. Given the relevance of scales in the distribution of constituent negation, we suggest that in the case of *todo dios* the impossibility of licensing CN follows from the absence of a descriptively rich-enough nominal restriction that allows setting a conceptual domain for the would-be scale. Following Israel (2011), we will assume that scalar reasoning involves two basic components: a scalar model and a conceptual scale. Scalar models are structured sets of propositions ordered in terms of one or more

conceptual scales. Conceptual scales refer to the ability that human cognition has to organize several entities in ordered relations concerning amounts or degrees, part/whole relations, or hierarchical taxonomies. According to Israel (2011), they are better seen as conceptual structures. For this author, the scalar relation between a set of words like *freezing*, *cold*, and *cool* reflects "the fact that our experience of cold things is itself fundamentally scalar." Scalar reasoning "is a way of thinking about these sorts of scalar experiences" (Israel 2011: 55–56). If this is correct, there is a sense in which conceptual scales rely on the descriptive content of language. In other words, mapping general cognitive scalar relations into linguistic scalar hierarchies requires a rich enough lexical component. It is in this sense that elements like *todo dios* (lit: "all god" = "everyone") may fail: they do not contribute enough descriptive content on which to build a conceptual scale.[8]

That the problematic aspect of expressions of the sort *todo dios* from the point of view of scalarity is related specifically to the nominal restriction is shown by the contrast in (31a,b). (31a) allows a scalar contrast based on the domain denoted by the nominal restriction. It is precisely this kind of contrast that cannot be established in the case *todo dios* (31b).[9]

(31) a. No   toda persona sino todo ser   vivo tiene derecho a   una
      not all   person but all   being alive has   right   to a
      vida en   libertad
      life   in   liberty
      "Not just every person – but every living being – has the right to live free."

   b. *No *todo dios/pichichi/quisque* sino todo ser   vivo tiene
      not   all   gods/pichichi/quisque but all   being alive has
      derecho a   una   vida en   libertad
      right   to   a   life   in   liberty
      "Not just everyone but all living beings in general have the right to live free."

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[8] *Todo dios* is actually one in a family of universal quantifiers built on highly idiomatic nominal restrictions, such as *todo quisqui* "everyone" (from the Latin borrowing *quisque* "anyone") and *todo pichichi* "everyone."

[9] That the relevant scalar component in the possibility of negating a QP is also related to the nominal restriction is further shown by the fact that although, as shown in (i), the Q can be easily modified in a way that implies a quantificational scale, the modified quantifier in (i) does not admit direct merge with negation: we did not find a single instance of the sequence CM/P+NEG+MODIFIER+QP of the sort of a *no casi todo dios* in Google or in monitored corpora:

(i) He   visto   a   casi   todo dios
    have(I) seen   to   almost all   god

   "I have seen almost everybody."

3   Where Is Negation?

We have seen that negation cannot be directly merged to all quantifiers; witness the semantic restrictions applying to sequences with the linear order CM/P+NEG+QP. This means that in those cases where the semantic restrictions apply, but negation still occurs in a position adjacent to the QP, there must be some configuration other than the one that corresponds to CN that underlies those sequences. Let us call this set of cases where negation is external to the QP "fake constituent negation." How can we account for those sequences? There are two possibilities that come to mind at this point: the first one is that Negation adjoins to some projection in the extended domain of the QP (see Kim and Sag 2002; also Zeljstra 2013, for a recent argument in favor of that idea). We will, however, show that this analysis is not appropriate for these structures. We will instead contend that the adjacency between negation and the QP in cases of fake constituent negation is an illusion produced by focus fronting of the QP into the specifier of a functional head which is in a very local relation with a very high negation. To be more specific, fake CN (sequences of *NEG+QP* outside the domain of degree quantifiers) must be represented as in (32), with a negative particle that sits in the CP-domain and c-commands a FocusP, whose specifier is occupied by a leftward-moved QP.

(32) $[_{\text{NegP1}} \text{Neg}_1 [_{\text{FocP}} \text{QP Foc} [_{\text{NegP2}} \text{Neg} \dots [\dots \text{(QP)} \dots]]]]$

The arguments we present in favor of this hypothesis are three: (i) cases in which the sequence *NEG+QP* is interrupted by clausal adverbs, (ii) the relative scope of *NEG+QP* sequences with respect to intensional verbs, and (iii) the existence of clauses with double negation.

3.1   Clausal Adverbs

We start by pointing out that in the fake cases of CN, adjacency between negation and the QP is not obligatory: when negation is external, it does not have to be immediately adjacent to the case-marked QP, and it can naturally occur separated from this quantificational element by an adverb taking clausal scope. This adverb can be a modal adverb (33a,b), or an evaluative one (33c). Note that in these examples the adverbs have clausal scope. Direct morphosyntactic evidence for the clausal scope of the adverb in (33a) comes from the fact that it licenses the occurrence of subjunctive inflection, as one expects from modal adverbs with sentential scope:

(33) a. *No   tal vez   a   todos*   les   guste   eso
        neg   maybe   to   all.pl   CL.dat   like$_{\text{SUBJUNCT}}$ that
        "Maybe not everybody likes that."

b. Cosas … que quise   compartir de   una forma que *no*
   things   that wanted(I) share.inf of   a   way   that neg
   quizás   a   todos les   gustó
   perhaps to   all.pl CL.dat   liked
   "Things that I wanted to share in a way that perhaps not everyone
   liked."
   (forums.lan.leagueoflegends.com/board/showthread.php?t=71433)

c. … *no afortunadamente   a   todos* los que   fueron mis subalternos
   neg fortunately   to   all.pl the that were   my subordinates
   en   la   Nacional,   sino a algunos   que …
   in   the National,   but to some   that …
   "Fortunately not to all those who were my subordinates on the Nacional but to
   some that …" (https://books.google.es/books?isbn=9703222528)

That the subjunctive in (33a) is licensed by the modal adverb and not by negation is shown by the fact that, without the adverb, the subjunctive is not licensed:

(34) *No   a   todos les   guste   eso
     not   to   all   CL.dat.pl   like.3.psg ₛᵤᵦⱼᵤₙcₜ   that
     "Not everybody likes that."

Assuming that in order to license subjunctive mood inflection in the finite form the modal adverb must be able to c-command it, it must be the case that the adverb *tal vez* is not embedded in a purported constituent headed by negation or the quantifier. The existence of sequences like those in (33a–c), where the linear adjacency between negation and the QP is interrupted by the sentential adverb, makes it difficult to uphold the hypothesis that these *NEG+QP* sequences correspond to adjunction structures in which negation is adjoined in the extended projection of the QP. Furthermore, the fact that in cartographic terms the element that interrupts the sequence is a very high adverb provides strong evidence that negation in those cases belongs in the high CP-domain.

Note also that the modal and evaluative adverbs involved in (33) are of the type that cannot be negated (see Etxepare 1997). Thus, in these examples negation negates not the adverb itself, but the quantifier lower down. A natural way of looking at this type of long-distance dependency between negation and the QP is in terms of association with focus (Jackendoff 1972). We will come back to this question below.

3.2   The Relative Scope of NEG+QP Sequences with Respect to Intensional Verbs

It has been observed that intensional predicates like *buscar* ("look for") cannot take negative objects of the sort of *no one*, *nobody*, or *nothing* (Zimmermann 1993;

see also Penka 2007). Such negative elements, on the other hand, have been recently analyzed as the result of spelling out two locally related features, *negation* and an *indefinite*, together (Zejlstra 2004, Penka 2007, Temmerman 2012). In this, the underlying form of those negative indefinites approaches the one we see in overt sequences of so-called constituent negation. We predict therefore that intensional predicates will not take complements with the order *CM/P+NEG+QP*, since they involve true constituent negation of an indefinite. We also predict that they will be able to take complements with the order *NEG+CM/P+QP*, since those do not necessarily involve constituent negation. This prediction is fulfilled, as shown in (35–36).[10]

(35) *Juan busca   a no mucha gente que le   pueda   ayudar
      Juan looks-for to not many   people that CL.him can_SUBJUNCT help
      "Juan is looking for a few people that can help him."

(36) a. Juan   busca   no   a   mucha   gente, sino   a   toda la
        Juan   looks-for not   to   many   people, but   to   all   the
        gente   que   le   pueda   ayudar
        people   that   CL.him   can_SUBJUNCT help
        "Juan is not looking for many people, but for all the people that can help him."

     b. Juan   busca   no   a   mucha   gente, sino (sólo) a
        Juan   looks-for not   to   many   people, but   to
        alguna   gente   que   le   pueda   ayudar
        some   people   that CL.dat   can-_SUBJUNCT help
        "Juan isn't looking for many people, but just for a few that can help him."

That the illformedness of (35) (a case of CN, with the word order *CM/P+NEG+QP*) has to do with the scope of the negative object with respect to the main

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10 Note that for examples like (36) to be felicitous they must be uttered as a corrective statement in a context like the one provided by the following conversation.

(i) Speaker A. Juan busca a   mucha gente que le   pueda   ayudar
               Juan looks for a lot of people that CL_dat can_SUBJUNCT help
               "Juan looks for a lot of people that can help him."

    Speaker B. No, Juan busca no a   mucha   gente
               Neg Juan looks not for   many   people,
               sino a   toda la   gente posible que   le   pueda   ayudar
               but for all the   people possible that CL_DAT can_SUBJUNCT help
               "Juan looks not just for many people that could help him, but for all people that could possibly help him."

If, as we propose, the negation particle in these cases involves a very high negation, a question arises regarding the word order of these types of examples: in particular, why the subject and the verb precede the *NEG+QP* sequence. We propose that this word order follows from a remnant movement operation of all the material below FocP to the specifier of a high Topic-like projection, along the lines of the analysis we have proposed for in situ wh-questions in Spanish in our earlier work (see Etxepare and Uribe-Etxebarria 2005, 2012 and Uribe-Etxebarria 2002 and references therein).

intensional verb finds further support in the fact that, as soon as we change the subjunctive in the relative clause in (35) and insert an indicative verb instead, the sentence becomes grammatical ((37a) vs. (37b)): the reason is that the indicative within the relative clause makes it possible for the CN-complement to take scope over the intensional predicate, something which is not possible when the embedded verb is subjunctive:

(37) a. Juan busca   a   no pocos amigos que le   han
        Juan looks-for to   not few   friends that CL.dat have$_{\text{INDICATIVE}}$
        traicionado estos   años
        betrayed   these   years
        "Juan is looking for no small number of friends who have betrayed him these years."
        Neg > few > look for

     b. *Juan   busca   a   no   pocos   amigos que   le
        Juan   looks-for to   not   few   friends that CL.dat
        hayan   traicionado estos años
        have$_{\text{INDICATIVE}}$ betrayed   these years

Notice that in cases involving what we have defined as sentence-level negation, a subjunctive verb in the relative clause creates no problem, as shown in (38). This is because the syntactic configuration underlying those sequences is not the one that corresponds to constituent negation: they involve no negative complement; Neg is external to the constituent.

(38) Juan busca   no   a   pocos   amigos que le hayan   traicionado
     Juan looks.for not to few   friends that cl have$_{\text{SUBJUNCT}}$ failed
     estos años,   sino a muchos de   ellos
     these years,   but to many   of   them
     "Juan is looking not for a few friends who may have betrayed him these years, but for many of them."

3.3   Sentences with Double Negation

On the basis of the previous two sections, we are led to the following conclusions. First, in the case in which negation precedes a QP headed by CM/P, the position of negation is rather high: it takes scope over several components of the expanded CP (Rizzi 1997), such as modal and evaluative adverbs. It also takes scope over intensional verbs. Let us say that negation in those cases occupies a very high position in the clausal spine: it thus occurs separately from the element it associates to. This means that the adjacency between negation and the associated QP does not reflect direct merge of negation and the QP. Further, the position negation occupies in this case must be different from the

one occupied by regular sentential negation, as the latter typically follows evaluative and modal adverbs:

(39) a. Afortunadamente/tal vez   no   han   venido
        fortunately/perhaps,   neg   have(they)   come
        "Fortunately/perhaps, they didn't come."
     b. *No   afortunadamente/probablemente   han   venido
        neg   fortunately/probably   have(they)   come

Further evidence that the negation involved in these fake cases of CN is not standard sentential negation comes from the fact that when it associates with a case-marked quantifier phrase it can cooccur with bona fide sentential negation. Although it has been claimed that this type of structure does not exist (see Rivero 1970), under the appropriate discourse conditions it emerges quite naturally. These structures typically involve objections to a previously uttered negative proposition. One instance of such a case of double negation is provided by the following example, gathered from a discussion website. The heading subject is the proposition "animals that do not smell" (40a). Following discussion about the heading subject, someone has been led to say that "not all animals do not smell" (40b):

(40) a. ¿Animales   que   no   huelan?
        animals   that   neg   smell?
        "Animals that don't smell?"
     b. Pues   no   todos   no   huelen
        the.truth.is   neg   all   neg   smell
        "The truth is that not all of them don't smell."
                                              (www.faunaexotica.net)

The following pair provides another instance of this type of structure: the news heading says that "the Spanish jobless do not wish to work the land" (41a); a reply to this statement in the comment section of the news counterargues, saying that "not all Spanish jobless don't wish to work the land" (41b):

(41) a. Los parados españoles no   quieren trabajar en el   campo
        the jobless Spanish neg want   work.inf in the   land
        "The Spanish jobless do not want to work the land."
     b. Que   ponga   en el   titular   "algunos parados"
        That   says _SUBJUNCT_ in the   headline some   jobless
        que   no todos   no quieren trabajar en   el   campo
        because neg all   neg want   work.inf in   the   land
        "The headline should say 'some jobless,' because not all of them don't
        want to work the land."

We are led to conclude that over and above standard sentential negation in Spanish, there is the possibility of projecting a higher negation (No_{Neg1}), whose

function is to object to an (implicit or explicit) previous assertion, and which can be combined with sentential negation (No_{Neg2}).

(42) $[_{\text{NegP1}} No_{\text{Neg1}} \quad [...[_{\text{NegP2}} \quad No_{\text{Neg2}} \quad [_{\text{IP}} \quad]]]]$

4   Conclusion: The Underlying Syntactic Structures of *NEG+QP* Sequences and the Different Position of Negation

In the previous sections we have argued that not all *NEG+QP* sequences are true instances of CN, and have provided syntactic and semantic evidence in favor of this hypothesis.
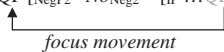
On the one hand, we have what we could define as bona fide cases of CN. This option is limited to those cases where the nominal restriction of the QP licenses the establishment of a conceptual scale. In true constituent negation, the *NEG+QP* sequence follows the CM/P, and the scope of negation is restricted to the QP (it cannot take scope outside). Its structure is roughly summarized in (43).

(43) [Case marker/Preposition [$_{\text{NegP3}}$ No_{Neg3} [$_{\text{DegreeP}\,...}$]]]

On the other hand, we have what we have referred to as fake cases of CN. In these cases, the *NEG+QP* sequence does not form a syntactic term; rather, negation (No_{Neg1} in (42)) occupies a very high position in the clausal spine, and it associates to the QP in the way other focus-sensitive particles do: by means of "association with focus, a context-sensitive dependency" (Uriagereka 2008). The very high position occupied by No_{Neg1} in this case and the movement that the QP undergoes to a focus projection in the left periphery explain: (i) the relative position No_{Neg1} occupies regarding propositional adverbs (such as evaluatives or epistemic modal adverbs) and the lack of adjacency between No_{Neg1} and the QP when these adverbs are overtly realized; (ii) the relative scope of the *NEG+QP* sequence with respect to intensional predicates; and (iii) the co-occurrence of two negative particles (No_{Neg1} and No_{Neg2}) as well as the position they occupy with respect to the QP and with respect to other elements (such as propositional adverbs).

We have summarized the basic tenets of our proposal in (44), with the local relation between the QP and the negative particle (No_{Neg1}) derived as a side effect of a focus movement operation of the QP to the specifier of a left peripheral focus projection, lower than NegP1, but higher than what we have referred to as regular sentential negation (No_{Neg2}).

(44) $[_{\text{NegP1}} No_{\text{Neg1}} [$ (evaluative/epistemic modal adverbs) $[_{\text{FocP}}$ QP $[_{\text{NegP2}} No_{\text{Neg2}} \quad [_{\text{IP}} ...QP...]]]]]$

focus movement

The focus projection we have proposed in our analysis is the one available in ordinary negative sentences in Spanish, as independently argued for in Etxepare and Uribe-Etxebarria (2008):

(45) a. TODOS   no   han   venido
        all   neg   have   come
        "EVERYONE did not come."
     b. [$_{FocP}$ TODOS Foc° [$_{NegP2}$ No_{Neg2} [$_{IP}$ han venido (todos)]]]

If the analysis is correct, we need to distinguish (at least) three different positions for the negative marker *no* in Spanish: (i) DP/QP-internal negation (No_{Neg3} in (43)); (ii) sentential negation (No_{Neg2} in (42)), which is higher than the IP but lower than evaluative and epistemic modal adverbs); and (iii) a higher negation (No_{Neg1} in (42)), which c-commands evaluative and epistemic adverbs, and possesses a metalinguistic function.

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5   Phasehood and Romance Adverbial *Because*-Clauses

Esther Torrego[1]

1   Introduction

The English sentence below illustrates a classic scope ambiguity between negation and a *because*-clause:

(1) Joan didn't win the case because the evidence had been destroyed.

On one reading, reading A, the *because*-clause is interpreted outside the scope of negation ("BEC> NEG") and the sentence asserts that Joan did not win the case, and the reason why she did not is that the evidence had been destroyed. On another reading, reading B, the sentence denies the *because*-clause but not the main clause ("NEG> BEC"), and the sentence means that Joan did win the case but not because the evidence had been destroyed but for some other reason. I will attribute these two readings to the hierarchical structure of the *because*-clause relative to negation: reading A corresponds to a structure in which the *because*-clause is attached high (2a); reading B corresponds to a low attachment of the *because*-clause with respect to negation (2b) (Johnston 1993):[2]

(2) a. Reading A: BEC> NEG
         [$_{IP}$ [$_{IP}$ Joan did**n't** [$_{VP}$ win the case]] [**because** the evidence had been destroyed]].
     b. Reading B: NEG> BEC
         [$_{IP}$ Joan did**n't** [$_{VP}$ [$_{VP}$ win the case] [**because** the evidence had been destroyed]]].

Causal clauses headed by *because* have received a fair amount of attention in the literature. The traditional view is that they are in adjoined positions,

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[2] The literature on negation for Spanish and other Romance languages is well known (Bosque 1980) and extremely vast. For reasons of space, it will be omitted for the most part.

structurally adjoined either to IP/TP (2a) or to VP (2b). In pre-minimalist frameworks, adjunction structures have been treated as creating two maximal projections (Chomsky 1986). Within Bare Phrase Structure (Chomsky 1995), though, adjuncts can no longer be distinguished from complements by a double projection. Hence, rather than (2b) we would have (3) instead:

(3) [$_{IP}$ Joan did**n't** [$_{VP}$ [$_V$ win the case] **because** the evidence had been destroyed]].

It has been observed in the literature that the syntactic placement of the *because*-clause correlates with a difference in prosodic phrasing: The BEC> NEG reading involves two Intonational Phrases and the NEG> BEC reading involves a single Intonational Phrase (see Hirschberg and Avesani 1997, 2000; Selkirk 2005 and references cited within). This prosodic difference is presumably grounded in syntactic structure, and following much of the work on the syntax–phonology interface, I will assume that this is correct.

In Romance, the syntactic placement of *because*-clauses under negation correlates with a Mood distinction in the causal clause. As we will see shortly, *because*-clauses appearing in the structure corresponding to (2a) are in the indicative, and those appearing in the structure corresponding to (2b) are in the subjunctive (Borgonovo 2001). On the PF side, the intonation pattern of the *because*-clause under negation is no different in Romance than in English: The BEC> NEG reading involves two Intonational Phrases, and the NEG> BEC reading involves a single Intonational Phrase.[3] The cluster of facts concerning Romance causal subjunctive clauses raises the question of what their phasehood status is, as subjunctive clauses have increasingly been analyzed as involving a non-phasal CP, in the sense of Chomsky (2001). Phasehood plays a role both in prosodic phrasing (Kratzer and Selkirk 2007) and in semantic effects such as *consecutio temporum* and obviation, which are characteristic of a certain class of subjunctive CPs (Picallo 1984). However, a phase-based syntax approach to Romance *because*-clauses in the subjunctive faces the challenge of how to characterize an adverbial clause as "dependent." Although the precise characterization of subjunctives has proven considerably challenging, subjunctive mood goes hand in hand with subordination. But if causal subjunctive clauses are adjuncts, we expect them to be structurally "out of sight," a fact hard to reconcile with a non-phasal analysis of their CPs. In this chapter I discuss this conflict, suggesting that the syntactic properties of Romance *because*-adverbial clauses in the subjunctive favor a Larsonian analysis, in which they are V-complements (Larson 1988, 2004, Alexiadou 1994, Stroik 1999).

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[3] The prosodic organization of Spanish *because*-clauses has not been studied, to my knowledge. However, I do believe it is the same as in English. See Prieto (2006) for an investigation of phonological phrasing in Peninsular Spanish, and references concerning other Romance languages.

2   Mood Marking

Mood marking has long been shown to disambiguate among readings involving scope (Quine 1956), and *because*-clauses in Romance are no exception. As shown below with examples from Spanish,[4] the reading that corresponds to structure (2a) has the verb of the *because*-clause inflected in the indicative (4a), whereas the reading that corresponds to structure (2b) has the verb inflected in the subjunctive (4b).[5]

(4) BEC> NEG
  a. Juana no ganó el caso porque la evidencia había sido destruída.
    'Joan didn't win the case because the evidence had.PST.IND been destroyed.'
  NEG> BEC
  b. Juana no ganó el caso porque la evidencia hubiera sido destruída.
    'Joan didn't win the case because the evidence had.PST.SUBJ been destroyed.'

Sentence (4a) says that Joan *did not win* the case, and the reason why she did not was that the evidence had been destroyed; (4b) says that Juana *did win* the case but not because the evidence had been destroyed but for some other reason (for example, because she was a good lawyer).

It is well known that the subjunctive in Romance is licensed by negation (Quer 1998). In *because*-clauses such as (4b), this is shown by the fact that in the absence of negation the verb of the *because*-clause can only be inflected in the indicative, as illustrated in (5):

(5) Juana ganó el caso porque la evidencia había/*hubiera sido destruída.
   'Joan won the case because the evidence had.PST.IND/*had.PST.SUBJ been destroyed.'

The contrast in (5) from Spanish provides further support for the different attachment sites of *because*-clauses proposed in Johnston (1993). When the verb is inflected in the subjunctive, the attachment of the *because*-clause must be low (VP-attachment), as the causal clause headed by *because* has to be c-commanded by negation (Lasnik 1975).[6]

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[4] I limit my examples to Spanish, although my syntactic claims extend across Romance.
[5] The following abbreviations are used in this chapter: BEC for because, NEG for negation, PRS for present, PST for past, IND for indicative, SUBJ for subjunctive, 1/2/3 for person.
[6] As discussed by Johnston (1993), a clause-initial *because*-clause in English can only have a BEC> NEG reading. The same is true in Spanish and other Romance languages: a clause-initial *because*-clause is only allowed in the indicative:

  (i) Porque la evidencia había/*hubiera sido destruída, Juana no ganó el caso.
     Because the evidence had.PRS.IND/*had.PST.SUBJ been destroyed, Joan did not win the case.

3   Phases and Clause Transparency

3.1   *Tense-Defective Subjunctive Clauses*

A fundamental finding of generative grammar has been that syntactic dependencies are subject to locality restrictions. The relevance of locality restrictions in the context of subjunctive/indicative causal clauses can be highlighted with negative polarity items (NPIs). A well-known restriction on the distribution of NPIs in Romance is that they require a negative marker within the same clause. But NPIs can also be licensed across clause-boundaries with subjunctives (see Quer 2005 for a summary of the research history on NPIs). As (6) shows, negation in the matrix clause does not license an NPI in the causal clause whose verb is inflected for indicative:

(6) *La reunión no terminó porque tenía prisa nadie.
     The meeting not ended because had.PST.IND hurry no one
     'The meeting didn't end because no one was in a hurry.'

By contrast, negation in the matrix clause licenses an NPI in the causal clause whose verb is inflected for subjunctive, as (7) shows:

(7) La reunión no terminó porque tuviera prisa nadie.
     The meeting not ended because has.PST.SUBJ hurry no one
     'The meeting didn't end because no one was in a hurry.'

   Based on contrasts of this sort in subordinate clauses, numerous researchers have sought to capture the generalization that Romance subordinate clauses in the subjunctive are somewhat "transparent." Since the early 1980s a variety of syntactic and semantic phenomena involving subordinate subjunctive clauses have been shown to be licensed from the matrix clause. Typically, predicates taking subjunctive complements exhibit temporal dependencies (Picallo 1984, Kempchinsky 1986, Padilla 1990 and references cited within):

(8) Querían que telefonearas/*telefonees.
     They-wanted.PST.IND that (you)
     telephone.PST.SUBJ/telephone.PRS.SUBJ
     'They wanted you to phone.'

In pioneering work, Picallo (1984) analyzes subjunctives as having "defective" Tense, making the Tense of the main clause the licenser of the Tense in the subjunctive clause.

   Since the introduction of the notion of the syntactic *phase* by Chomsky (2001, 2004, 2008), researchers have invoked the non-phase status of subjunctive CPs to capture their properties. Assuming that the computation builds the syntactic derivation in phases, and that once a phase is completed it is transferred to the

phonetic and semantic interfaces, the Spell-Out domain of the subjunctive-head C cannot be TP. Both C and v can be phases (in Chomsky's terminology *strong* phases). A phase-based locality approach to NPIs requires assuming that the C of subjunctive clauses is not a phase.

The study of distinctions between non-phase CPs and phase CPs also includes raising constructions. As widely discussed in the literature, raising is another family of structures in which the absence of phase boundaries has been argued to be a determining factor. With respect to subjunctives, there has been debate as to whether raising is attested out of subjunctive clauses (Grosu and Horvath 1984, Dobrovi-Sorin 2001, Roussou 2001, Rivero and Geber 2003, Siegel 2009, among others). Much of this work has concentrated on Balkan languages like Greek, which for the most part lack infinitives, but it has also included Rumanian, which does have infinitives. A well-known fact about the Romance languages is that raising to subject is attested with infinitives, but no English Exceptional Case Marking constructions (ECMs) of *believe*-type are attested (Kayne 1981). Nonetheless, several properties of Romance sub-junctive clauses are reminiscent of the properties of ECMs, as often noted. Uriagereka and Gallego (2007) (and Gallego 2010) draw a link between the Tense-defectivity of lexically selected subjunctives (*Juan quiere*.PRS *que María venga*.PRS.SUBJ/**viniera*.PST.SUBJ, *Juan wishes that Mary come*) and the absence of a CP-layer in ECMs, analyzing Tense-defective subjunctive clauses as ECMs.

Uriagereka and Gallego (2007) argue that feature-defectivity is relevant to define phase heads not just for φ-features but for Tense as well. Looked at from the perspective of Pesetsky and Torrego (2004, 2007), a Tense-defective C lacks a Tense value, which makes C a non-phase head. Phase heads cannot have unvalued features, an assumption discussed by Chomsky (2000) (see Pesetsky and Torrego 2007, footnote 23). Their approach to Tense-defective C unifies several syntactic phenomena of subjunctives and allows the matrix v*-T complex to license case on the subject of the embedded subjunctive clause without resorting to NP-movement, with consequences for obviation.

3.2   (Because)-*Subjunctive Clauses*

Causal adverbial clauses in the subjunctive and, more generally, non-lexically selected subjunctives behave as non-phases in several respects. Yet, criteria such as defective Tense do not apply to them. Romance *because*-subjunctive clauses are temporally independent; hence something else must make their CP transparent.

Broadly speaking, subjunctive clauses fall into two groups: those that are lexically selected, which observe properties such as *consecutio temporum*

(*Juan desea que María venga*.PRS.SUBJ/*viniera.PST.SUBJ, *Juan wishes that Mary come*), and those that are "induced" or "triggered," which do not (Kempchinsky 1986, 2009). The temporal interpretation of subjunctives triggered by negation is independent from the Tense of the matrix clause (*María no cree*.PRS.IND *que te llamara*.PST.SUBJ, *María doesn't think that she/ he called you*). The Spanish examples in (9) show that both causal clauses in indicative (9a) and also causal clauses in subjunctive (9b) are temporally independent (i.e., no *consecutio temporum* holds):

(9) a. Yo no me marché porque tengo/tenía prisa.
          I not left because have.1.PRS.IND/had.1.PST.IND hurry
          'I did not leave because I am/was in a hurry.'
     b. Yo no me marché porque tenga/tuviera prisa.
          I not left because have.1.PRS.SUBJ/had.1.PST.SUBJ hurry
          'I did not leave because I am/was in a hurry.'

Looked at from the perspective of "negation-induced subjunctives," a plausible conjecture is that subjunctive clauses under negation have a defective C with respect to negative features, making the subjunctive C dependent on the matrix for valuation. The present suggestion recalls proposals by Progovac (1994) and Laka (1990), who posit negative complementizers as well as proposals concerning the postulation of negative features in the CP-domain.[7] I will not, however, develop this conjecture here, since my main goal in this chapter is to emphasize the conflict between analyzing causal clauses in the subjunctive as adjuncts and their non-phasal behavior rather than to delve into these or other properties of subjunctives.

The non-phase hypothesis for Romance adverbial *because*-clauses in the subjunctive predicts a parallel pattern in their behavior at the interfaces; the fact that NPIs are licensed by negation in the matrix clause on the LF side and that the prosody of adverbial *because*-clauses in the subjunctive corresponds to a single Intonational Phrase on the PF side confirm this result. Empirically, *because*-clauses in the subjunctive behave as CP-dependents rather than adjuncts. We will also see that they have an impoverished left periphery, further suggesting a defective C.

3.3   Because-*Subjunctive Clauses and the Left Periphery*

One more domain in which Romance *because*-clauses in the subjunctive behave as defective CPs is in their impoverished peripheral domain. As discussed by Torrego and Uriagereka (1992), subjunctive clauses have the property of

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[7] For an interesting discussion of the interaction between scope possibilities and NP licensing, see Uribe-Echevarria (1994).

disallowing "as for"-Topicalization (10b), which is attested in Romance subordinate clauses in the indicative (10a):

(10) a. Aristóteles creía que, *en cuanto a la tragedia*, debía haber tres unidades.
'Aristotle thought that, as far as Tragedy was concerned, there should.PST.IND be three units.'

b. *Aristóteles quería que, *en cuanto a la tragedia*, hubiera tres unidades.
'Aristotle wanted that, as far as Tragedy was concerned, there should.PST.SUBJ be three units.' (Examples from Torrego and Uriagereka 1992)

The indicative-subjunctive contrast in (10) also holds for *because*-clauses:

(11) a. Juana no ganó el caso porque, *en cuanto a los testigos*,
Juana not won the case because, as for the witnesses,
habían mentido todos.
they-had.PST.IND lied all
'Joan did not win the case because, as far as the witnesses were concerned, they had all lied.'

b. *Juana no ganó el caso porque, *en cuanto a los testigos*,
Juana did not win the case because, as for the witnesses,
hubieran mentido todos.
they-had.PST.SUBJ lied all
'Joan did not win the case because, as far as the witnesses were concerned, they had all lied.'

We see that the causal subjunctive clause behaves as a reduced CP.[8]

For the contrast exemplified in (11) to follow from phase theory, the C of subjunctive clauses will have to lack some feature(s) responsible for the availability of Topicalization in the CP of indicative clauses. On this point, Chomsky (2008: 143) remarks: "C is a shorthand for the region that Rizzi (1997) calls the 'left periphery,' possibly involving feature spread from fewer functional

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[8] Clitic Left Dislocation (CLLD), however, is permitted in Romance *because*-clauses in the subjunctive, as illustrated by the Spanish example (ib).

(i) Juana no ganó el caso
Joan not won the case
a. porque a los testigos los habían comprado.
because to the witnesses to them-had.PST.IND bought
b. porque a los testigos los hubieran comprado.
because to the witnesses to them-had.PST.SUBJ bought
'Joan did not win the case because the witnesses have been bought.'

Unlike in English, Romance CLLD is allowed in any type of subordinate clause (Cinque 1990, Zubizarreta 1998).

heads (maybe only one)." Given that Mood has consequences for the phase-hood nature of C, the features of C must be involved in contrasts such as (11). This issue is tackled by Haegeman (2004), who works out a proposal on how to account for distinctions in the reduced CP of typologically different adverbial clauses on the basis of the functional projections that in Rizzi (1997) constitute the CP.

Although English does not differentiate the two readings of *because*-clauses under negation by a Mood distinction, the reduced character of the structure of *because*-clauses under negation is manifested, for example, by the impossibility of Left Dislocation, a root transformation in English, in the sense of Emonds (1976).

Sawada and Larson (2003), on the basis of Hooper and Thomson (H&T, 1973), work out an account of why the availability of root transformations correlates with the semantics/pragmatics of adverbial clauses. As noted by H&T, adverbial clauses whose content is presupposed (*when/before/after*-clauses) do not tolerate root transformations, whereas adverbial clauses whose content is asserted do (*because*-clauses). Sawada and Larson (2003) point out that such a correlation is confirmed by *because*-clauses associated with negation, which are necessarily interpreted as presupposed. They show that whereas Left Dislocation in English is allowed in the *because*-clause of (12), Left Dislocation yields ill-formedness in the *because*-clause under negation (13a):

(12) Mildred drives a Mercedes [because her son, he owns stock in Xerox].
      (Sawada and Larson 2003: (2a))

(13) a. *Sam is going out for dinner [not because his wife, she can't cook] but
          because he wants to discuss Q-magic with Stella. (Sawada and Larson
          2003: (3))
      b. Sam is going out for dinner [not because his wife can't cook] but
          because he wants to discuss Q-magic with Stella. (=H&T's (245))

When we turn to the availability of other left periphery phenomena of subordinate clauses in the subjunctive, we find some discrepancies between them and Romance *because*-subjunctive clauses. For example, pre-sentential Focalization is allowed in indicative clauses (14a) (Torrego 1984), but not in subjunctive clauses (14b) (Torrego and Uriagereka 1992):

(14) a. Juan dijo que *muchas cosas* había visto.
          Juan said that a lot of things he-had.PST.IND seen
          'Juan said that he had seen a lot of things.'
      b. *Juan quiso que *muchas cosas* hubiera visto.
          Juan wanted.PST that many things he-had.PST.SUBJ seen

'Juan wished to have seen a lot of things.'
(Examples from Torrego and Uriagereka 1992)

By contrast, pre-sentential Focalization is somewhat deviant in causal clauses headed by Spanish *porque* ('because'). It yields a slightly stronger deviance when the *because*-clause is in the subjunctive, but the contrast is considerably weaker than with Topicalization. Compare example (15a) with (15b):

(15) a. Don Quijote no se disgustó [porque había combatido muchos gigantes].
        Don Quijote not got upset because he-had.PST.IND fought many giants
        'Don Quixote did not get upset because he had fought many giants.'
     b. ??Don Quijote no se disgustó [porque *muchos gigantes* había combatido].
        Don Quijote not got upset because many giants he-had.PST.IND fought
        'Don Quixote did not get upset because many giants he had fought.'

Accordingly, example (16b) contrasts with (16a):

(16) a. Don Quijote no se disgustó [porque hubiera combatido muchos gigantes].
        Don Quijote not got upset because many giants he-had.PST.SUBJ fought
     b. ??Don Quijote no se disgustó [porque *muchos gigantes* hubiera combatido].
        Don Quijote not got upset because many giants he-had.PST.SUBJ fought
        'Don Quixote did not get upset because many giants he had fought.'

Ignoring for the moment the prohibition of pre-sentential Focalization in Romance *because*-clauses regardless of Mood, let us discuss the overall behavior of Romance *because*-clauses vis-à-vis phase theory.

Phase theory will allow us to make sense of the facts of Romance *because*-clauses in the subjunctive if they are dependent clauses at the interfaces rather than adjoined clauses. Adjuncts are "on a separate plane" (Chomsky 2001, 2004), introduced into the structure by pair-Merge, a form of Merge that creates a pair rather than a set.

(17) *Set-Merge*
     a. Merge $(\alpha, \beta) \rightarrow \{\alpha, \beta\}$ = "symmetrical, unordered"
     Pair-Merge
     b. Merge $(\alpha, \beta) \rightarrow \langle\alpha, \beta\rangle$ = "asymmetrical, ordered" (α adjoins to β)

Pair-Merge attempts to capture the asymmetries characteristic of adjuncts, precisely those missing from VP-attached *because*-clauses. One possibility would be to invoke the operation called *Simplification* (SIMPL), proposed by Chomsky (2004), which converts ordered pairs $<\alpha, \beta>$ to unordered sets $\{\alpha, \beta\}$ at Spell-Out.

(18) *Simplification*

   "We know that at the stage where $<\alpha, \beta>$ is spelled out, it also becomes a simple structure at SEM …Therefore, there is an operation SIMPL that converts $<\alpha, \beta>$ into $\{\alpha, \beta\}$" (Chomsky 2004: 118).

But it is doubtful that the *Simplification* operation can capture all the properties of causal clauses in the subjunctive if the computation "sees" a defective C.

   A plausible alternative to the adjunct view of *because*-clauses and other sentence-final adverbs is Larson's (1988, 2004) analysis. Larson analyzes adverbs as innermost complements of V rather than as adjuncts (Stroik 1999). The arguments that Larson uses in support of his approach include structures of c-command such as (19a). Here the NPI *any* in the final adverb (*during any of our meetings*) needs to be licensed under c-command by an element such as *rarely*. This structural condition is met in Larson's analysis (19b), but not in the structure in which the final adverb is VP-adjoined (19c); the following structures are adapted from Larson (2004: (4)):

(19) a. John spoke [rarely] [during *any* of our meetings]
      b. [John [$_{VP}$ spoke [$_{VP}$ rarely [~~spoke~~ during any of our meetings]]]]
      c. [John [$_{VP}$ spoke rarely [$_{VP}$ during any of our meetings]]]

Following Davidson (1967), Larson (2004) argues that "*because*-clauses do not merely add additional information about those events, but contribute to determining what events they actually are." On this view, "*because* doesn't relate propositions expressed by verb phrases or sentences; rather, it relates the simple event objects that the latter describe (…); *because*-adverbials introduce a quantification ($\exists e´$) over events together with the primitive cause-relation" (Larson 2004: section 2.3.2). This proposal is further developed by Sawada and Larson (2004), who bring cross-linguistic evidence in support of the larger size of *because*-clauses. The structure proposed for the two types of adverbial clauses is given below.

(20) a. *when/before/after:* [$_{YP}$ …]
      b. *because* [$_{XP}$ X $\exists$e [$_{YP}$ …]]

   The "larger size and Operator analysis" of *because*-clauses is consistent with the facts of *wh*-extraction out of Spanish causal clauses. Factually,

wh-extraction out of causal clauses yields very strong deviance (21).[9] This is in spite of the fact that *wh*-extraction takes place out of a subjunctive clause, which usually lessens the degree of deviance obtained in islands.

(21) *Qué (evidencia) no ganó el caso *porque* hubiera sido destruída?
       What (evidence) not won the case because had.PST.IND been destroyed?

Sawada and Larson's (2004) general proposal might help explain the sharp deviance of Spanish (21). Roughly, movement of a *Wh-Q* operator in a structure requiring an Existential operator will be impossible by Minimality (Rizzi 1990), as the Existential operator will act as an intervener for the *Wh-Q* operator, besides the structurally large size of the causal clause (20b).[10]

I will end this section by making a suggestion concerning the ban against pre-sentential Focalization in Spanish *because*-clauses in the indicative (example (15b)). Although indicative clauses do not have an impoverished left periphery, it is conceivable that pre-sentential Focalization is excluded in causal indicative clauses because it enters into a conflict with the existential quantifier proposed by Sawada and Larson (2004) for these clauses. This is especially plausible if Horvath's (2007) proposal that pre-sentential focus is induced by a separate quantificational operator (an Exhaustive Identification Operator) is correct. As with *Wh*-Movement, Focus Movement will be prevented by Minimality.

3.4   Because-*Clauses and Intonation*

Further evidence for the non-phasal status of "VP-attached" *because*-clauses comes from prosody. As discussed in the literature (Ishihara 2007, Kratzer and Selkirk 2007, and others), Spell-Out domain of phases (roughly) corresponds to prosodic phrases (see Cheng and Downing 2012). This raises the possibility that the common prosody of neg-*because* structures in Romance and English can be derived from phase theory.

It is extensively recognized that English uses prosodic phrasing to convey the two readings of *because*-clauses (Hirschberg and Awesani 2000). In the BEC> NEG reading, the *because*-clause is uttered as two prosodic phrases; in the NEG> BEC reading, the *because*-clause is uttered as a single phrase. As noted at the outset, the intonation patterns of *because*-clauses found in the Romance languages are the same: the prosodic phrasing of IP/TP-attached

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[9] As pointed out by a reviewer.
[10] Whether the *wh*-extraction facts of Spanish causal adverbial clauses support Sawada and Larson's (2004) proposed distinction between causal and temporal adverbial clauses depends in part on comparison with the *wh*-extraction facts from within Spanish *cuando/antes de/después de* (*when/before/after* clauses), which also yield degraded results. The issue deserves further investigation.

because-clauses involves two Intonational Phrases; the prosodic phrasing of VP-attached *because*-clauses involves a single Intonational Phrase.[11]

The literature on the syntax–phonology interface has established an intermediate level of prosodic representation. Following Selkirk (1986, 1995), prosodic representations are built by mapping certain syntactic boundaries onto prosodic boundaries (Nestor and Vogel 1986, Wagner 1995, Truckenbrodt 1999, and others). In Selkirk's theory, prosodic domains (φ-phrases, p-phrases, or Minor Phrases) are formed by matching up or aligning the Left or Right edges of syntactic XPs with those of phonological phrases.[12] The formation of prosody involves hierarchically organized domains of different sizes, with φ-phrases (or Minor Phrases) combining into Major Phrases, and Major Phrases combining into Intonational Phrases, with the utterance at the top. I will ignore aspects of prosodic structure that do not directly impact the configuration of prosodic phrases in causal clauses.

Simplifying considerably, the prosodic structure that corresponds to example (4a), repeated below as (22a), would then be two separate φ-phrases:

(22) BEC> NEG
 a. Juana no ganó el caso porque la evidencia había sido destruída.
 b. (   )φ (   )φ
  'Joan didn't win the case because the evidence had.PST.IND been destroyed.'

As shown in (22b), the left edge of the IP will be aligned with a prosodic boundary, and the right edge of VP will be aligned with another boundary (and similarly in the PP-causal clause).

However, the prosodic structure that corresponds to example (4b), repeated below as (23a), would be a single φ-phrase (23b):

(23) NEG> BEC
 Juana no ganó el caso porque la evidencia hubiera sido destruída.
 (   )φ
 'Joan didn't win the case because the evidence had.PST.SUBJ been destroyed.'

In sum, the single prosodic phrase that neg-*because* structures exhibit in both Romance and English can be attributed to the non-phasal status of their CP.

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[11] See Selkirk (2005) for discussion of the prosodic properties of *because*-clauses in English, and the literature dealing with them.
[12] The system that relates syntactic and prosodic structure ignores functional vocabulary.

4 Final Remarks

This chapter has focused on *because*-clauses under negation in Romance, and the relationship between their properties and the phase status of their CP. It has been suggested that *because*-clauses under negation are not phases, a conclusion that challenges the assumption that causal *because*-clauses are adjuncts. This chapter has presented Romance evidence from NPIs, from a reduced left periphery and from prosody in support of this claim. These results are consistent with Larson's (1988, 2004) analysis of rightward adverbs, where they are innermost V-complements rather than adjuncts.

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6 No-Choice Parameters, Phi-Features, and the Structure of DP

Ian Roberts

1 Introduction

In this chapter, I will build on two strands of earlier work. In §2, I will describe the notion of 'no-choice parameter' as it has been developed in recent collaborative work (Biberauer, Holmberg, Roberts & Sheehan 2014; Biberauer, Roberts & Sheehan 2014). In §3 I develop a general proposal concerning the nature of Agree, which involves two principal ideas: that Agree always involves incorporation in the sense of Roberts (2010a) and that many cases of variable binding arise through Agree. In §4 I introduce the proposal for the structure of DPs put forward in Roberts (2017), which is close to a number of proposals in the current literature (see Giusti 1993; Brugè 1994, 1996, 2000, 2002:33–42; Brugè & Giusti 1996; Giusti 1997, 2002; Panagiotidis 2000; Rosen 2003; Shlonsky 2004; Grohmann & Panagiotidis 2005; and Guardiano 2010). Finally, §5 brings the various strands together to give an account of the existence of ϕ-features in natural language as a kind of no-choice parameter.

2 No-Choice Parameters

In recent work Biberauer, Holmberg, Roberts and Sheehan (2014; henceforth BHRS) and Biberauer, Roberts and Sheehan (2014; henceforth BRS) have put forward the idea of 'no-choice parameters'. These are parametric options made available by Universal Grammar (UG) which have the formal structure of familiar parametric options, i.e. they are binary choices left open by UG which are selected from in first-language acquisition. However, the nature of the choice is such that one option is effectively unavailable in practice; hence the choice is not a real one.

A central aspect of the BHRS/BRS proposal is that parametric variation does not, as has been usually thought since Chomsky (1981), arise from a pre-specified list of options given by UG, and therefore part of the general, domain-specific genetic endowment for language. Instead, following Roberts (2012a), Biberauer (2015) and Biberauer and Roberts (2015, 2017), we take an

'emergentist' view of parametric variation, seeing it as arising from the interaction of the three factors in language design discussed in Chomsky (2005) (see Lohndal & Uriagereka 2017 for discussion). The three factors are given in (1):

(1) F1: Universal Grammar (the genetic endowment)
     F2: Primary Linguistic Data (PLD, experience)
     F3: General, non-domain-specific, principles of computational economy, optimality, etc.

Against this background, the sole contribution of UG to parametric variation lies in leaving certain formal properties underspecified. The interaction of the other two factors creates the observed variation.

   More precisely, BHRS/BRS assume that first-language acquisition involves the determination of which formal features participate in Agree relations in a given language, and how these formal features interact with movement diacritics (see also Gianollo, Guardiano & Longobardi 2008). The 'sequence' in which these features are acquired is guided by a small range of UG-specified elements, such as the availability of a distinction between interpretable and uninterpretable features, a movement diacritic (which, following Biberauer, Holmberg & Roberts 2014, I write '^'), and the operations Merge (both Internal and External) and Agree. These features must of course be extractable from the PLD. These ideas are developed in most detail, and supported by a range of case studies, in Biberauer (2015). In addition, two third-factor-imposed acquisition strategies play a central role. These are Feature Economy (FE) and Input Generalisation (IG), formulated as follows:

(2) Feature Economy (Roberts & Roussou 2003: 201):
     a. Given two structural representations R and R' for a substring of input text S, R is less marked than R' iff R contains fewer formal features than R'.
     b. Input Generalisation (Roberts 2007: 274):
        If a functional head F sets parameter P_j to value v_i then there is a preference for similar functional heads to set P_j to value v_i.

By FE, acquirers posit as few formal features as possible; by IG, they assume the minimum number of distinct elements/operations compatible with the PLD, maximally generalising patterns in the input. Together, FE and IG constitute a minimax search/optimisation strategy. Roberts (2012a) argues that the interaction of FE and IG with the PLD and underspecified UG gives rise to hierarchies of parameters.

   To give a simplified example of this approach, consider the parameters governing word-order variation across languages. In line with much current thinking in minimalist approaches, we take it that the narrow syntax only exploits hierarchical relations, with linear order being imposed at the PF

interface. Following Kayne (1994) and Chomsky (1995), we take it that the linearisation operation is fundamentally asymmetric, in that it maps asymmetric c-command relations (hierarchical relations created by Merge) onto linear order. For now, let us follow Kayne (1994, 2013) and assume that the linear order is head-complement order. But UG makes available the movement diacritic ^, which, if associated with a given head H, will cause the complement to move to – i.e. remerge in – the specifier of H (see again Biberauer, Holmberg and Roberts 2014 for details on this and a discussion of issues concerning antilocality). This gives rise to complement-head, i.e. head-final, order.

Head-initial order is the default, since it involves no movement diacritic, thereby respecting FE, and moreover the absence of that feature is generalised, following IG. In this way, harmonic head-initial order arises. Harmonic head-final order is the next most-preferred option, since, although FE is violated, IG still holds across the board. The PLD is what causes acquirers to abandon relative defaults and move to less highly valued options. If an acquirer encounters head-final orders, this triggers the postulation of generalised head-final order. If then a mix of head-final and head-initial orders is encountered, a still less highly valued system, for example one involving head-initial order in [+V] projections and head-final in [+N] projections, emerges. In this way a hierarchy of parameters emerges from the interaction of the three factors. (For more detailed discussion of this conception of acquisition, see Biberauer 2015 and Biberauer & Roberts 2015, 2017.)

However, behind all of this lies the question of why asymmetric c-command should be linearised by default as head-complement order. Kayne (1994, 2013) offers two different answers to this question. BHRS/BRS propose a third one. They suggest that UG does not specify the linear order to which a pair of terminals (*a*, *b*) such that *a* asymmetrically c-commands *b* is mapped. PF imposes the necessity for linear order, given the linear nature of the speech modality (Sign may be a different matter, but see BHRS/BRS for some discussion), and UG leaves the precedence versus subsequence option open. In other words, there is a (very deep) parameter determining whether (*a*, *b*) where *a* asymmetrically c-commands *b* is mapped onto *a*>*b* (precedence) or *b*>*a* (subsequence). However, the subsequence option is never chosen, since, given that movement (i.e. Internal Merge) always extends the tree and thereby creates a structure in which the moved element asymmetrically c-commands its copy, this option would generate gap>filler orders. It is known from the psycholinguistic literature (for a summary see Ackema & Neeleman 2002) that gap>filler orders are harder to process than filler>gap orders. Hence any grammar taking the putative subsequence option for this parameter would generate many difficult-to-process structures. Hence this option is not taken, and so the precedence/subsequence option is effectively a non-option, a no-choice

parameter: precedence is always the option taken. In this way, the default nature of head-complement orders follows.

To summarise BHRS/BRS's reasoning, let us see the role that each of the three factors plays in determining the nature of word-order variation. UG determines the nature of linearisation as in (3):

(3) *a* precedes/follows *b* iff *a* asymmetrically c-commands *b*, or *a* is dominated by a node *g* which asymmetrically c-commands *b*.

Here we see the 'precedes/follows' option directly (although recall that this is not actually specified anywhere; these are the only two options for linearisation, and so UG is really just unspecified for ordering, i.e. (3) could be more accurately formulated as '*a* is linearly ordered with respect to *b* iff ...'). The contribution of the PLD lies in the fact that filler>gap (i.e. movement) structures with moved elements consistently on the left are encountered (there are structures, such as remnant topicalisation in German, in which gap>filler orders are found, but they are quite rare in the PLD as compared to the canonical filler>gap orders). The third factors at work here have to do with ease of parsing, which can plausibly be related to non-domain-specific short-term memory limitations.

The interest of no-choice parameters is twofold. On the one hand, this idea allows us to simplify UG by treating certain putative universals as underspecified options, such as the mapping from asymmetric c-command to precedence in our example here. Second, by invoking third-factor considerations in 'forcing the choice', as it were, it gives us a new slant on the old debate between formal and functional approaches to typology and universals (on which see in particular Newmeyer 1998). As BHRS put it: 'The juxtaposition of formal and functional is misleading – commonalities and asymmetries across human languages are shaped by both formal constraints and functional pressures.'

The above discussion provides a simplified view of the nature of no-choice parameters, as BHRS/BRS have conceived them. Clearly, there are many aspects of linearisation, word-order variation, the relevant parameter hierarchy and the processing constraints that are not touched on here; see again BHRS/BRS for more details. But this suffices for present purposes. In §5 I will suggest a further case of a no-choice parameter, this time concerning φ-features in DP. Before that, however, it is necessary to introduce some relevant considerations concerning the nature of Agree.

3   Agree and Incorporation

In this section, I first recapitulate the analysis of object cliticisation in French from Roberts (2010a) and then give two important modifications. This will set the stage for the more general conceptual discussion of Agree.

Consider a simple example of object cliticisation in French (which in this respect could stand for the majority of Romance languages), as in (4):

(4) Jean la voit.
    John her(cl) sees
    'John sees her.'

According to Roberts (2010a), here v has unvalued φ-features, while the object clitic, first-merged as the complement of V, has valued variants of exactly the same features:

(5) v[Pers:--, Num:--, Gen:--] [$_{VP}$ V φ[Pers:3, Num:Sg, Gen:f]]

Here v is the Probe and the clitic the Goal in an Agree relation.[1] Roberts takes Agree (or more precisely its Match subcomponent) to involve copying of the clitic's feature values under the standard locality restrictions (the Probe asymmetrically c-commands the Goal and no distinct potential Goal intervenes between the Probe and the actual Goal, etc.). The result of the Agree operation is that the clitic looks like a copy of a subset of v's features, namely its φ-features. Hence at PF copy-deletion applies to the Goal, and the φ-features are realised on the Probe only. In this way, the effect of movement is derived directly from Agree.

A central idea in Roberts' account is that the effect of incorporation results just where the Goal's features are (properly) included in those of the Probe; in this way the copying of the feature values under Agree/Match gives rise to the appearance that the Goal is a copy of (part of) the Probe and as such can be deleted at PF by the usual copy-deletion operation. Accordingly, the notion of defective goal is defined:

(6) Defective goal: a goal G is defective in relation to a probe P iff G's formal features are properly included in those of its probe P.

Incorporation is possible if and only if the goal of the relevant Agree relation is defective as defined in (6), for the reasons given above.

Roberts assumed that clitics were undifferentiated φ-bundles. This was arguably problematic for two reasons. First, it implies that arguments can be either DP or φP, thereby complicating the statement of c-selection relations, etc.

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[1] On this account, the clitic appears to lack a Case feature. If that is correct, then there is no uninterpretable feature rendering it active in the sense of Chomsky (2001). We can assume either that goals, especially defective goals, do not have to be active, or that the clitic in fact does have a Case feature which is valued by v*'s Case feature. Following Roberts (2010a), we will take the former option here. See also Bejar and Rezac (2009, Note 35) for discussion and a list of apparent counterexamples to the activity condition. This has the consequence, pointed out by Boeckx and Gallego (2008), that clitics will never be 'frozen in place' by being probed. Instead, they can be probed repeatedly by distinct goals. This is in fact advantageous in accounting for clitic-climbing, as Roberts (2010a) shows.

(this point was made by Manzini 2012). Second, it leaves the clear connection between (third-person) clitics and definite articles in Romance unaccounted for, and, as a related point, makes it impossible to state a 'decompositional' analysis of Romance clitics of the kind suggested in Kayne (2000, Chapter 8) and Cardinaletti (2008). However, for the notion of defective goal as stated in (6) to work, it seemed essential that the clitic object could not have, for example, a D-position. If there were such a D-position, the clitic would no longer be a defective goal (since v in French by assumption has no D-feature) and cliticisation/incorporation, as described above, would be impossible.

It is, though, possible and arguably desirable to rethink this last point. Very much in the spirit of applying a feature-based version of relativised minimality to Agree (and to locality relations in general; see Starke 2001), as in Bejar and Rezac (2009) and elsewhere, we can relativise the notion of defectivity as follows:

(7) φ-defectivity: a goal G is φ-defective in relation to a probe P iff G's φ-features are properly included in those of its probe P.

It is natural to suppose that φ-defectivity is the relevant notion for φ-Agree, and so clitics are φ-defective Goals in relation to their φ-Probes. This allows us to assume that clitics do have a D-position, but that this position (or really the D-feature that defines it) doesn't interfere in the Agree relation between v and the clitic's φ-features, and hence does not affect the computation of defectivity. So we can assume a 'big DP' structure for clitics of the kind first proposed by Uriagereka (1988). Indeed, we take this to be the structure of non-clitic pronouns and DPs in general (I will say more about this structure in §4):[2]

(8) $[_{DP}$ D $[_{NumP}$ Num $[_{nP}$ Cl n (NP)]]]

Following a proposal in Cardinaletti and Starke (1999), I assume that in the case of weak pronouns and clitics NP is null, but, following Williams (1981), n assigns the external θ-role (Reference) to Cl. Here 'Cl' is just a cover term; it can be seen slightly more precisely as an undifferentiated φ-element (unlike Roberts 2010a, though, this is not a bundle of φ-features but really something more akin to a referential index, as in Bazalgette 2015; see also Safir 2014). More precisely, it has interpretable Person and Number features. Suppose that (definite) D has the uninterpretable counterparts (see also Longobardi 2008 and Richards 2008). Hence, Cl Agrees with and incorporates to D, creating a complex head which has valued Number and Person features. From D it is able to incorporate to v exactly as described above; since only φ-defectivity

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[2] As a reviewer points out, the structure in (8) corresponds to an unattested base order. I assume that, in nominals as in clauses, base order never surfaces as something is always required to move (see Alexiadou & Anagnostopoulou 2001 and Roberts 2017).

counts for (φ-driven) incorporation, the fact that the clitic DP has a D-feature is immaterial.[3]

So we arrive at in essence the same account of how objects cliticise to v in Romance languages as in Roberts (2010a), but with two important differences: (i) the clitic object – the element which is first-merged as sister to V – is no longer seen as a φ-bundle but rather, 'from the outside' as it were, looks just like any other DP; this overcomes the objections raised above to the earlier account; (ii) the condition on incorporation is relativised to φ-features. Both of these seem like advantages over the earlier account.

What appears to be lost on this account is the specific property of clitics that leads to cliticisation. In Roberts (2010a), this was precisely the defectivity of clitics in being 'pure' φ-elements: for example full DP objects in Romance or object pronouns in English could not incorporate to v because they possess a D-feature which v lacks (in these languages). The revised account just given no longer guarantees this. Instead, we seem to be predicting now that (φ-)incorporation will take place wherever there is (φ-)agreement. I will now suggest that this is in fact advantageous and can provide an account of why Agree exists at all.

In order to see this, let us look briefly at subject-verb agreement in a non-null-subject language, for example French (I choose French rather than English as French unambiguously has Person-agreement, while it is not clear that English has anything more than Number-agreement; see Kayne 2000, Chapter 10). It is fairly well known that French has a reasonably rich system of subject-agreement inflection, and it is standardly (although by no means universally – see Roberts 2010b) thought that (Standard, literary) French is a non-null-subject language. As is typical of Romance languages, subject agreement involves person and number features, but not gender. The configuration for subject-agreement in French is as in (9):

(9) T[Pers:--, Num:--] … [$_{vP}$ DP[Pers:3, Num:Pl] …]

By Agree/Match, the relevant feature values of D ('3' and 'Pl') are copied onto T, where they are realised as agreement morphology (in this case, the almost always PF-deleted /-t/ of the 3pl).[4] However, if we leave aside the question of morphological realisation, taking that to be separate in principle from

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[3] Since D has an uninterpretable Num feature, Num can also Agree/incorporate with it, as it is defective in relation to D. The definition of defectivity causes Cl to incorporate 'first', although we might, in the spirit of Chomsky (2008), see these operations as effectively simultaneous (especially if cyclicity is defined purely in relation to phase heads and D is a phase head). It is also worth pointing out that Roberts (2010a) argues that the Head Movement Constraint does not exist: the only constraints on incorporation are the non-intervention constraint on Agree and the Phase Impenetrability Condition.

[4] As has been known since Emonds (1978) and Pollock (1989), the inflected verb raises through v to T in French; following Roberts (2010a), I assume that v raises to T as it has unvalued T-features and T has an unvalued V-feature; here a different class of features is involved in

the mechanisms of the narrow syntax, and if we likewise allow for the possibility – which Nunes (2004) shows that we must – that copy-deletion does not always delete lower copies (i.e. it allows copied elements to have a PF-realisation in a non-chain-head position), then Agree/Match simply reduces to D-incorporation here too.[5]

This may appear at first sight to be a notational or terminological variant of the standard ideas about Agree. However, it has certain advantages. One important potential advantage is that DP-movement to SpecTP in languages like French, usually thought to be driven by an EPP-feature on T, can now be seen as a kind of pied-piping: D-incorporation in T 'pied-pipes' its DP which cannot adjoin to the T-head but instead forms a specifier (following Kayne 1994, we may want to see specifiers as adjuncts in any case). So the EPP reduces to pied-piping here.

It is known that languages vary in cases of potential pied-piping: some languages require it in a given case, others allow it, still others ban it. French (like English) clearly requires pied-piping under subject agreement. Many null-subject languages allow it, allowing also the non-pied-piping option (i.e. 'free inversion'). VSO languages of the Celtic type (see McCloskey 1996 on Irish; Roberts 2005 on Welsh) disallow it.[6]

This idea extends in a very natural way to wh-movement. Suppose, following Cheng (1991), that the basic configuration in wh-interrogatives is as in (10):

(10) C[wh:--] … D[wh:Y]

Here C has an unvalued wh-feature, while the wh-D has a valued one (where the question of the nature of the values of the wh-attribute is left aside). The wh-feature Agrees/incorporates with C. In languages where we see overt wh-movement, DP is pied-piped (and of course larger categories containing DP may or must be pied-piped depending on the language and the construction). Languages such as Mandarin and Japanese, which lack overt wh-movement, lack all pied-piping options here.[7] The null-operator movement proposed for Japanese by Watanabe (1992) can of course be seen as the incorporation operation itself. Of course there is much more to say about wh-movement and

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triggering Agree/Incorporation. See Biberauer and Roberts (2010) for more on how tense-features may be related to verb movement.

[5] This idea was put forward by Holmberg (2010).

[6] This does not imply that the subject doesn't move out of SpecvP in these languages; it clearly does, as both McCloskey and Roberts show for their respective languages. What is not allowed in these languages, however, is subject-raising to SpecTP. I have nothing to say here on where the subject moves to and why in these languages.

[7] On multiple wh-movement, see Bošković (2002), who argues that only one wh-phrase actually moves to SpecCP in the relevant languages. On partial wh-movement and wh-scope marking, see den Dikken (2009) and the references given there.

how it is parametrised, but this sketch indicates how the approach can work in general, and how straightforward the parallel with supposed 'EPP-driven' A-movement is.

Seeing Agree as a form of incorporation has the further advantage of giving us a way to see why Agree should exist at all. An uninterpretable formal feature [F:---] can be thought of as a free variable, in the exact sense that it lacks a value. The Attribute can be thought as 'typing' the variable, and so '[F:---]' should be read as 'variable *x* of type F'. In these terms, we can understand why unvalued features cannot be tolerated at the C-I interface. This becomes a case of the general ban on free variables, which we take to be due to the Bijection Principle, stated in (11):

(11) Bijection Principle (Koopman & Sportiche 1982; Chomsky 1986):
      There must exist a bijective relation between quantifiers and variables, i.e.
      a. Free variables are not allowed;
      b. Vacuous quantification is not allowed.

As Chomsky (1986:99) points out, the Bijection Principle does not have to hold of logical systems; it is perfectly possible to define the syntax of predicate calculus, for example, in such a way that expressions such as $\forall x[F(a)]$ or $F(x)$ are well-formed, and design the semantic rules such that the quantifier is ignored in the first case and introduced in the second. But it seems to be true that in natural language expressions where the wh-quantifier has no variable to bind, such as *Who did John see Bill?*, are ungrammatical. This ungrammaticality can be attributed to case (b) of the Bijection Principle: no vacuous quantification. Case (a) of the Bijection Principle motivates Agree, if unvalued features are free variables. Hence Probes seek out Goals in order to 'avoid' being interpreted as unbound variables at the C-I interface.

This leads to a substantive empirical claim: C-I does not allow unselective binding (which could otherwise always license a free variable). If unselective binding were allowed, our motivation for Agree would fail to hold. This conclusion has important implications for the analysis of arbitrary pronouns, which are sometimes thought of as free variables (e.g. in Chierchia's 1995 analysis of Italian impersonal *si*). However, it is possible, and indeed advantageous, to analyse arbitrary pronouns as always bound either by a Generic operator or by a temporal/modal operator. Showing this in detail would take us too far afield here, though, so I will leave this point aside.

To conclude this section, we treat Agree as incorporation motivated by the general ban on free variables. Moreover, I am assuming that the interpretable φ-features of D arise through successive incorporation through the structure of DP. Let us now look at the DP in more detail.

4   The Structure of DP

4.1   *Demonstratives as the External Argument of N*

In (8), I gave the structure for the DP as follows:

(8) $[_{DP}$ D $[_{NumP}$ Num $[_{nP}$ Cl n (NP) $]]]$

I suggested that Cl is the external argument of n. There is an obvious parallel with the standard structure of the CP, as can be seen by comparing (8) with (12):

(12) $[_{CP}$ C $[_{TP}$ T $[_{vP}$ DP $[$ v $[_{VP}$ V .. $]]]]]$

In Roberts (2017), following proposals by Giusti (1993), Brugè (1994, 1996, 2000, 2002:33–42), Brugè and Giusti (1996), Giusti (1997, 2002), Panagiotidis (2000), Rosen (2003), Shlonsky (2004), Grohmann and Panagiotidis (2005), and Guardiano (2010), I suggested that demonstratives are always first-merged in Spec,nP. In many languages, they raise to SpecDP (this could be seen as another case of pied-piping of φ-features, as sketched for clausal subjects in the previous section). As Roberts (2017) shows, there is a weak typological correlation between subject-raising in TP and demonstrative-raising in DP, in that many VSO languages lack both, i.e. they have low demonstratives (which violate Greenberg's Universal 20; see Cinque 2005 and Dryer 2008 for discussion). The Celtic languages are a case in point.

    Here Williams' (1981) proposal that the external argument of the nominal is its reference becomes relevant. Thus, using Williams' notation for underlining the external argument of a predicate, we have something like the following (I leave aside the question of whether there are unaccusative Nouns):

(13) a. *hit* (x, y), *run* (x), *fall* (x)
        b. *dog* (x), *father* (x, y)

The single argument of a non-relational Noun such as *dog* is its external argument, and this argument bears the Reference role of that Noun. In other words, the values of *x* in (13b) are referents of the Noun *dog*. Thus, in a predicative clause such as *Fido is a dog*, *Fido* can be seen as bearing this θ-role: the relevant part of the logical form is *dog(f)* (Williams 1994:34).

    In these terms, the above proposal regarding Dem can be stated as follows:

(14) Dem can be first-merged to the *x*-position in nP as Dem is able to be interpreted as a 'logically proper name'.

In other words, Dem is able to directly establish the reference of NP without the intermediary of a propositional function, i.e. some form of quantification, or what Russell (1905) called a 'description'.

In this connection, we can think that what can be the external argument of nP is inherently restricted by the nature of n (alternatively, we could think of this restriction as definitional of n, and of nominals more generally). Arguably the only other elements that can appear in Spec,nP are pronouns, or perhaps more precisely, bundles of interpretable φ-features, as described in §3, and variables (which may also be bundles of interpretable φ-features).[8] Fox (2002:67–8) proposes that variables arise at the semantic interface thanks to the operation of Trace Conversion, which applies to copies of A'-moved DPs, as follows:

(15) a. Variable Insertion: (Det) Pred → (Det) [Pred λy (y = x)]
     b. Determiner Replacement: (Det) [Pred λy (y = x)] → the (Det) [Pred λy (y = x)]

These conventions convert *Which boy Mary visited which boy* to *Which boy λx [Mary visited the boy x]*. These operations are designed by Fox in such a way as to apply to copies of A'-bound DPs, and he leaves open the question of how they may generalise to other types of copy. For quantifier-movement inside DPs, a simpler convention suffices, as follows:

(16) The chain (Q, Q), where Q is a strong quantifier, is interpreted as (Q, x), where x is a variable bound by Q.

The operation introduces a variable ranging over possible denotations of a predicate, which I take to be N; hence this defines the restriction of the quantifier: Qx_N.

Aside from demonstratives, arguably the only other elements that can appear in Spec,nP are pronouns and variables. The latter include copies of quantified elements, as just described. The interpretable features of these external arguments of n value those of D, which in turn value the clausal functional heads. So we see that the referential property of the external argument of n has the formal correlate of contributing a fully specified φ-set to the formal-feature system, and thus making the Probe-Goal Agree system work. Roberts (2017) investigates the consequences of this proposal for DPs which do not contain demonstratives. Here I will restrict attention to the analysis given there of definite and indefinite articles.

Regarding definite DPs, the central idea is that the definite article is a clitic Dem. Thus, from a structure like (17a), Art (to use a neutral term) cliticises to D by incorporation following precisely the mechanisms from Roberts (2010a)

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[8] Both pronouns and demonstratives can appear with an associated NP: *this man*, *we students* (see Höhn 2017 on the latter). These cases are semantically more complex than their simple counterparts, although it is unclear what the best account of their semantics would be.

described in the previous section, giving (17b) (see also Giusti 2001, Borer 2005:160f. and Corver & van Koppen 2010):

(17) a. [$_{DP}$ D$_{[uPers, uNum]}$ [$_{NumP}$ Num$_{[uNum]}$ [[$_{nP}$ Art$_{[iPers, iNum]}$ [n [$_{NP}$ N …]]]]]]
   b. [$_{DP}$ [$_{D}$ Art$_{[iPers, iNum]}$+Num +D] [$_{NumP}$ (Num) [$_{nP}$ (Art$_{[iPers, iNum]}$) [n … [$_{NP}$ N]]]]]]

Note that Art and the Cl-element described in §3 are identical in their feature make-up; this underscores the strong similarities between definite articles and pronouns which we observe in many languages both synchronically and dia-chronically (and is in line with the proposals in Safir 2014). In (17), Art incor-porates with D in virtue of being non-distinct in formal features. On the other hand, the demonstrative does not incorporate with D because it has a feature not shared with D, presumably related to deixis (see Alexiadou, Haegeman & Stavrou 2007:96f.); hence Dem is not a defective goal in relation to D while Art in (17) is.

   As shown in (17), I assume that D is first-merged with uninterpretable/ unvalued φ-features. Definite articles, indicated in (17) as Art, on the other hand, have a full set of interpretable φ-features, which gives rise to the 'uniqueness/ exhaustivity' interpretation associated with definiteness (see also Longobardi 2008 and Roberts 2010b on the connection between fully specified Person fea-tures and definite reference). Raising these features from Spec,nP to D endows D with interpretable features, making D in turn able to value the features of a clause-level category such as C/T or v. In this way, we see how the clausal Agree system depends on DP-internal relations which are intimately connected with the referential properties of DP. This idea is connected with the propos-als developed extensively in Longobardi (1994, 1996, 2010) to the effect that certain features of N or NP must raise to D in order for DP to be licensed as an argument. There is a parallel here with T's φ-set in a fully null-subject lan-guage, which has the same property and licenses a definite pronominal inter-pretation of the subject (see the papers in Biberauer, Holmberg, Roberts and Sheehan 2010). Lyons (1999:282f.) argues that person and definiteness should be conflated; see also the proposals in Biberauer *et al.* (2010) to the effect that a fully specified φ-set is equivalent to a D-feature.

   Enclitic definite articles most clearly illustrate the cliticisation of Art to D. In Romanian, for example, we find the following paradigm (from Longobardi 2010):

(18) a. lup-ul
       wolf-the
       'the wolf'
   b. batrân-ul   lup
       old-the   wolf
       'the old wolf'

   c. *lup   batrân-ul
      wolf old-the
   d. *batrân   lup-ul
      old   wolf-the

Here we see that the Noun or adnominal Adjective must raise to a position preceding the enclitic definite article *-ul*. We can account for this in terms of the general approach to second-position clausal enclitics in Roberts (2012b): there it is proposed that second-position effects arise where a clitic incorporates to a phase head bearing an Edge Feature (EF) of the kind discussed in Chomsky (2008). Incorporation, by its nature, cannot satisfy EF and so some further category must move to the phase edge. This category can be a head or an XP. As Longobardi (2010) points out, it is very difficult to tell whether N- and A-raising inside DP is head-movement or XP-movement. But we can account for the difference between the Romanian article, which is obligatorily enclitic, and its English or Italian counterpart, in terms of the presence vs absence of EF associated with D. The order in (18c) is ruled out if we assume that APs appear on the edge of the nP phase, since there is no way to derive a constituent containing N(P) and AP in that order, which would move to satisfy D's EF here.[9]

Art-Incorporation leaves a copy in Spec,nP which is interpreted as a variable at the semantic interface by (16). If we identify the full set of interpretable φ-features, with the associated interpretation of uniqueness and exhaustivity, with the iota-operator, then we can see how *the NP* is interpreted as ιx [NP(*x*)].[10]

A major advantage of this approach is that it naturally captures the common diachronic relation between demonstratives and definite Ds. In many languages, the definite article derives from an earlier demonstrative (e.g. all the Romance definite determiners derive from the Latin demonstratives *ille* and *ipse*; Modern English *the* derives from Old English *se*, *seo*, *þæt*, etc.; see Vincent 1997, Lyons 1999:331f., Giusti 2001, Roberts & Roussou 2003:131–6, Alexiadou, Haegeman & Stavrou 2007:96f.). On the view just sketched, definite articles simply lack one formal feature borne by the former (the deictic feature). It is often observed that feature-loss is a common diachronic process (see in particular Roberts &

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[9] The Scandinavian languages also have enclitic definite articles, but Longobardi (2010) shows that the N-D/A-D elements occupy lower positions in the DP in these languages than in Romanian. It appears, in fact, that the Art is a clitic in n in these languages, and binding of the variable in the external-argument position of n is effected purely by the Agree relation with D. The order in (18d) could perhaps involve nP movement, but then (16) would create an unbound variable in the fronted nP (assuming the order of operations Art-incorporation > (16) > nP-raising, the former two taking place in the n-phase, the latter in the D-phase). Alternatively, if *batrân lup* is a head-initial AP here, we have a Final-Over-Final Condition (FOFC) violation. See also the discussion of FOFC in Biberauer, Holmberg and Roberts (2014).

[10] The 'iota'-operator, introduced in Russell and Whitehead (1910–13), is the description operator. From the predicate F*x* it forms $\iota x[F(x)]$, denoting the unique thing that is F, if there is such a thing. For example, if F is the predicate *King of France*, $\iota x[F(x)]$ denotes the unique existing individual such that that individual is the King of France (i.e. no entity, in the actual world, hence the falsity of *The King of France is bald*).

Roussou 2003). The loss of the deictic feature on Art creates the conditions for incorporation of Art to D, since once this feature is lost, Art's formal features are a subset of those of D. Art thus becomes a D-clitic.

Turning now to indefinites, we take these to involve a D which lacks the Person features (see again Longobardi 2008 and Richards 2008 for the idea that Person is intrinsically connected to definiteness). If the Art first-merged in Spec,nP is identical to the one we find in definites, it therefore cannot incorporate into either D or Num, since it has a superset of their formal features. Therefore it can only be interpreted as a variable. In that case, the indefinite article can be regarded as an existential quantifier first-merged in Num, which binds this variable. The structure of an indefinite DP would thus be as follows (see Lyons 1999:286, 301):

(19) $[_{DP}\ D_{[u\varphi,\ EPP]}\ [_{NumP}\ [_{Num}\ a\ ]\ [_{nP}\ x\ [\ n\ [_{NP}\ N\ ..\ ]]]]]$

More generally, weak quantifiers may be merged in Num and bind a variable in Spec,nP (and, again, cliticise to D in English-style languages):

(20) $[_{DP}\ D\ [_{NumP}\ [_{Num}\ some\ ]\ [_{nP}\ Art/x\ [\ n\ [_{NP}\ N\ ..\ ]]]]]$

Strong quantifiers, on the other hand, raise from Spec,nP to SpecDP leaving a copy interpreted as a variable by (16) (see Borer 2005:140f. for a very similar proposal):

(21) $[_{DP}\ every\ D_{[u\varphi]}\ [_{NumP}\ Num\ [_{nP}\ \text{every} = x\ [\ n\ [_{NP}\ N\ ..\ ]]]]]$

This can be seen as a further case of 'EPP-driven' movement, i.e. pied-piping of a larger category to the SpecDP position associated with abstract incorporation of *every*'s φ-features to D. Strong quantifiers presumably contain further formal features in addition to φ-features which prevent their direct incorporation into D. See Roberts (2017) for an extension of this general approach to the 'Definiteness Effect', generalised quantifiers and proper names.

This approach implies that indefinite D lacks a Person specification. How, then, can it act as a Goal for uninterpretable Person features at the clausal level? If we treat indefinite D as a defective phase, then Art in Spec,nP will be accessible to DP-external material with no violation of Phase Impenetrability; since Art has an [iPers] feature, it will value the [Pers] feature of a DP-external Probe. Support for the idea that indefinite DPs are defective phases comes from long-standing observations (going back to Ross 1967) that indefinites are easier to extract from than definites, and indeed may offer a phase-based account of Fiengo and Higginbotham's (1981) Extended Name Constraint.

5   φ-features as a No-choice Option

The analysis of Agree/incorporation and the proposals for the internal structure of DP given above have the very interesting result that the general ability of

DPs to license functional elements thanks to their interpretable φ-features can be traced back to the ways in which DPs refer. This provides an important conceptual justification for Agree theory. We have also seen that the Agree relation itself may derive from the Bijection Principle.

Let us assume that there is no specification at all for φ-features in UG. Following Biberauer (2015) in particular, we assume that the only aspect of Agree which is given by UG is the relation between interpretable and uninterpretable features (which in turn may follow from Bijection, as outlined in §3). Φ-features are thus optional as far as UG is concerned. In other words, the presence of DP-internal φ-features is potentially a parametric option.

However, this is a further no-choice parameter, of the kind discussed in §2 and in BHRS/BRS. If the φ-feature option is not taken, the consequence will be that nominals cannot be descriptions in the Russellian sense, since it is only through the presence of φ-features that the DP-internal variable-binding operations needed for both definite descriptions and typical cases of quantification come about, as we saw in §4. Without φ-features, nominals can only function as logically proper names, again in the Russellian sense, since the only elements able to bear n's R-role, i.e. to act as the external argument of n, are simple referential pronouns and simple demonstratives (i.e. those without an accompanying NP).

If natural language is limited to logically proper names, its semantic expressive power is greatly limited: Nouns would only be able to appear as predicates (as in *This thing is a dog*), or as modified by a demonstrative. However, UG, as a purely formal system, is entirely indifferent to any aspect of the interpretation of the syntactic objects it generates, including their semantic expressive power. Therefore, UG allows the 'no-ϕ-feature' option. But this is clearly a no-choice option in the sense that taking this option would entail restricting the expressive power of the Conceptual-Intentional interface dramatically. To put things rather simplistically, if a system has no φ-features its DPs are unable to express descriptions in the classical Russellian sense. Therefore, there isn't much to talk about. But UG is, as it were, not concerned with what we talk about; it is a purely formal system. Hence, for a reason entirely extraneous to the internal functioning of UG and the range of formal options it makes available, no actual system takes the no-φ-feature option. Therefore all languages have φ-features, even though in principle this is optional at the UG level (of course, languages vary greatly in which sets of φ-features they have, and where and how they may instantiate them, but these questions are distinct from the more general one of the presence or absence of φ-features). It appears, then, that the universality of φ-features derives from functional-communicative needs as is often claimed of various universals in the functional/typological literature. However, we have arrived at this conclusion in a rather different way, and on the basis of rather different assumptions, from those typically adopted in that literature.

If we adopt the view that syntactic (and perhaps other) variation is to be described in terms of a series of distinct but interrelated emergent parameter hierarchies, as argued in Roberts (2012a), Biberauer and Roberts (2015, 2017) and elsewhere, then the above argument has an important consequence. If there is a parameter hierarchy which deals with the distribution and inventory of φ-features in grammatical systems, as seems very plausible (see again Roberts 2012a and BHRS), then arguably the first choice in that hierarchy would be 'are ϕ-features present in the system?' As we have just seen, the 'no' option here is in practice unavailable, but this does not alter the idea that it exists in principle. More concretely, the hierarchy most closely associated with the inventory and distribution of φ-features is that informally referred to in the references above as the 'null-argument hierarchy' (this may not in fact be a fully accurate characterisation of the aspects of grammatical systems this hierarchy regulates). According to the argument just given, that hierarchy, in its highest reaches, should look as follows:

(22)

a. Are uφ-features present?

    No   Yes
Non-option   b. Are uφ-features present on probes?

        No   Yes
    Radical pro-drop   c. Are uφ-features present on all probes?

         Yes   No
  Pronominal arguments   d. Are uφ-features fully specified on some probes?

         No   Yes
    Non-pro drop   e. Are uφ-features fully specified on T?

         Yes   No
  Consistent null subject   …
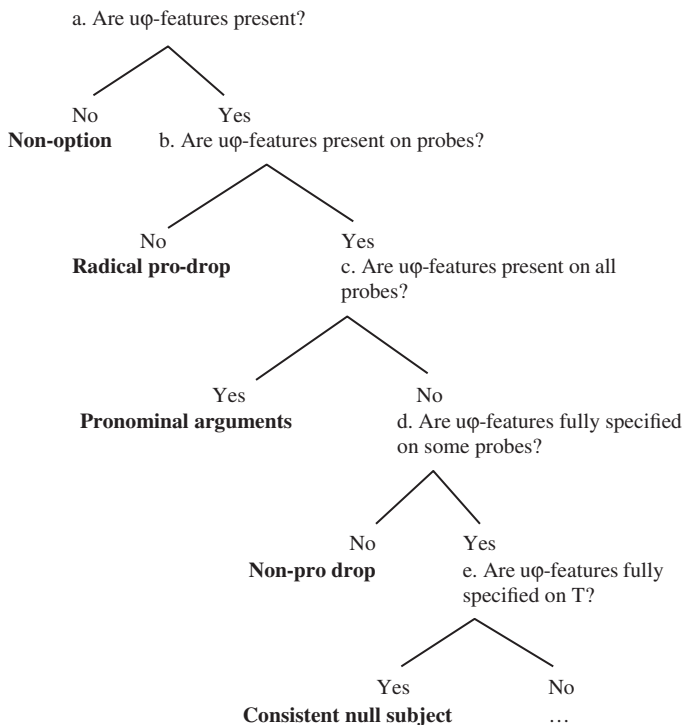
On this view, the first choice in this hierarchy is a no-choice macro-parameter. Once the (non-)choice is made, the first macro-option has to do with radical pro-drop systems of the East Asian type. The details of the rest of the hierarchy, as it is given here, are presented in the references given.[11]

6   Conclusion

In this chapter I began by describing the notion of 'no-choice parameter' as it has been developed in recent collaborative work (BHRS; BRS). I then developed a general proposal concerning the nature of Agree, which involves two principal ideas: that Agree always involves incorporation in the sense of Roberts (2010a) and that many cases of variable binding arise through Agree. In §4 I introduced the proposal for the structure of DPs put forward in Roberts (2017), which is close to a number of proposals in the current literature (see the references given there). Finally, I argued that the presence of φ-features represents a further no-choice parameter and briefly considered some consequences of that idea.

Since parameters are standardly seen as choice points, it might seem idle to posit parameters which instantiate non-choices. However, there is a significant conceptual advantage in that this move allows us to simplify our conception of UG. If φ-features are part of the innate endowment, they represent a highly domain-specific property. If UG is simply underspecified with respect to φ-features, then their presence or absence follows from this impoverishment; more precisely, their universality follows some other, possibly functional/communicative, aspect of language.

As a final point, it is worth considering that we may be able to deepen our conception of 'functional/communicative aspects of language'. It is a plausible speculation that language-independent cognitive abilities, our capacity to compute sets and functions, give us the ability to cognitively apprehend propositional functions, quantifiers and the like, and therefore to cognise definite descriptions (in the sense of Chomsky 1975). In that case, the no-choice option may not have directly to do with 'external' notions such as the function of language in communication, but rather with internal cognitive interfaces. The presence of φ-features makes possible the integration of our 'set-theoretic' cognitive competence with the language faculty. This takes us a very significant

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[11] One question that arises from this is the status of semantic parameters such as Chierchia's (1998) nominal mapping parameter. It is not possible to go into this matter in full detail here, but it is doubtful that semantic parameters of this kind exist; BHRS and BRS adopt the general idea that parameters are to be stated in terms of the formal features of functional heads (the 'Borer–Chomsky conjecture'). In these terms, the effects of the nominal mapping parameter can probably be captured in terms of parameters involving the Person feature, along the general lines of Longobardi (2008).

step in the direction of the externalisation, i.e. the expression in communicative and other forms of linguistic behaviour, of descriptions (in the sense of Berwick & Chomsky 2011).

A very natural question to raise at this point is that of the connection between setting the no-choice φ-feature parameter to the positive value and the morphophonological realisation of φ-features in pronominal and agreement systems. Once again, if we take seriously the idea that UG, more specifically narrow syntax, is a blind, formal system, there is no reason to expect any systematic mapping between the presence of φ-features in narrow syntax and their realisation at the articulatory-perceptual interface. But of course cross-linguistic work has revealed that there are connections, although on close scrutiny they are somewhat inconsistent in nature. Radical pro-drop languages tend to lack agreement inflections, pronominal-argument languages tend to show very 'rich' agreement marking for subjects, direct objects and indirect objects, as well as DP-internal marking of possessors, etc., while consistent null-subject languages tend to show 'rich' verb-subject agreement only. I will not speculate here on what underlies these tendencies but merely observe two things: first, these are indeed only tendencies; second, if UG does not require φ-features it is highly unlikely that it contains some internal specification for the morphophonological realisation of φ-features. Whatever these generalisations are, then, they too must either be attributable in full to the second or third factor (or their interaction), or be a further case of emergence.

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Part II

Interfaces

7   Linearizing Chains at LF

Jairo Nunes

1   Introduction

Reconstruction effects clearly show that PF and LF may differ regarding the chain links they select for interpretation.[1] The truism of this observation has led researchers to (tacitly) assume that the mechanisms that convert chains into their PF and LF outputs are themselves different. In this chapter I explore a different possibility. I propose that although one may have different PF and LF outputs for a given chain, both are ultimately derived by a single linearization procedure that triggers applications of deletion within chains. I will show that differences between chain outputs at PF and LF are determined by distinct convergence requirements imposed by the interfaces, whereas their similarities (e.g. their general format) follow from economy considerations.

Before we proceed to the discussion proper, some remarks are in order. The standard assumption in the field is that linear order is relevant for PF, but not for LF. However, this seems to me to be an unwarranted extrapolation of the assumption that the A-P system is sensitive to precedence relations, but C-I is not. Precedence is just one of the infinite relations that share linear order properties (transitivity, asymmetry, irreflexivity, and totality). Thus, it is perfectly conceivable that C-I does not operate with precedence but operates with some other type of linear order. In Kayne's (1994) influential work, for example, the LCA applies to all syntactic representations, including LF (see his section 5.2). Again, this does not entail that the LF interfaces are sensitive to precedence. All it means is that LF is structurally organized in such a way that it can be mapped into a linear order. Thus, the question is whether C-I requires a linearly

ordered object, and if the answer is affirmative, the next question is what kind of linear order relation C-I operates with (keeping the standard assumption that it is not precedence).

In this chapter I argue that the answer to the first question is affirmative, while remaining uncommitted regarding the specific type of linear order relation C-I is sensitive to.[2] The argument is essentially based on Nunes's (1995, 1999, 2004, 2011) proposal regarding the linearization of chains at PF and Chomsky's (1993) analysis of reconstruction at LF. For Nunes, nondistinct copies induce violations of the asymmetry and irreflexivity conditions on linear order, preventing structures containing nontrivial chains from being linearized at PF; these problems can, however, be remedied through deletion within chains. In Chomsky's proposal, in turn, reconstruction effects or lack thereof arise as a byproduct of applications of deletion within chains at LF. From an abstract point of view, the PF and LF outputs resulting from deleting material within chains turn out to be too similar for it to be an accident. Based on this similarity, I explore the hypothesis that deletion within chains at LF is also triggered by linearization in the sense that it obliterates the violations of the asymmetry and irreflexivity conditions on linear order induced by the "repeated" material within different chain links.

The chapter is organized as follows. In sections 2 and 3, I review Nunes's (2011) linearization approach to deletion within chains on the PF side and Chomsky's (1993) approach on the LF side. In section 4, I then argue that Nunes's approach can be extended to LF by showing that reconstruction effects (or lack thereof) may follow from optimal applications of deletion within chains, triggered by linearization.

2   Deletion within Chains at PF and Linearization

Nunes's (1995, 1999, 2004) linearization approach to phonetic realization of chains combines convergence requirements and economy considerations. In his Agree-based implementation (Nunes 2011), the system works in the following manner. Take the abstract structure K in (1), where the syntactic object α with an unvalued feature $F{:}u$ has been copied and merged in a higher position, valuing F and forming the chain CH = (α, α).

(1)   K = $[[_\alpha \, \beta \, \gamma]_{F:\surd} \, ... \, [X \, ... \, [_\alpha \, \beta \, \gamma]_{F:u} \, ...]]$

The idea is that when K is transferred to the phonological component, it cannot be linearized in accordance with Kayne's (1994) LCA as is, because the two copies of α induce problems of symmetry and reflexivity. If copies

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[2] See Hornstein (2001:85) for a suggestion that the relevant notion of linear order for LF is scope (hence his Scope Correspondence Axiom).

count as nondistinct in virtue of being associated with the same material of the numeration (see Chomsky 1995:227),[3] X in (1) is required to precede and be preceded by α, for it asymmetrically c-commands and is asymmetrically c-commanded by (a copy of) α. Similarly, α is required to precede itself, for its higher copy asymmetrically c-commands the lower one. In order to circumvent these contradictory requirements, the phonological component resorts to Chain Reduction, as described in (2).

(2) *Chain Reduction* (Nunes 1995:279)
      Delete the minimal number of constituents of a nontrivial chain CH that
      suffices for CH to be mapped into a linear order in accordance with the
      LCA.

(2) does not instruct deletion to target particular links. The choice of the terms to be deleted is determined by optimal interactions of convergence requirements and economy considerations. For instance, if the two copies of α in (1) are deleted, the linearization problems disappear. However, this is not an optimal solution: it arguably violates recoverability and employs two applications of deletion (each targeting a different copy), whereas a single application targeting one of the copies suffices. Similarly, simple deletion of the upper link circumvents the linearization problems but does not lead to a convergent result at PF, for the surviving lower link does not have its F-feature valued. All of these convergence and economy computations conspire to yield the result that, all things being equal, the optimal chain output at PF is the one in which the chain head is pronounced.

Although this is the most common situation, it is not the only one (see e.g. the collection of papers in Corver and Nunes 2007 and references therein). One may also find cases where a lower copy is pronounced (cf. (3)), cases where different parts of different links are pronounced (cf. (4)), and even cases where more than one link is fully pronounced (cf. (5)):

(3) a. *Romanian* (Bošković 2002):
         Ce   precede   **ce**?
         what precedes   what
         'What precedes what?'
     b. *Chain output at PF* (Bošković 2002):
         [ce$_{SU}$ ~~ce~~$_{OB}$ precede **ce**$_{OB}$]

(4) a. *Bulgarian* (Rudin, Kramer, Billings, and Baerman 1999):
         Dal   li   **si**   **mu**   **(gi)**   parite?
         given   Q   are   him-DAT   them   the-money
         'Have you given him the money?'

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[3] See Martin and Uriagereka (2014) for relevant discussion.

b. *Chain output at PF* (Bošković 2001):
[[s̶i̶-̶m̶u̶-̶g̶i̶-**dal]-**li … **[si-mu-gi-**d̶a̶l̶] …]

(5) a. *German* (McDaniel 1986):
Wen   glaubt   Hans   **wen**   Jakob   gesehen   hat?
whom   thinks   Hans   *whom*   Jakob   seen   has
'Who does Hans think Jakob saw?'

b. *Chain output at PF* (Nunes 2004):
[$_{CP}$ **wen** glaubt Hans [$_{CP}$ #[$_{C^0}$**wen**-C^0]# Jakob w̶e̶n̶ gesehen hat]]

The noncanonical patterns illustrated in (3)–(5) precisely involve cases where things are not equal. Take (3a), for example, which appears to involve *wh-in situ* in a multiple *wh*-fronting language such as Romanian. Bošković (2002) shows that this exceptional pattern arises when both subject and object *wh*-elements are identical and argues that pronunciation of the lower link of the object *wh*-chain circumvents this identity avoidance restriction (see (3b)). As for the Bulgarian pattern in (4a), Bošković (2001) argues that, in the syntactic component, the complex head involving the verb and the clitics (*[si-mu-gi-dal]*) moves and left-adjoins to the interrogative particle *li*, leaving a copy behind. Deletion of the lower copy yields a grammatical output in Macedonian but not in Bulgarian, because in the former, the clitics are proclitic and *li* is enclitic, but in the latter, these elements are all enclitic. A convergent reduction of the complex head chain in Bulgarian must therefore delete the copies of the clitics in the higher link and the copy of the verb in the lower link (see (4b)). Finally, Nunes (2004) argues that in languages that allow *wh*-copying, an intermediate *wh*-copy can be fused with a declarative C^0 in the morphological component (see (5b)). The fused copy then becomes invisible to (syntactic) linearization and ends up occupying a slot in the PF output in virtue of being an integral part of the linearized C^0 head.

Independent convergence requirements of the phonological component can therefore alter the set of optimal chain outputs at PF and trigger more (cf. (4b)) or less (cf. (5b)) applications of deletion than one usually finds. There is still a question pending, though. Recall that pronunciation of the head of the chain in (1) instead of the lower copy was taken to follow from convergence requirements, as the latter does not have its F-feature valued. What then happens in cases such as (3b) and (4b) where a lower link or its parts are phonetically realized? Nunes (2011) argues that, again, economy is at play. He proposes that after the higher link of (1) has its F-feature valued, it could probe the structure and value the corresponding F-feature of its next lower copy in a cascade fashion, and at the end of the day all chain links could have all of its features appropriately valued. From the point of view of PF, this convergent result is not optimal, though. (Why should the system bother to fix objects that will not appear at PF?) Nunes's proposal is that such costly additional probing and

valuation are licensed only when forced by convergence requirements at PF. That is, if pronunciation of the chain head violates a convergence requirement at PF, probing and valuation of the next copy is sanctioned; otherwise, no extra probing or valuation take place.[4]

To sum up, phonetic realization of anything other than the chain head is in principle not an economical solution, but it may be licensed in case independent convergence requirements of the phonological component so demand.

3   LF Deletion within Chains in Chomsky (1993)

Chomsky (1993) resorts to constrained applications of deletion within chains at LF to account for contrasts such as the one between (6a), where reconstruction is obligatory, and (6b), where reconstruction is optional.

(6) a. Which picture of John$_i$ did he$_{k/*i}$ see?
    b. John$_i$ wondered which picture of himself$_{i/k}$ Bill$_k$ saw.

Chomsky (pp. 35–36) proposes that a phrase like *[$_{wh-}$ which picture of John]* should be converted into *[[which picture of John] [$_{wh-}$ t]]* or *[[which] [$_{wh-}$ t picture of John]]* "by an operation akin to QR," coupled with the requirement that "in the operator position [Spec,CP], everything but the operator phrase must delete" and "[i]n the trace position, the copy of what remains in the operator position deletes, leaving just the phrase *wh-*." Applied to (6a), this algorithm yields one of the outputs in (7).

(7) a. **[[which picture of John]** [$_{wh-}$ ~~t~~]] did he see **[[~~which picture of John~~** [$_{wh-}$ *t*]]
    b. **[[which]** [$_{wh-}$ ~~t picture of John~~]] did he see **[[~~which~~]** [$_{wh-}$ *t* picture of John]]

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[4] A reviewer points out that this proposal seems to resort to look-ahead computations. The point is well taken and seems related to a more general point concerning the spell-out of material containing chains. For A-movement and head movement, the problem appears to be more tractable as the relevant copies are distributed within a single phase span. For A'-movement, things get more complicated thanks to the possibility of successive cyclic movement across phases. Take the (simplified) derivation of the sentence in (ia) sketched in (ib), for instance.

(i) a. Which book did John say that Mary bought?
    b. [$_{CP}$ **[which book]**$_{F:\surd}$ did-Q John [$_{vP}$ [which book]$_{F:u}$ say-v [$_{CP}$ **[which book]**$_{F:u}$ that Mary [$_{vP}$ **[which book]**$_{F:u}$ bought-v **[which book]**$_{F:u}$]]]]

Arguably, the *wh*-phrase is merged in (ib) with an unvalued feature, which gets valued later on, after the *wh*-phrase reaches the matrix [Spec,CP]. Let us consider the lowest phase. If Transfer applies to the complement of the phase head, the derivation should in principle crash, due to the unvalued feature of the *wh*-phrase. Similar considerations apply to the next two higher phases. This unwanted result seems to suggest that when chains are involved, either Transfer is delayed or it is employed, but lower copies are held in a buffer until the head of the chain is computed. It is likely that whatever is the solution for the problem posed by (ib) can also be extended to account for the look-ahead problem noted by the reviewer.

If both outputs were to feed C-I, (7a) should incorrectly allow co-reference between *he* and *John*. In order to prevent this unwanted result, Chomsky (p. 41) adds a preference principle that chooses the option illustrated in (7b) over the one in (7a) whenever possible. Thus, this preference principle enforces the option in (7b) for (6a), yielding a Principle C effect.

As for the different behavior of anaphors illustrated in (6b), Chomsky (p. 40) assumes that at LF "the anaphor or part of it raises by an operation similar to cliticization." That being so, the two readings in (6b) result from cliticization applying to the lower or the upper copy of the anaphor, as respectively shown in (8a) and (9a), which are then converted into (8b) and (9b).

(8) a. John wondered [which picture of himself] Bill **self-**saw [which picture of him**self**]

   b. John wondered **[[which]** [$_{wh-}$ ~~*t* picture of himself~~]] Bill self-saw **[[which]** [$_{wh-}$ *t* **picture of himself**]]

(9) a. John **self-**wondered [which picture of him**self**] Bill saw [which picture of himself]

   b. John self-wondered **[[which picture of himself]** [$_{wh-}$ ~~*t*~~]] Bill saw **[[which ~~picture of himself~~]** [$_{wh-}$ *t*]]

Crucially, the preference principle is taken to be inapplicable in (9a), for deletion of *picture of himself* in the upper *wh*-copy "would break the chain (*self*, t_{self}), leaving the reflexive element without a θ-role at LF" (p. 41).

Although Chomsky's system has some appeal and covers a broad range of data, there are some conceptual and empirical problems that call for a reanalysis of his selective chain deletion approach. The QR-like operation that creates the structures to which deletion applies, for instance, appears to rely on self-adjunction, which is arguably at odds with Last Resort, and employs both copies and traces. Crucially, this use of traces is not just a shorthand for copies, for they are to be interpreted as variables in the relevant logical forms. However, the resort to both copies and traces ends up undermining part of the rationale for assuming copies instead of traces within minimalism.

The preference principle also raises some questions of its own. It is formulated as an economy principle, choosing among convergent derivations. The problem is that there is no clear reason why the option illustrated in (7b) should be more economical than the one in (7a). At face value, the two options seem to have the same derivational cost, as they both employ two applications of deletion. Further questions arise in cases like (10), where the *wh*-chain has more than two copies (see Thoms 2010 for relevant discussion).

(10) a. Which picture of John$_i$ did Mary say he$_{k/i}$ saw?

   b. [[**which picture of John]** did Mary say [[**which picture of John]** he saw **[which picture of John]**]]]

If the *wh*-copies of (10b) undergo raising and deletion along the lines of (7b) in consonance with the preference principle, we incorrectly predict a Principle C effect for (10a).

As Chomsky restricts the QR-like operation and the applications of deletion illustrated in (7) to A'-relations, there remains the issue of how copies in A-chains are to be interpreted. The fact that *pictures* in (11a) below, for instance, can be interpreted as being part of the idiom *take pictures* indicates that the lower copy in object position is accessed for interpretation. In turn, the lack of a Principle C effect in (11b) indicates that lower copies of *that picture of John* in the embedded clause cannot be interpreted. Discussing these sorts of facts, Chomsky suggests (p. 42) that, in the case of A-chains, the (lowest) trace of an A-chain is computed for purposes of θ-marking and idiom interpretation, whereas the head of the chain is interpreted for scope "and other matters."

(11) a. Several pictures were taken.
      a'. **[several pictures]** were taken **[several pictures]**
      b. That picture of John$_i$ seems to him$_{k/i}$ to be embarrassing.
      b'. **[that picture of John]** seems to him [that picture of John] to be embarrassing

This suggestion does describe the facts, but if we focus just on the lower copies, the picture gets a bit awkward. In order to account for the lack of Principle C in (11b), the tacit assumption is that the lexical content of the lower copy in (11b') is ignored/deleted. If this is to hold generally, the idiom interpretation in (11a) should then not be based on the content of the lower link of the A-chain in (11a'), which should be deleted as in (11b'), but rather on its position as sister of *taken*. However, to assume that a syntactic position may be interpreted if its lexical content is ignored/deleted does not accord well with bare phrase structure.

In addition, A-movement may sometimes allow reconstruction. Two well-known cases involve indefinites and bound pronouns, as illustrated in (12) below. In the most natural reading of (12a), the indefinite is interpreted under the scope of *likely* and in (12b) the matrix subject must be interpreted in an intermediate position lower than the quantifier (allowing the pronoun to be bound), but not lower than *her* (bleeding Principle C).

(12) a. Someone is likely to win the lottery.
      b. [His$_i$ mother]$_k$'s bread seems to [every man]$_i$ to be known by her$_k$ to be the best there is. (Lebeaux 1991)

In the next section, I show how the relevant applications of deletion within A- and A'-chains of the type discussed by Chomsky can be better understood if they are analyzed as being triggered by linearization, some plausible convergence requirements of C-I, and economy considerations.

4   Deletion within Chains at LF as Linearization

4.1   *General Proposal*

In sections 2 and 3 we saw several similarities in the way PF and LF assign interpretation to nontrivial chains. In particular, the most common situation is the one in which "repeated" material within a chain does not receive an interpretation, which suggests that such material is deleted before it reaches the interfaces. Extending Nunes's (1995, 1999, 2004, 2011) linearization approach regarding chain outputs at PF, I would like to propose that the type of deletion within chain links at LF proposed by Chomsky (1993) is also motivated by linearization considerations. More specifically, I propose that the C-I interface can only operate with syntactic objects that can be mapped into a linear order (not necessarily precedence; see section 1). In particular, a nontrivial chain induces linearization problems analogous to the ones we witnessed on the PF side and must undergo Chain Reduction in order for the relevant syntactic structure to be readable by C-I. I argue below that the different types of chain outputs at LF also follow from optimal applications of Chain Reduction, taking into consideration convergence at C-I and economy considerations.

4.2   *Analysis*

4.2.1   *Interpreting the Head of the Chain or a Lower Copy*

Let us start with the (simplified) structures in (13) (cf. (11b') and (6a)), which have been formed in the overt component after the boldfaced constituents moved in order to have an uninterpretable feature valued (and deleted for LF purposes).[5]

(13) a. **[[that picture of John]**$_{F:\sqrt{}}$ seems to him **[[that picture of John]**$_{F:u}$ to be embarrassing]]

  b. **[[which picture of John]**$_{F:\sqrt{}}$ did-Q he see **[which picture of John]**$_{F:u}$]

  As proposed above, the two copies in both (13a) and (13b) prevent the structure from being linearized and their chains must undergo Chain Reduction. In each case, deletion of either of the copies allows the structure to be linearized. However, there is a crucial difference between the two copies in each structure: the higher copy has its F-feature valued, but not the lower one. In more general terms: copies rather than occurrences constitute the relevant notion for movement, and once a copy is created, it has a derivational life of its own. Hence, a derivation involving deletion of the upper link can only converge if, prior to deletion, the upper copy probes and values the F-feature of the lower copy (see section 2). In turn, deletion of the lower link does not require this additional

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[5] For expository purposes, I ignore copies at the edge of vP. For relevant discussion that is compatible with the approach to be defended here, see especially Thoms (2010).

operation of probing and valuation. Thus, like what we saw on the PF side, deletion of the lower link is more economical than deletion of the higher link if everything else remains constant. Hence, the lack of a Principle C effect in (11b) results from an optimal application of Chain Reduction to (13a), as sketched in (14).

(14) [[**that picture of John**]$_{F:\surd}$ seems to him [[~~that picture of John~~]$_{F:u}$ to be embarrassing]]

That being so, one wonders what prevents this reasoning from applying to (13b), thereby incorrectly bleeding Principle C. It is worth observing in this regard that Chomsky (1995:291) adds unselective binding to the two interpretive mechanisms exemplified in (7) in order to account for *wh-in situ*. Suppose we then simplify the system by dropping the mechanisms illustrated in (7) and adopt unselective binding as the only convergent option, as stated in (15).

(15) Generalized Q-Binding Condition (GQBC)
      If the lexical item LI has a *wh*-feature, LI must be within the scope of an interrogative complementizer Q at LF.

(15) basically says that Q is the element that marks scope and *wh*-elements are to be unselectively bound by Q. Applying to (13b), the GQBC prevents Chain Reduction from deleting the lower copy of the *wh*-phrase, for the surviving copy would not be in the scope of Q. In a convergent derivation, the higher copy must therefore probe and value the F-feature of the lower copy in the covert component, as represented in (16a) below, before the *wh*-chain undergoes Chain Reduction. Applying to (16a), Chain Reduction then yields the (simplified) structure in (16b), which is in consonance with the GQBC, correctly yielding a Principle C effect.

(16) a. [[**which picture of John**]$_{F:\surd}$ did-Q he see [**which picture of John**]$_{F:\surd}$]
      b. [[~~which picture of John~~]$_{F:\surd}$ did-Q he see [**which picture of John**]$_{F:\surd}$]

Let us now consider the lack of Principle C in cases with more than one copy like (10), whose updated (simplified) representation is given in (17).

(17) [[**which picture of John**]$_{F:\surd}$ did-Q Mary say [[**which picture of John**]$_{F:u}$ he saw [**which picture of John**]$_{F:u}$]]

In order for (17) to be properly linearized to be shipped to C-I, the *wh*-chain must undergo Chain Reduction. Deletion of any two copies suffices for linearization purposes. However, the derivation can only converge if the surviving copy has all of its features valued and is bound by Q, in accordance with the GQBC. Applying to (17) as is, no output of Chain Reduction can meet these two requirements. In this scenario, the higher copy is then allowed to probe and value the F-feature of the next lower copy, as illustrated in (18a) below.

Applying to (18a), Chain Reduction can then delete the highest and the lowest copy, yielding the convergent output in (18b), which does not induce a Principle C effect, as desired.[6]

(18) a. **[[which picture of John]**$_{F:\sqrt{}}$ **did-Q Mary say [[which picture of John]**$_{F:\sqrt{}}$ he saw **[which picture of John]**$_{F:u}$**]]**

b. ~~[[which picture of John]~~$_{F:\sqrt{}}$ ~~did-Q~~ Mary say **[[which picture of John]**$_{F:\sqrt{}}$ he saw ~~[which picture of John]~~$_{F:u}$**]]**

Notice that after the intermediate copy in (18a) had its F-feature valued, it could probe the lowest copy and value the F-feature of the latter, in which case Chain Reduction could also yield a convergent result deleting the two higher copies (and enforcing a Principle C effect). This additional probing and valuation is blocked by economy considerations, though. If the derivation can converge with a single additional probing by a copy with valued features, further valuations in a cascade fashion are preempted.

Like what one finds on the PF side, the optimal output of an application of Chain Reduction at LF is, in principle, the one in which the head of the chain is interpreted, for its features have all been valued. However, if accessing this link does not meet independent convergence requirements of C-I, the computational system is forced to value the unvalued features of the next lower link (in a cascade fashion) so that it can satisfy the relevant convergence requirements if it survives Chain Reduction.

Note that this approach only tangentially relies on A/A' properties, thus being also compatible with cases of reconstruction in A-chains. Take the sentence in (12a), for example, whose updated (simplified) structure is provided in (19).

(19) **[someone**$_{F:\sqrt{}}$ is likely **[someone**$_{F:u}$ to win the lottery]]

The pragmatically odd reading where *someone* scopes over *likely* can be obtained via deletion of the lower copy of *someone*. More relevant to our concerns is the derivation that conveys the pragmatically more natural interpretation of (19), with wide scope for *likely*, which could be generated via deletion of the upper copy of *someone*. The question is why the two readings are available, if the former looks more economical than the latter, in that it does not require additional probing to value the F-feature of the lower copy of *someone*.

The fact that reconstruction is optional with the A-chain of (19) but blocked with the A-chain of (13a) indicates that what matters for reconstruction is the content of the chain links rather than the type of chain involved. In the case at hand, the difference seems to revolve around (in)definiteness. Following Heim

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[6] In section 4.2.3 below I address the issue of how C-I interprets a representation such as (18b), for instance, as involving a variable in the most embedded object position.

(1982), among others, let us assume that indefinites do not have quantificational force on their own and that their existential interpretation results from the default insertion of existential quantifiers in the mapping to logical form. For concreteness, let us further assume that a default ∃ can in principle be associated with any link of an indefinite chain. That being so, there are in fact two derivations to consider in the case of (19), depending on whether the existential quantifier is associated with the upper or the lower copy of *someone*, as respectively illustrated in (20).

(20) a. [∃**someone**$_{F:\surd}$ is likely [**someone**$_{F:u}$ to win the lottery]]
      b. [**someone**$_{F:\surd}$ is likely [∃**someone**$_{F:u}$ to win the lottery]]

If Chain Reduction deletes the lower copy of *someone* in (20a), the interpretation ∃ > *likely* is appropriately derived. In turn, deletion of the lower copy in (20b) yields a nonconvergent structure with an unbound variable in the matrix clause and vacuous quantification in the embedded clause. However, an alternative derivation can converge if the higher copy of *someone* values the F-feature of the lower copy, as shown in (21a) below; Chain Reduction may then delete the upper copy, yielding the structure in (21b), which gives rise to the reading *likely* > ∃.

(21) a. [**someone**$_{F:\surd}$ is likely [∃**someone**$_{F:\surd}$ to win the lottery]]
      b. [~~someone~~$_{F:\surd}$ is likely [∃**someone**$_{F:\surd}$ to win the lottery]]

I should emphasize that what is relevant for our present concerns is not the specific interpretive mechanism that licenses indefinites, such as ∃-insertion in (20). Whatever the most appropriate mechanism is, what matters is that it alters convergence computations in such a way that feature valuation per se cannot provide the basis for economy to determine which copies to delete. In other words, reconstruction in (12a) is not really optional; rather, the two different readings arise from two different noncomparable derivations, and an apparently nonoptimal route may be taken once deletion of lower links does not result in a convergent output.[7]

4.2.2 *Linearization of Overlapping Chains at LF*
Let us now return to the ambiguity of cases such as (6b), repeated below in (22a). Given what was proposed in section 4.1, in order for the GQBC to be complied with, the upper copy of the *wh*-phrase in (22b) must probe and value the F-feature of the lower copy, as shown in (23a). An optimal application of

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[7] I will keep the discussion to the simplest case. From the current perspective, complexities such as the blocking effect on A-reconstruction induced by negation (see e.g. Lasnik 1999 for relevant discussion) or the lack of ambiguity induced by the Parallelism Requirement (see e.g. Fox 2000), for example, should be viewed as additional convergence conditions that may tip the balance toward one or another copy.

Chain Reduction should then convert (23a) into (23b). However, (23b) incorrectly predicts that only the embedded subject reading for the anaphor should be available.

(22) a. John$_i$ wondered which picture of himself$_{i/k}$ Bill$_k$ saw.
   b. [John wondered [[**which picture of himself**]$_{F:\sqrt{}}$ Q [Bill saw **[which picture of himself**]$_{F:u}$]]]

(23) a. [John wondered **[[which picture of himself**]$_{F:\sqrt{}}$ Q [Bill saw **[which picture of himself**]$_{F:\sqrt{}}$]]]
   b. [John wondered [[~~which picture of himself~~]$_{F:\sqrt{}}$ Q [Bill saw **[which picture of himself**]$_{F:\sqrt{}}$]]]

Again, the logic of the system leads us to expect that a nonoptimal reduction of the *wh*-chain in (22b) to license the matrix subject reading can only be enforced if other convergence requirements prevent full deletion of the higher *wh*-copy. Suppose we follow Chomsky (1993) in assuming the anaphors involve movement, leaving aside the issue of whether this movement takes place covertly, as in Chomsky's proposal, or overtly, as in the proposals by Lidz and Idsardi (1997) and Hornstein (2001), among others. Applied to (23a), anaphor movement yields one of the structures in (24) depending on whether it targets the lower or the upper copy of the reflexive.

(24) a. [John wondered **[[which picture of himself**]$_{F:\sqrt{}}$ Q [Bill **himself**-saw **[which picture of himself**]$_{F:\sqrt{}}$]]]
   b. [John **himself**-wondered **[[which picture of himself**]$_{F:\sqrt{}}$ Q [Bill saw **[which picture of himself**]$_{F:\sqrt{}}$]]]

The *wh*-chain and the reflexive chain in each of the structures in (24) overlap in the sense that they share a constituent. In (24a), for instance, the lowest copy of *himself* is at the same time the tail of the reflexive chain and part of the tail of the *wh*-chain. The question is how Chain Reduction should proceed in these circumstances. Interestingly, a similar situation has been discussed with respect to the PF side. Nunes (1995, 2001, 2004, 2012) has argued that a parasitic gap construction such as (25a) below involves sideward movement from within the adjunct clause to the object of *file*, followed by standard movement to [Spec,CP], yielding the (simplified) representation in (25b) (with numbered copies for expository purposes). In (25b), two chains are formed: CH_1 = (copy^3, copy^1) and CH_2 = (copy^3, copy^2). These chains induce problems of linearization at PF and must undergo Chain Reduction. There is an additional complexity, though. As Nunes observes, copy^3 is the head of both chains. Thus, if Chain Reduction deletes it in its first application, the derivation is bound to crash. The two surviving copies (copy^1 and copy^2) prevent the structure from being linearized because they do not form a chain and, accordingly, cannot

undergo Chain Reduction. A convergent derivation must therefore delete the tail of the first chain being reduced, before handling the second chain, eventually yielding the sentence in (25a).

(25) a. Which paper did John file without reading?
    b. [[**which paper**]³ did John [[file **[which paper]²**] [without reading **[which paper]¹**]]]

If the interpretation of chains at LF is conditioned by linearization, as advocated here, we can now recast Chomsky's (1993) suggestion that deletion at LF cannot break a chain (see section 3) in more general linearization terms:

(26) Generalization on the Reduction of Overlapping Chains (GROC):
    Given a term τ such that τ is part of more than one chain, Chain Reduction must not delete τ if it is still part of another chain.

As stated in (26), the GROC is not a new principle, but just a convenient description of how the system works in an optimal way when overlapping chains are to be linearized, be it at PF or at LF. Suppose, for instance, that Chain Reduction targets the *wh*-chain in (24b) and deletes the upper copy in consonance with the GQBC, as sketched in (27) below. The two surviving copies of *himself* in (27) are now in the same situation of copy² and copy¹ in (25b) if copy³ is deleted: as they do not form a chain, they cannot undergo Chain Reduction and prevent the whole structure from being linearized.

(27) [John **himself**-wondered [[~~which picture of himself~~]$_{F:\surd}$ Q [Bill saw **[which picture of himself**]$_{F:\surd}$]]]

The optimal application of Chain Reduction of the *wh*-chain in (24b) must therefore be one that both satisfies the GQBC and is in consonance with the GROC. This is what we have in (28) below, where *which* is deleted in the higher copy of the *wh*-phrase (allowing the GQBC to be met) and *picture of himself* is deleted in the lower copy (in compliance with the GROC). The *himself*-chain in (28) can then undergo Chain Reduction and the whole structure can be properly linearized at LF, yielding the matrix-reading interpretation for the anaphor of (22a).

(28) [John **himself**-wondered [[~~which~~ **picture of himself**]$_{F:\surd}$ Q [Bill saw **[which** ~~picture of himself~~]$_{F:\surd}$]]]

Notice that if scattered deletion of the sort seen in (28) could also be resorted to in the reduction of the *wh*-chain of (16a), repeated below in (29), the output should incorrectly bleed Principle C, as shown in (30).

(29) **[[which picture of John]**$_{F:\surd}$ did-Q he see **[which picture of John]**$_{F:\surd}$]

(30) **[[~~which~~ picture of John]**$_{F:\surd}$ did-Q he see **[which** ~~picture of John~~]$_{F:\surd}$]

Nothing special needs to be added in order to block (30), though. Like its PF counterpart (see section 2), scattered deletion is in principle not an optimal output of Chain Reduction at LF and is enforced only when deletion of the whole link does not lead to a convergent result, as was the case in (27). In particular, Chain Reduction of the *wh*-chain of (29) as in (30) leads to a convergent result (the structure can be linearized and the GQBC is satisfied) but is not economical: it involves (at least) two operations of deletion, whereas a single application targeting the upper copy should suffice for a convergent result to obtain (cf. (16b)). In sum, the proposal entertained here deduces Chomsky's (1993) preference principle from economy computations regulating applications of deletion under Chain Reduction.

This approach also provides a rationale for cases like (12b), repeated here in (31) (see Lebeaux 1991), where reconstruction in A-chains seems to be forced in order for the pronoun to be bound.

(31) [His$_i$ mother]$_k$'s bread seems to [every man]$_i$ to be known by her$_k$ to be the best there is.

If (31) simply involved A-movement of *his mother's bread*, as represented in (32), we should not expect reconstruction, for the head of the chain is the optimal link to survive Chain Reduction.

(32) **[[his mother's bread]**$_{F:\sqrt{}}$ seems to every man **[[his mother's bread]**$_{F:u}$ to be known by her **[[his mother's bread]**$_{F:u}$ to be the best there is]]]

Again, the logic of the system tells us to look for convergence reasons that would prevent the head of the chain in (32) from surviving Chain Reduction. Here is one possibility, based on Hornstein's (2001:177) proposal that bound pronouns are not part of the numeration and are inserted when movement fails. According to this proposal, the derivation of (33) below, for instance, proceeds along the lines of (34a–b), where *everyone* moves to the external argument position in violation of the Left Branch Condition; this derivation can, however, be saved if a pronominalization operation targets the source of such movement and replaces it with a pronoun, as sketched in (34c).

(33) Everyone$_i$ loves his$_i$ mother.

(34) a. [loves [everyone's mother]]
     b. [**everyone** loves [**everyone**'s mother]]
     c. [**everyone** loves [**pronoun**'s mother]]

Leaving details of implementation aside, suppose the step in (34c) does not take place in the syntactic component but is a matter of spell-out in the phonological component. For concreteness, suppose that an illicit instance of movement assigns * to the relevant copy, signaling to the phonological component that if

pronounced, that copy should be realized as a pronoun. That being so, the structure that feeds C-I is (34b), rather than (34c). If something along these lines is on the right track, the derivation of (31) should then be as sketched below: in (35a) *[every man's mother's bread]* moves from the most embedded to the intermediate clause; in (35b) *seems* is merged and *[every man]* moves to its experiencer position in violation of the Left Branch Condition, triggering assignment of * to the lower copy; finally, after additional material is merged in (35c), *[*[every man]'s mother's bread]* moves to the matrix subject position, valuing its Case-feature.

(35) a. [$_{VP}$ seems **[[[every man]'s mother's bread]**$_{F:u}$ to be known by her **[[[every man]'s mother's bread]**$_{F:u}$ to be the best there is]]]

      b. [$_{VP}$ **[every man]** seems **[[*[every man]'s mother's bread]**$_{F:u}$ to be known by her **[[[every man]'s mother's bread]**$_{F:u}$ to be the best there is]]]

      c. [$_{TP}$ **[*[every man]'s mother's bread]**$_{F:\sqrt{}}$ T [$_{vP}$ **[every man]** seems **[[*[every man]'s mother's bread]**$_{F:u}$ to be known by her **[[[every man]'s mother's bread]**$_{F:u}$ to be the best there is]]]]]

In the phonological component, the chain involving *[[every man]'s mother's bread]* and the chain involving movement of *seem* to the light verb (see Chomsky 1995:305) are optimally reduced (i.e. the lower copies are deleted), as shown in (36a). Finally, the inherent Case assigned by *seem* to *every man* is realized as *to* and the **[every man]* is realized as *his*, as shown in (36b). Crucially, *his* and *every man* in (36) are distinct on the PF side and do not prevent the structure from being linearized in this component.

(36) *PF*:

      a. *Chain Reduction*:

          [$_{TP}$ **[*[every man]'s mother's bread]**$_{F:\sqrt{}}$ T [$_{vP}$ **every man** ~~seems~~ [[~~*[every man]'s mother's bread~~]$_{F:u}$ to be known by her [[[~~every man]'s mother's bread~~]$_{F:u}$ to be the best there is]]]]]

      b. *Phonological realization*:

          [$_{TP}$ **[*his* mother's bread]**$_{F:\sqrt{}}$ T [$_{vP}$ seems-v [$_{VP}$ *to*-**[every man]** ~~seems~~ [[~~*[every man]'s mother's bread~~]$_{F:u}$ to be known by her [[~~every man]'s mother's bread~~]$_{F:u}$ to be the best there is]]]]]

Things are different on the LF side, though. By assumption, *-assignment only has effects on the PF side; hence, the structure that feeds the covert component is actually the one in (37) below (= (35c) without *s), with three chains to be reduced: the one involving *seem*, the one involving *[[every man]'s mother's bread]*, and the other involving *[every man]*.

(37) [$_{TP}$ **[[every man]'s mother's bread]**$_{F:\sqrt{}}$ T [$_{vP}$ seems-v [$_{VP}$ **[every man]** seems **[[[every man]'s mother's bread]**$_{F:u}$ to be known by her **[[[every man]'s mother's bread]**$_{F:u}$ to be the best there is]]]]]

Since reduction of the chain involving *seems* is immaterial to the present discussion, let us simply assume that it proceeds in an optimal way, deleting the lower copy. The case of interest is the reduction of the other two chains, for they overlap: the copy of *every man* within the intermediate clause is at the same time the tail of its own chain and part of the intermediate link of a bigger chain. In situations like this, the GROC states that Chain Reduction cannot delete a link that is shared by more than one chain, for otherwise the structure cannot be later linearized (surviving copies that are not in a chain relation induce linearization problems but cannot undergo Chain Reduction). Reduction of the chain involving *every man's mother's bread* must therefore preserve the intermediate link and delete the other two, which in turn requires that the upper copy first value the intermediate copy. After valuation and reduction, we obtain the structure in (38), which can be properly linearized after the chain involving *every man* is further reduced:

(38) [$_{TP}$ [[every man]'s mother's bread]$_{F:√}$ T [$_{vP}$ seems-v [$_{VP}$ **[every man]** seems [[[**every man]'s mother's bread**]$_{F:√}$ to be known by her [[[every man]'s mother's bread]$_{F:u}$ to be the best there is]]]]]

Similar considerations apply to the well-known cases of reconstruction blocked by a bound pronoun. (39) below, for instance, does not have the reading *every > some*, which should be licensed if the matrix subject could be reconstructed. If bound pronouns are disguised copies as suggested above, (39) is to be derived as sketched in (40).

(39) [Some student]$_i$ seems to his$_i$ classmates to like every professor

(40) a. K = [[**some student**] to like every professor]
        L = [[**some student**]'s classmates]
     b. [$_{vP}$ [**some student**]'s classmates] seems [[**some student**] to like every professor]]
     c. [$_{TP}$ **[some student]** T [$_{vP}$ seems-v [$_{VP}$ [*[**some student**]'s classmates] seems [[**some student**] to like every professor]]]]

In (40a) *[some student]* undergoes sideward movement from K to L, which then merges in the specifier of *seem* (cf. (40b)). After further computations, *[some student]* moves from within the specifier of *seem* to the matrix subject position (triggering *-assignment), yielding (40c), where the highest copy forms a distinct chain with each of the lower copies. On the PF side, the starred-constituent is realized as a pronoun and the other lower copy is deleted. On the LF side, on the other hand, both chains in (40c) must be reduced. In accordance with the GROC, Chain Reduction cannot delete the highest copy (otherwise, the other copies, which do not form a chain, prevent the structure

from being linearized). Chain Reduction at LF then deletes the lower link of each chain in (40c), yielding lack of reconstruction in (39).

Following Chomsky (1993), I have assumed that it is not the case that all the material in each link of a given nontrivial chain is assigned an interpretation at C-I. Based on the fact that a comparable state of affairs is also found on the PF side, I have argued that deletion within chains is triggered by the same requirement (linearization) and executed by the same mechanism (Chain Reduction). Mismatches with respect to the outputs of Chain Reduction at PF and LF are claimed to follow from the different convergence conditions each level is subject to, in combination with economy considerations on how these demands can be satisfied in an optimal way.

4.2.3   *Uriagereka's Address Problem*

Any derivation in which Chain Reduction at LF deletes the lowest copy of a chain raises the issue of how C-I recovers the relation that was established upon merger of this copy. This recoverability problem is reminiscent of Uriagereka's (1999:267) "address" problem. If Spell-Out can apply multiple times in the course of the derivation, as proposed by Uriagereka, there arises the question of how spelled-out structures are appropriately "plugged in" where they belong when the whole structure is computed. Nunes and Uriagereka (2000:23) propose that labels can provide the "address" for the appropriate plugging in. Extending Nunes and Uriagereka's solution to the case under discussion, I propose that labels are preserved when chains are linearized at LF, providing the means for the relevant information to be recovered. To be specific, when Chain Reduction targets a given syntactic object K = {χ, {α, β}}, with label χ and terms α and β (see Chomsky 1995), it may delete α, β, or the set {α, β}, but not its label χ.[8] Under this view, (14), for example, should be seen as a shorthand for (41), where the head of the chain is to be interpreted as being thematically related to the embedded predicate because its label is nondistinct from the label of the reduced lower copy.

(41) [**{that, {that, [picture of John]}}** seems to him [**{that,** {that, [picture of John]}} to be embarrassing]]

This proposal captures the intuition underlying Chomsky's (1993) system with respect to the interpretation of the tail of chains, but does so in a way compatible with bare phrase structure and without assuming traces in addition

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[8] For purposes of discussion, I am assuming with Chomsky (1995) that labels are produced as part of the inner workings of the operation Merge. As far as I can see, the proposal to be presented below may also be compatible with approaches under which labels are produced by a specific operation like Hornstein and Nunes's (2008) and Hornstein's (2009) Label operation, or by a labeling algorithm, as in Chomsky (2013).

to copies. It is worth pointing out that the linearization problems induced by nontrivial chains relate to the nondistinct lexical items present in each link. Labels are constructed from lexical items (see Chomsky 1995) but are not lexical items themselves. Thus, the presence of nondistinct labels after a given chain undergoes Chain Reduction, as in (41), does not prevent the structure containing them from being linearized. Labels therefore play an important role in the mapping to C-I, as they preserve information that could be lost if Chain Reduction at LF radically erased the whole chain link.

Independent evidence for this approach comes from cases where labels are arguably computed with respect to binding theory. Consider the data below, for instance.

(42) a. *Which picture of who$_i$ did he$_i$ like?
     b. *Who$_i$ did he$_i$ like?

(43) a. Which picture of who$_i$ did Mary say he$_i$ liked?
     b. *Who$_i$ did Mary say he$_i$ liked?

Given the GQBC (see section 4.2.1), the optimal convergent reduction of the *wh*-chain associated with each sentence in (42) is the one which deletes the higher link so that the surviving link is c-commanded by the interrogative complementizer; hence the Principle C effect in both sentences. The lack of such an effect in (43a) is accordingly tied to the presence of a copy of the *wh*-phrase in the embedded [Spec,CP]; if this copy survives Chain Reduction at LF, it complies with the GQBC and is not c-commanded by the pronoun. (43b), which also involves a copy of *who* in the embedded [Spec,CP], should then behave in the same way. However, its ungrammaticality indicates that the availability of this additional copy does not suffice to mitigate the Principle C violation that is arguably involved in (42b). Neither can the mere difference in syntactic complexity between the *wh*-phrases of (43) be responsible for their grammaticality contrast, for the syntactically complex *wh*-phrase in (44a) below patterns like *who* in (43b). And to make matters more puzzling, if the *wh*-phrase of (44a) is embedded as in (44b), we again find a case of Principle C bleeding similar to the one in (43a).

(44) a. *Whose$_i$ mother did Mary say he$_i$ called?
     b. Which picture of whose$_i$ mother did Mary say he$_i$ liked?

These data can be accounted for if traditional (*wh*-)pronouns may spell out phrasal objects (see e.g. Déchaine and Wiltschko 2002). For concreteness, let us assume that *who* involves a *wh*-layer on top of a φ-layer and *whose* involves a more complex structure with a *wh*-layer on top of a DP-layer, on a par with Dutch *wie zijn vrouw* (lit. who his wife) 'whose wife' (see Barbiers,

Koeneman, and Lekakou 2010:9). After Chain Reduction, the sentences in (42)–(44) should then be respectively associated with the (simplified) LF structures in (45)–(47).

(45) a. [{**which**, {~~which, [picture of who]~~}} did-Q he like {**which, {which, [picture of who]}}**]
      b. [{**who**, {~~who, φP~~}} did-Q he like {**who, {who, φP}}**]

(46) a. [{**which**, {~~which, [picture of who]~~}} did-Q Mary say [{**which, {which, [picture of who]}}** he liked {**which**, {~~which, [picture of who]~~}}]]
      b. [{**who**, {~~who, φP~~}} did-Q Mary say [{**who, {who, φP}}** he liked {**who**, {~~who, φP~~}}]]

(47) a. [{**who**, {~~who, [his mother]~~}} did-Q Mary say [{**who, {who, [his mother]}}** he liked {**who**, {~~who, [his mother]~~}}]]
      b. [{**which**, {~~which, [picture of whose mother]~~}} did-Q Mary say [{**which, {which, [picture of whose mother]}}** he liked {**which**, {~~which, [picture of whose mother]~~}}]]

Satisfaction of the GQBC necessarily places *who(se)* in the c-command domain of *he* in (45), but not in (46a) or (47b), thanks to the copy in the embedded [Spec,CP]; hence, they must be disjoint in the former, but not necessarily in the latter. The interesting cases for our discussion are the ones in (46b) and (47a), which require a disjoint reading between *he* and *who(se)* despite the fact that they are not in a c-command relation. When labels are taken into account, the puzzle disappears. In (46a) and (47b), *who(se)* is buried within the deleted material of the lowest copy and is not available for binding theory computations. By contrast, in (46b) and (47a) *who(se)* is deleted in the lowest copy but its label survives deletion and is available for binding theory purposes, which forces it to be interpreted as disjoint from the c-commanding pronoun. The correlation between syntactic complexity and availability of additional copies above the pronoun is therefore spurious. What really matters is the label of the reduced copies that remain in the c-command domain of the pronoun.

   The Principle C effect in (46b) and (47a) mimics the pronunciation of more than one copy (see section 2). In the case of PF, an additional pronounced copy does not cause problems of linearization because it has been morphologically fused with some head (Nunes 2004). Hence, it is not computed for linearization purposes on its own because it is not an independent lexical item, but an integral part of the reanalyzed lexical item. In the case of (46b) and (47a), *who(se)* is in a sense being interpreted in more than one position at LF, also without creating problems of linearization. Crucially, we do not have two nondistinct copies of the lexical item *who(se)*, but a lexical item and a label determined by this lexical item.

4.2.4   Additional Similarities: Bottom-up Linearization

4.2.4.1   Across-the-Board (ATB) Extraction
Consider the contrast in (48) (based on Munn 1993), which appears to show that reconstruction under ATB affects only the first conjunct.

(48) a. Which of John$_i$'s cousins does Mary like and he$_i$ hate?
     b. *Which of John$_i$'s cousins does he$_i$ like and Mary hate?

Under a sideward movement approach to ATB extraction (see Nunes 1995, 2001, 2004, 2012), the *wh*-phrase of (48b) moves from the object of *hate* to the object of *like*, before moving to [Spec,CP], yielding the (simplified) structure in (49), with the chains $CH_1 = (copy^3, copy^1)$ and $CH_2 = (copy^3, copy^2)$. The linearization of these chains at LF yields the output in (50) or (51), depending on whether Chain Reduction targets CH_1 or CH_2 first.

(49) [[**which of John's cousins**]^3 does [he like [**which of John's cousins**]^2] and [Mary hate [**which of John's cousins**]^1]]

(50) [[~~which of John's cousins~~]^3 does [he like **[which of John's cousins]^2**] and [Mary hate ~~[which of John's cousins]~~^{1}]]

(51) [[~~which of John's cousins~~]^3 does [he like ~~[which of John's cousins]~~^{2}] and [Mary hate [**which of John's cousins**]^1]]

If the order of applications did not matter, the sentence in (48b) should incorrectly allow co-reference between *he* and *John* thanks to the output in (51). The fact that we have a Principle C effect in (48b) but not in (48a) thus shows that Chain Reduction must apply to CH_1 prior to CH_2. This seems to indicate that Chain Reduction proceeds in a bottom-up fashion, perhaps as a consequence of phase-based computations. Tentatively, I propose that linearization of chains unfolds along the lines of (52).

(52) Bottom-up Linearization:
Given two chains CH_1 and CH_2, Chain Reduction applies to CH_1 first if links of CH_1 are lower than links of CH_2, where α is lower than β if α is asymmetrically c-commanded by β or α is asymmetrically c-commanded by γ and γ dominates β.

In the case of (49), $CH_1 = (copy^3, copy^1)$ must be reduced first, because $copy^1$ is lower than $copy^2$ ($copy^1$ is asymmetrically c-commanded by the first conjunct, which dominates $copy^2$).

The above discussion leads us to expect that linearization at PF should also proceed in a bottom-up fashion, along the lines of (52). In the case of (49), we cannot see the effects of (52) at PF because reduction of each chain deletes the lower copy. But if pronunciation of the chain head causes the derivation to crash, lower copy pronunciation should involve the first conjunct, in a way parallel to what we saw with reconstruction in (49). An interesting case illustrating

this possibility involves the contrast in (53) in (noncolloquial) Czech, as dis-
cussed by Dotlačil (2008).

(53) *Czech* (Dotlačil 2008):
    a. *Zavolal **jsem Petra** a představil známým.
      called aux$_{1SG}$ Petr$_{acc}$ and introduced friends
      'I called Petr and introduced him to friends.'

    b. Zavolal **jsem ho** a představil známým.
      called aux$_{1SG}$ him$_{acc}$ and introduced friends
      'I called him and introduced friends.'

(53a) shows that Czech does not allow auxiliary gapping and object drop
under coordination. In this regard, the grammaticality of (53b), which differs
minimally from (53a) in having a pronominal clitic in place of *Petra*, is rather
unexpected. Dotlačil (2008) argues that the auxiliary and the pronominal clitics
in (53b) in fact undergo ATB extraction (via sideward movement), yielding the
simplified structure in (54a) below (with English words), where the highest
copy of the clitic cluster forms a different chain with each of the lower copies.
Reduction of the chain involving the second conjunct deletes the lower copy,
as shown in (54b). Similar reduction of the chain involving the first conjunct
would leave the clitic cluster in clause-initial position, which is not allowed in
Czech. Chain Reduction then deletes the higher copy, as shown in (54c). As
the reader can see, the order of applications of Chain Reduction in (54) is the
one required by (52).

(54) a. [**aux-him** [[called **aux-him**] and [introduced **aux-him**]]]
    b. [**aux-him** [[called **aux-him**] and [introduced ~~aux-him~~]]]
    c. [~~aux-him~~ [[called **aux-him**] and [introduced friends ~~aux-him~~]]]

We thus have another case of parallelism between linearization of chains at
PF and linearization of chains at LF.

4.2.4.2 Parasitic Gaps Chomsky (1986:60), citing Kearney (1983),
observes that reconstruction in the parasitic gap position of constructions
like (55a) is not possible. However, Williams (1989/1990:271) shows that in
constructions such as (55b), the *wh*-phrase does reconstruct into the parasitic
gap, inducing a Principle C effect. In addition, Munn (1994) shows that even in
the case of Principle A, we may get the opposite pattern from the one discussed
by Chomsky if the parasitic gap is within a subject, as illustrated in (55c).

(55) a. Which books about himself/*herself did John file *t* before Mary read
      PG?
    b. *Whose$_i$ mother did we warn *t* before he$_i$ arrested *PG*?
    c. Which picture of himself/*herself did every boy who saw *PG* say
      Mary liked *t*?

The complex pattern in (55) finds a simple account under the present analysis. Let us start with (55b). Recall that labels may give rise to Principle C effects even in absence of true reconstruction (see section 4.2.3). This appears to be the case of (55b). Notice that once *whose mother* is embedded in a *wh*-phrase, as in (56) below, the Principle C effect disappears. (57) further shows that reconstruction into the "real" gap is indeed full reconstruction and not just an effect of labels. This leads to the conclusion that once the role of labels is filtered out, (55b) actually patterns with (55a).

(56) Which picture of whose$_i$ mother did Mary buy *t* after he$_i$ found *PG*?

(57) *Which picture of whose$_i$ mother did he$_i$ buy *t* after Mary found *PG*?

Let us then examine the contrast between (55a) and (55c), whose (simplified) representations under a sideward movement approach are given in (58).

(58) a. **[[which books about himself]³** [did-Q John [file **[which books about himself]²**] [before Mary read **[which books about himself]¹**]]]
      b. **[[which picture of himself]³** did [every boy who saw **[which picture of himself]²**] say Mary liked **[which picture of himself]**¹]

Abstracting away from the details involving reflexive movement (see section 4.2.2), the determination of the site for reconstruction follows from the bottom-up approach to linearization outlined in section 4.2.4.1. If copy^1 counts as lower than copy^2 in both (58a) and (58b), Chain Reduction must apply to $CH_1 = (copy^3, copy^1)$ before $CH_2 = (copy^3, copy^2)$, yielding reconstruction into the site occupied by copy^2.

The assumption that copy^1 is lower than copy^2 in (58a) is admittedly less trivial, as it relates to the independent issue of how "right-adjoined" adjuncts are to be linearized. Putting aside eventual amendments to (52) prompted by this issue, the directionality of Chain Reduction proposed above predicts that in adjunct PG constructions where pronunciation of the head of the chain causes the derivation to crash, the trace to be pronounced should not be the one within the adjunct, for its chain counts as lower and is reduced first. Evidence for this conclusion is provided by the Romanian sentence in (59) (see Bošković 2002 and Niinuma 2010).

(59) *Romanian* (Bošković 2002):

Ce	precede	**ce**$_i$	fără	să	influenţeze	**PG**$_i$?
what	*precedes*	*what*	*without*	*SUBJ.PRT*	*influence.3.SG*	

'What precedes what$_i$ without influencing it$_i$?'

Under a sideward movement analysis, (59) involves movement of *ce* from the object of *influenţeze* to the object of *precede* before undergoing *wh*-fronting, as represented in (60) below, with the chains $CH_1 = (copy^3, copy^1)$ and

CH_2 = (copy^3, copy^1). Applying to CH_1, Chain Reduction deletes the lower copy of *ce*, yielding (61a). By contrast, if Chain Reduction deletes the lower copy of *ce* when applying to CH_2, the derivation will not converge due to the ban on adjacent homophonous *wh*-phrases in Romanian (see section 2). In order to circumvent this problem, Chain Reduction deletes the higher copy, as shown in (61b) (see Bošković 2002), and the structure surfaces as (59), which superficially seems to involve a *wh-in situ* licensing a parasitic gap. As we saw with respect to the reconstruction in (55a), the copy within the adjunct counts as lower than the copy in the matrix object position. Importantly, the correct output is obtained only if chains are reduced in a bottom-up fashion, as proposed in (52).[9]

(60) [ce$_{SU}$ **ce$_{OB}$**^{3} [[precede **ce$_{OB}$**^{2}] [fără să influenţeze **ce$_{OB}$**^{1}]]]

(61) a. [ce$_{SU}$ **ce$_{OB}$**^{3} [[precede **ce$_{OB}$**^{2}] [fără să influenţeze ee$_{OB}$^{1}]]]
      b. [ce$_{SU}$ ee$_{OB}$^{3} [[precede **ce$_{OB}$**^{2}] [fără să influenţeze ee$_{OB}$^{1}]]]

5   Concluding Remarks

It goes without saying that the proposal outlined in the preceding sections is very programmatic and does not do proper justice to the large literature on the interpretation of chains under the copy theory that has emerged under minimalism. But even being programmatic, it at the very least points out similarities in the way PF and LF handle chains, which do not seem to be coincidental and call for a unified approach. Here I have sketched a unified approach that extends my earlier proposal that the different patterns of chain outputs at PF are ultimately determined by linearization. Taking Chomsky's (1993) original proposal on how to interpret copies at LF as a testing ground, I have argued that the different patterns of chain outputs at LF are determined by optimal linearization taking into account LF convergence conditions and economy considerations.

   To say that LF is sensitive to linearization definitely causes some eyebrows to raise. However, I believe this is due to the fact that we informally equate

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[9] This analysis predicts that an analogous case involving ATB extraction should enforce pronunciation of a lower copy in the first and not the second conjunct. However, Niinuma (2010) reports that the reverse is true, as shown in (i) below. At the moment, I do not have an account of the unexpected pattern in (i).

(i) a. *Ce   a   precedat   ce   şi   a   influenţat?
        what   has   preceded   what   and   has   influenced

     b. Ce   a   precedat şi   a   influenţat   ce?
        what   has   preceded and   has   influenced   what
        'What preceded and influenced what?'

linear order with precedence in our discussions on how overt syntax is to be mapped into a PF object and it is generally assumed that precedence is relevant for PF, but not for LF. As I mentioned in the introduction, I remain uncommitted as to which specific linear order relation C-I is sensitive to. What I hope to have shown is that some linear order relation seems to be ultimately responsible for the deletion of "repeated" material within a chain so that asymmetry and irreflexivity are observed.

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8   On the Rationality of Grammar

Wolfram Hinzen[1]

1   Hierarchies

What the rationality of grammar consists in is not an easy question to answer. The project of a universal grammar, historically, of course *is* that of a rational one (Arnauld & Lancelot 1660). Such grammars are concerned with grammar as a scientific domain, and they are also called general ones, since any scientific approach would by its nature treat its domain in its general aspects. Yet what makes this domain look rational is nonetheless not an easy thing to tell, even if we could answer the seemingly easier question of what the general principles of this domain are. Thus, if we wanted to be specific and mention, say, the formal principles of argument licensing, then these may look universal to us, but opinions will differ and they seem to lack a deeper rationale. If we attribute them to a genetic endowment, they will to that extent be unexplained (Chomsky 2005). Indeed, rationalizing Case as a principle for the licensing of arguments has remained a major challenge even in the course of renewed efforts within Minimalism devoted to it (Chomsky 2000a; Sigurðsson 2012). If in turn we wanted to be less specific and point to, say, a basic process of forming hierarchies recursively which embeds binary sets of syntactic objects in other such binary objects, then the resulting algebraic structure is a generic one. Linguistic specificity will now have to come from the lexicon in particular – a priori not a likely place to rationalize grammar from.

Hinzen and Uriagereka (2006) cast their eye on a different kind of hierarchy, namely of types of denotations in the domain of nominal reference:

(1) **The nominal hierarchy**: abstract< mass< objectual/count< animate

The noun *beauty* illustrates an abstract nominal space (i.e. a noun with an abstract denotation), *beer* a mass noun, *mug* a count noun, *man* an animate count noun. The formal complexity of these denotations generates hierarchical entailments denoted by "<" above. In particular, a mass is formally or

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[1] I am very grateful to an anonymous reviewer and Roger Martin for comments on this chapter, and even more grateful to Juan Uriagereka for getting me to think about grammar in the first place.

topologically more complex than a purely abstract space, and as for the former we need a substance that extends in time and space and has (mass)-quantifiable parts. In turn, to be countable is to involve more than a mass, namely some sort of boundary, and an animate object is always a countable one. So looking at this hierarchy from top to bottom, an animate object contains a countable one, which contains a mass, which in turn is more complex than an abstraction. In line with this intuition, Hinzen and Uriagereka (2006) note that a canonically animate noun like *man* can also occur in contexts in which non-animate count nouns, mass nouns, and abstract nouns can appear – but not the other way around:

(2) a. We gave the man/*institution/*beauty our pictures.
     b. I saw most men/*beer/*beauty/*beauties.
     c. It's a man eat man world.
     d. He's more man than you'll ever be.

Moreover, as we go up the hierarchy of nominal denotation, we observe that syntactic complexity increases, as is clear from such facts as that abstract nouns do not take articles or are measurable, and do not pluralize. Mass nouns do not pluralize either and only take quantifiers assessing rough estimates like *much* or *little*, while languages apply more classificatory material (e.g., number and gender markers) to count nouns, and more still to animate nouns (e.g., personal markers). In short, formal-ontological complexity in nominal denotation unfolds as grammatical complexity does.

This, however, is just the beginning when studying hierarchies in language. Thus any given noun can be put to multiple referential uses, which also form a system. For example, a bare NP like *man* can denote abstractions or indefinite amounts of a mass (3–4). In the plural it can denote indefinite amounts of individual instances of the relevant kind or generalize over its instances (5–6). With overt determiners present, readings can existentially quantify over single individuals (7) or involve reference to them which can be either non-deictic (8) or deictic (9):

(3) It's a **man** eat man world.
(4) He ate **man**   [cf. He ate beef]
(5) He saw **men**
(6) He likes **men**
(7) He likes **a man**
(8) He likes **the man**
(9) He likes **this man**

Individual denotations, indefinite existential interpretations, and specific and deictic ones are not available without a nominal "edge" being projected, which houses determiners and puts these forms of reference in place, and which gets

stronger as we build complexity into the edge, with *this* entailing *the*, which in turn entails *a*:

(10) this >> the >> a

Noun phrases with an edge of course in turn entail those without, i.e., bare NPs. Martin and Hinzen (2014) more specifically show for the domain of Romance object clitics that the grammatical complexity of the DPs that these project increases as we move from predicative clitics, which as such are weakest in referentiality, to Accusative clitics, which can but need not exhibit referential specificity, to Dative clitics, which must be referential, and finally to personal ones, which are strongest in terms of referentiality.

Beyond the domain of nominals, we see that clauses necessarily entail verb phrases which necessarily entail noun phrases, where entailment has again an architectural sense: The more complex type of phrases take the less complex ones as inherent parts, without which they would not exist, suggesting the falsehood of interpreting them as lexical features of labels, in which case they would be atomistic and logically independent of each other:

(11) CP >> vP >> DP

These are not arbitrary formal entailments, moreover, but they again reflect an aligned hierarchy in the *formal ontology* of the denotations associated with these types of syntactic objects.[2] Thus, speaking in terms of formal-ontological types, there can be no proposition without an event architecturally embedded in it, and no event without objects/persons as participants:

(12) propositions << events << objects

Within the domain of events, we find in turn that complex causative events necessarily entail less complex events (states) – and again, not only in such a way that the grammar generates two distinct events, one more complex and one less, but in such a way that the less complex one emerges as an inherent *part* of the more complex one (e.g., being *dead* as the end-state of an event of *killing*).

We thus see hierarchies wherever we look in language, they are inherently interpretable, and syntactic complexity tracks the formal ontology of what we are talking about in language: this is the formal structure of meaning, as organized mereologically. Moreover, the hierarchies are clearly an inherent aspect of what universal grammar is all about: Grammar is, of its essence, a mechanism that generates hierarchies of this very kind. The question of what substantive

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[2] Formal-ontological distinctions are *formal* in the sense that the distinction between an event and an object, say, is not distinct in the way that water and beer are, or men and women; and *ontological*, because they concern the structure of reality as referred to in language.

content a general grammar can have is answered as well – now at an intriguing level of specificity, moreover, which is not as specific as the principles of Case-licensing, yet not as generic as the recursive formation of binary sets (Merge). Last but not least, these hierarchies are eminently *rational*, given the formal ontology of meaning they inherently entail: In fact, they *amount* to the fine structure of rationality as such, in which all human thinking and referring take place.

2   Foundational Questions

The deeper question that Hinzen and Uriagereka raised is what these hierarchies follow from – especially if they do not plausibly follow from any independently given semantic ontology, or the intrinsic structure of reality. They cannot do the former, since we see the semantic complexity in question building up as grammatical complexity does. I know of no evidence that the formal ontology of meaning in question is fully available in perception, say. To whatever extent we might grant it to be, the extent would be limited: Proposition, say, is not a perceptual category; nor are truth or reference. Furthermore, recent psycholinguistic evidence (DeVilliers 2014) suggests that even complex, transitive events cease to be part of the world we experience when our language faculty is not operative.

Even less can formal-ontological distinctions follow from our lexical concepts, i.e., the primitives of our system. SMILE, say, as a lexical concept, entails nothing about whether it will be used to denote an object (e.g., Mary's smile) or an event (e.g., Mary smiles). This instead is a distinction in *reference*, which correlates with a grammatical difference, as a consequence of which the latter expression has Tense and Aspect and a truth value, while the former only denotes an object. Lexical semantic content (what is being talked about, rather than how it is being referred to) does clearly *not* co-vary with this difference. Reference is thus not a matter of lexical content – also in the sense that distinctions like those between the man I saw, a man I like, men I met, men in general or as a kind, or manhood are not lexical distinctions: These depend on the grammatical configurations in which a given lexical item appears. Reference is a grammatical notion.

The formal ontological hierarchies also do not follow from the intrinsic structure of reality, if we look at the latter in purely physical terms, i.e., unbiased by the format of language, in which we know this reality. Nor can we say that they follow from the independent structure of thought: Thought of the kind that is here relevant *is*, intrinsically, thought that has a formal ontology of the exact kind we have depicted. Moreover, we have a system, grammar, which correlates with these hierarchies. Postulating an independent generative mechanism in an independent system of thought that would have to replicate the

grammatical distinctions seems redundant. Indeed, since the relevant formal ontology significantly if not strictly co-varies with grammatical complexity, a real option arises: that it is or was the grammaticalization of the hominin mind that put the formal ontology in place, in which all human thinking and referring now takes place (Hinzen & Sheehan 2015).[3]

This would also enrich, if not somewhat dramatize, conclusions on the metaphysics of linguistics that Hinzen and Uriagereka suggested. One might think that as long as we interpret the workings of grammar in purely formal terms, we stay free of extravagant ontological commitments. It is precisely in this sense that philosophers have widely interpreted the generative grammar enterprise as an instance of the doctrine of functionalism, which is in turn consistent with the general so-called physicalist commitments in the philosophy of mind. Syntax viewed as a purely meaningless structure fits snugly into a physicalist universe as depicted in this philosophical paradigm, since it is meaning that is meant to cause offense, according to the physicalist philosophers (Hinzen 2017). Chomsky (2000b), on the other hand, has tirelessly argued that such physicalist commitments simply make no sense, since they are logically based on a particular notion of the physical defined so as to exclude the mental. Yet since Newton, no such notion of the physical (or the body) is available anymore, with the mental having become an object of naturalistic inquiry like any other, with no good prospects of reduction to be expected. Linguistic structure, in short, is part of the physical as much as the chemical, and there is no point trying to nail down its ontology metaphysically. Moreover, Chomsky for one has never separated meaning from grammar, taking the meaning of an expression as an inherent aspect of it and a universal semantics to be an inherent part of a universal grammar. This deprives the functionalist/physicalist metaphysics of generative grammar of a basis.

So, maybe, there simply is no metaphysics of generative grammar: The structures that grammar builds are not part of physics, we have argued, or of psychology in some non-grammatical sense, *and* they are inherently meaningful. But Hinzen and Uriagereka actually suggested otherwise. The formal-ontological hierarchies in question are logical and dimensional, of the kind that we see in the architecture of number, where the natural numbers are entailed by the whole numbers, which are in turn entailed by the rational numbers, which are part of the real numbers, and so on. The relation between number and the physical is not comparable to that of the chemical to the physical. The mathematical has no foundation in the physical but grounds it instead. Could

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[3] This is not to exclude other forms of thought that are perhaps language independent, such as thinking in images, emotions, maps, or perhaps mathematics. "Thought" is not a univocal notion. Nor does anything prevent us from applying it to non-linguistic animals. Yet Brian, the very thinking dog of *Family Guy*, who is also a very talkative one, clearly does not process the same thoughts as a real dog. Comparative cognition research is barely needed to establish this result.

the grammatical be foundational in a similar sense? What, we might ask, would be more foundational, and more rational in this sense, if grammar is the basis of human thought itself, and hence of the world as known? (See Hinzen & Sheehan 2015: chapter 9.)

These are questions at the limits of inquiry, yet arguably meaningful ones, and they definitely arise, and should be addressed, when questions of a "general" grammar are being raised. A universal grammar that grounds a thought system *is* as such rational, and it is also general, as the relevant kind of thought is uncontroversially general or universal in humans, whether or not neo-Whorfian claims will turn out to be right; it is not a contingent genetic accident in this sense. But the problem is obvious: Much of grammar as currently described simply makes no rational sense. It falls into the "unexplained" box mentioned above.

This is the point where I will return to the recalcitrant issue of (structural) Case, which I will stick to for the rest of this chapter. If anything, Case is part of the heartland of grammar in the most so-called "autonomist" sense, since for long it has seemed so clear that it lacks a semantic rationale. Where we even contemplate the prospect of a rational grammar, Case should therefore either be rationalized in other terms, or perhaps simply not exist as part of narrow syntax. Both options have been contemplated widely, and the latter in particular has gained more support recently within Minimalism (e.g., Marantz 1991; McFadden 2004; Landau 2006; Sigurðsson 2008, 2012). Here I defend the former option (see Hinzen 2014 for an earlier and fuller development, on which the remainder heavily relies), based on the foundational idea above: that with grammatical organization a new kind of meaning arises, namely referential meaning, unavailable lexically, and associated with a formal ontology. I will argue that this process may empirically depend on the kind of structural relations classified as Cases. While this new approach is surely and deeply controversial, the stakes in the debate on the rationality of Case are too high to not critically pursue it.

3   Case and Phases

The Case filter (Chomsky 1981) is one of the early significant results of the mature GB framework:

(13) *NP if NP has phonetic content and has no Case (Chomsky 1981:49)

That lexically overt NPs (NPs other than PRO or the traces of movement) need Case assigned to them was a powerful – even if puzzling – generalization making sense of the overt distribution of such NPs, i.e., the positions in which we see them either appearing or else banned. Over 30 years later, the uninterpretability of (structural) Case is still a wide consensus in generative grammar.

Pesetsky and Torrego (2011:52) point out that principles of Case assignment "look quite specific to syntax and morphology, with little apparent connection to external cognitive systems" (see also Svenonius 2007:20). Chomsky (2000a:127) points out that "[s]omething like θ-theory [governing the assignment of thematic roles to arguments] is a property of any language-like system, whereas [Case] checking theory is specific to human language." In current mainstream Minimalism, the rationale of Case remains at best indirect. Here Case and φ-feature agreement have become two sides of the same coin, deleted in a single application of Agree. Case-checking has become part of the process of grammatical Agreement, and Case, while "demoted in significance," still plays a role mediating the process of valuing unvalued and uninterpretable features (Chomsky 2000a).

The question whether Case can be rationalized in terms of meaning can only be rationally asked if we tell what meaning we are talking about. There are two related but entirely different kinds of meaning. One is the meaning encoded in the form of lexicalized concepts. The cognitive function of the lexicon, I will take it here, is to codify, through lexical roots, a form of semantic memory in the sense of Binder and Desai (2011), i.e., a repository of general and impersonal world knowledge that we have of things and people, feeding into the use of language and encoded in such lexical roots as WOMAN or MAN, which serve us to *classify* an experienced human world. Lexical knowledge is encoded in, say, MAN, through feature specifications, like TWO-LEGGED, HAIRY, MALE, etc., which (I will here assume) are ultimately based on perception and sensory-motor processing, although they abstract from sensory-motor experience to various degrees and involve supramodal elements as well.[4]

Lexical meaning, however, is not all the meaning there is. In fact, most of the meaning that has marked discussions in philosophy and formal semantics over the last 100 years is not of that kind. It is meaning that uniquely arises at a grammatical level. As noted above, referential meaning, in particular, is uniquely grammatical. So could grammar be an independent input to semantic interpretation, contributing something that the lexicon, by its nature, cannot? Arguably, it must, for it is not clear what else would contribute reference in particular. It is unlikely, say, that while lexical content comes from lexical knowledge, reference comes from "referential intentions," say – unlikely, at least, if we don't see similar referential intentions in non-linguistic beings, and we see their inherent forms co-evolving with language in infancy in humans (Mattos & Hinzen 2015).

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[4] Such specifications could explain why we can tell the "odd-one-out" in the sequence CAR, BI-CYCLE, TAXI, MAN, or why, in any human lexicon, hierarchical relations of homonymy and hyperonomy form, such as MAN<MAMMAL<ANIMAL, which we do not find, or not in the same way, in grammar.

If grammar is meaningful, and in a different sense of meaning from the one we find in the lexicon, then what matters as an independent input to semantic interpretation must be the *relations between* words, which grammar represents. These are manifest in patterns of morphological Agreement. So is Agreement interpretable? If the grammatical relations it manifests are interpretable, then the morphological features it brings to a match do not need to be eliminated in the grammatical process. A Person feature on a verb, say, does not need to be eliminated on the grounds that events denoted by verbs are not persons, for what is interpreted is not the *feature* but the *relation* that it reflects. As it happens, Person is not interpreted on nouns either. Instead, the meaning of Person as marked on Nouns is purely *relational* and interpreted only at the level of the verbal phrase, not the noun. Thus suppose I utter (14):

(14) Ich sehe   GERMAN
     I-1P see-1P
     'I see'

(14) expresses for a certain event of seeing that its agent (the person seeing) is identical to the agent of a certain speech event (the person speaking), as and when this latter event takes place. (15) with a 3rd Person subject expresses no such thing, even if I am again the speaker:

(15) The speaker sees.

1st Person (1P) is thus interpreted as a particular relation holding between (the participants of) an event of seeing (configured, we may assume, in *v*P) and (the participants of) a particular speech act (configured, we assume, in CP, where such features as assertoric force or propositionality are grammatically encoded and reference is made to the speech context: see Sigurðsson 2004). In sum, as a feature specified on the verb, 1P is uninterpretable; but as a relation, it is not; as a feature specified on the noun, it is interpretable, but again strictly only relationally: It crucially captures an aspect of *grammatical meaning*, which cannot be determined on the basis of the noun alone.

If φ-features are interpretable via the *relations* they morphologically mark, the contention that φ-features such as Person as specified on verbs are uninterpretable and have to be eliminated before the semantic interface is reached rests on a conceptual mistake. The contention will hold true only if the meaning of relations is ignored (grammar is meaningless), relations are reduced to features, and all meaning is non-relational – effectively lexical, interpreted through features on words. If relations rather than features are interpreted, then movement does not happen to eliminate any features that shouldn't be there, but it is an aspect of how such relations *arise* (or are configured), with much variance thereafter on how (or whether) such relations are morphologically signaled. The relations, once established grammatically, are interpretable in

ways that no feature is, no matter whether it is specified on the noun or on the verb: words *never* carry relational meaning in the sense in which 1P is interpreted relationally in our example above.[5]

That Person viewed as a relation is interpreted in grammatical semantics does obviously not mean that Case is, too, when equally viewed as a relation. However, there appears to be no inherent connection between the relational meaning of Person (or other φ-features such as Number) and the notion of argument: A word marked 1P need not be an argument or be referential.[6] So where does the argument relation come from? We cannot obviously assume that arguments are somehow simply given by logic. Nor does a semantics require them, which could in principle operate with adjunct relations alone. Could this, then, be the meaning of Case? I have suggested (Hinzen 2014) that the key to the answer to the distinctive grammatical meaning of Case indeed lies in the *formal-ontological distinctions* that systematically arise as and when words become grammatical arguments that as such enter the event- and proposition-denoting, hierarchically ordered phases mentioned earlier. The generation of thought content with such a formal ontology appears to *depend* on relations interpreted morphologically as Cases. In the absence of argument-positions, which do not exist in Minimalist grammar, Case is the only thing that *yields* argument relations: Thematic roles, in particular, exist in the adjunct system and *require* no arguments. It is unclear, too, how Agreement between features could yield such relations. Predicativity, argumenthood, and referentiality are not *lexical* features: no predicate, referential expressions, or argument exists in the lexicon. Like "referential" or "predicative," "argument" is a theoretical term denoting how a given constituent – noun or clause – *grammatically functions*, which it can only do *relationally* (as opposed to intrinsically), and only at the *stage* in the derivation where the relation is established.

Consider, then, some specific argument relations mirrored morphologically in Case features, following standard assumptions in that all arguments are introduced by dedicated functional (applicative) heads (e.g., Appl as in Pylkkänen 2008): e.g., normal agentive subjects by an active Voice head, interpreted causatively, and indirect objects by an applicative head Appl:

(16) $[Voice...NP_3...[Appl...NP_2...[v\text{-}V...NP_1]]]$

A formal ontology is generated *alongside* such licensing. Thus, licensing NP_1 in relation to $v\text{-}V$ gives rise to an *event* or *state*. Voice/v gives rise to a more complex event, of which the previous event or state now becomes a part.

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[5] Thus the word *speaker* carries lexical content, and its lexical content indeed relates to events of speech. But it cannot as such express that some particular event of seeing has an agent identical to a speaker involved in an act of speech. Such meaning arises only in grammar.

[6] Cf. the sentence *I am me*, where the 1P is in an argument position and the second (arguably) in a predicative one.

This process is interpreted morphologically in terms of Case-marking, as (17) illustrates, where different kinds of Voice-*v* head constellations generate different Case-marking patterns in the resulting full sentences, correlating with a difference in the formal ontology of meaning:

(17) a. We [Voice$_{ACT}$-*v* killed **him**$_{ACC}$]
     b. **He**$_{NOM}$ [Voice$_{PAS}$-*v* was killed]
     c. **He**$_{NOM}$ [Voice$_{UNACC}$-*v* died]

In (17a), the relation expressed by ACC is that between the internal argument and the verb, which together yield only a grammatical *predicate* but crucially no truth value (*killed him* is not true or false). By contrast, in (17b), NOM expresses the relation between an external argument and the (finite) verb, which *does* correspond to a truth value and a full propositional claim: A formal ontology is generated, which has nothing to do with thematic roles, and for which Person does not account (though Person-relations are always involved in a propositional claim). In (17c), NOM similarly expresses cross-phasal dependencies, but the fine structure of the formal ontology is different, with no transitivity/agentivity implied. Case morphology therefore *reads* argument relations. These are non-local dependencies arising when one phasal unit (DP) crosses into another phase, *v* or C, becoming an argument. This happens irrespective of thematic roles, which are identical in the case of *him/he* in (17a–b), where, instead, the NOM/ACC difference on this argument tracks different cross-phasal relations into which this nominal enters, with interpretive consequences. Movements "for Case reasons" therefore are interpretable.[7]

NOM and ACC, then, are among the morphological features that interpret grammatical relations arising as cross-phasal dependencies between the nominal, on the one hand, and *v* and C, respectively, on the other. In all three cases above, the grammatical relations marked by these Cases are

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[7] An anomymous referee notes an interesting case in point from Japanese, where ditransitive *oku-ru* 'send' can take both a goal argument case-marked by *-ni* (1a) and an adjunct with the postposition *-e* (1b):

(1) a. Taro-ga   Hanako-ni   hana-o   oku-tta.
      Taro-Nom   Hanako-Dat   flowers-Acc   send-Past
      'Taro sent Hanako a bunch of flowers (and she received it).'
   b. Taro-ga   Hanako-e   hana-o   oku-tta.
      Taro-Nom   Hanako-to   flowers   send-Past
      'Taro sent a bunch of flowers to Hanako.'

According to Miyagawa (2012), in (1a) but not (1b), the event that Hanako received a bunch of flowers is entailed. (1a) therefore involves a more complex and complete event, unlike the latter example, suggesting that case *-ni* plays a role in this increase in formal-ontological complexity while leaving thematic event structure untouched. Miyagawa suggests that an applicative head assigning the Case in question is responsible for this difference. I am thankful to the referee for this illustrative observation.

both interpretable and interpreted, and they mean that a DP has undergone relational licensing with respect to a higher head with a different formal ontology: either the first phase (v) into which nominals enter (the edge of the verb), or C-T, the edge of the clause. Such licensing is therefore not merely formal, and movement into the v and C-domains has to do with *reference* acquiring its proper formal ontology. As the phasal boundaries are crossed, the formal ontology of the denotation of the expression changes, first giving rise to an event denotation complete with a participant and exhibiting Aspect, and then to a proposition with a truth value. In this way, the progression from D (the functional edge of the nominal), to v, and to C, is a phase-by-phase progression, from objects to events to finally propositions (or propositionally complete speech acts), which are the end and outer limit of the grammatical process. Relations marked by the Cases thus span the universe of grammatical meaning.

It follows that if, as Chomsky (2001) maintains, the phases are Case domains – domains within which they have to be checked, in his terms – Case is rationalized, and the task we have set ourselves here is accomplished: Case will be interpretable because phases are Case domains, and phases are interpretable in terms of the formal ontology of semantics as arising grammatically (and never lexically). The phasal dynamics is not a purely formal process of deleting uninterpretable features. Note that there is no entailment here from the existence of grammatical relations visible as morphological Cases to the idea that Cases are (possibly abstract) *features* that figure as such in narrow syntax (whether abstract or not). Case relations will only reduce to (matching relations between) lexical features, if we endorse such a reductive view. There is therefore no such requirement either as a one-to-one mapping between specific abstract Cases in syntax and their morphological correlates. In fact, the "Case-chaos" noted by Sigurðsson (2012) is what we expect: Grammar is a purely relational system. The relations as such can obtain whether or not they have any morphological reflex. Where they have one, we expect that such a relation can be marked either on the noun or the verb, or both or neither, in language-specific and variable ways. If the relations are marked, moreover, it is the relations, not the features, which are interpreted. Nothing is uninterpretable in syntax; nothing needs to be checked before the interface. Everything is as it should be; no cleansing of syntax is required.

4   Case, Reference, and Tense

This approach predicts that principles of Case assignment should reflect the build-up of referential meaning in grammar. Such a connection between Case and referentiality would make initial sense of the fact that Case is paradigmatically assigned to nominals: referentiality is connected to nominality (though

not the same notion). Second, the most obvious fact about PRO, which has been so central to Case theory ever since it appeared to be escaping from the Case filter, is that while controlled PRO is referential (sharing the reference of the controlling nominal), PRO, being non-overt, *ipso facto* and necessarily lacks referential independence: No *independent* referent is introduced into the derivation and needs to be licensed to an event-denoting head or proposition. The clause that contains it is destined never to become a truth-denoting proposition, remaining dependent on another clause that will bear the truth value. The answer to a basic question of classical GB-Case theory, why Case assignment should be sensitive to phonetic content, would now also be immediate: In nominals, reference can be maximally or minimally dependent on lexical descriptive content. But where there is *no* lexical content, there is *no* referential independence, and it is rational to expect that PRO might escape from normal Case requirements in English-type languages.

Third, it is now expected that *clauses* should be exempt from the Case filter, as the contrast between **John is proud [his son]* and *John is proud [that his son won]* suggests, for clauses do not canonically refer to objects. It also falls into place that where they come closest to being referential, namely in the factive case, they should *have* to pass the Case filter – and indeed they do, as argued in Kitagawa (1986) and Boskovic (1995).

Fourth, it now becomes unsurprising why languages that do not (or barely) mark Cases on nouns, like English or German, nonetheless mark them on pronouns or determiners: For pronouns are paradigmatically referential devices and determiners have long been regarded as regulating the referentiality of the common nouns to which they attach.[8] Moreover, ACC and DAT morphology shows up obligatorily in the relational interpretations of strongly referential (deictic and personal) object clitic pronouns in Romance, rather than in clitics picking up the reference of weakly referential or predicative nominals, or of embedded clauses that function as predicates (Martín 2012). In general, canonical accusative Romance object clitics *can* but *need* not refer to specific objects or persons, while dative clitics *must* be object-referential and have a deictic and personal interpretation (i.e., 1st Person or 2nd Person, hence targeting speech participants). As argued in Martín (2012), it is the latter that are grammatically more complex, properly *containing* the phrasal complexity of accusative clitics. In other words, as we move from predicative and neuter clitics deprived of any φ-features, which cannot be referential, to accusative clitics, which *can* be referential, and then to personal and dative clitics, which *must* be referential, grammatical complexity increases, mirrored in the sequence of Cases assigned, and referentiality does as well (Martín & Hinzen 2014). Outside of the world

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[8] Consistent with this, the augments on nominals in Bantu languages that seem to be inherently Case-bearing are often said to be D^0-categories and to be semantically/pragmatically linked to such notions as definiteness and specificity (see e.g. Taraldsen 2010).

of clitics, too, it has often been noted that ACC tracks definiteness as opposed to quantificational or indefinite readings in languages with morphologically rich Case systems like Finnish (cf. Belletti 1988; Kiparsky 1998).

Fifth, it is now also expected that the exceptional (ECM) accusatives would show up in clauses that are referentially weak, incomplete, and dependent, lacking finiteness, referential independence, and deictic anchoring in the speech context. For in this case the phase boundary of the embedded clause remains penetrable from the outside – an independent Case domain is not demarcated – and therefore an exceptional Case, assigned by *v* from within the next phase, can enter. When the embedded clause is projected further and includes a C-layer, on the other hand, making it referentially more complete, such exceptional marking becomes impossible again:

(18) I *v* hope [$_{CP}$ C (*John) to be at the door]
(19) John tries [$_{CP}$ C (*Mary) to like French toast]

Once again, on the other hand, ECM is predicted to be illicit in *factive* complements, under the assumption that factivity is as close as embedded clauses can come to being referentially complete and truth-denoting, short of occurring as matrix assertions (Sheehan & Hinzen 2011). And indeed, as Kiparsky and Kiparsky (1970) noted, in the canonically factive (20), ECM into the embedded clause is ruled out:

(20) *John regretted/resented Mary to be pretty.
(21) John believed Mary to be pretty.

We may be looking, then, at a hierarchy of referential completeness or strength, now in non-finite embedded clauses. Raising is lowest in the hierarchy: The embedded clause can never incorporate any Case on its subject; it never becomes a Case domain, whether the Case comes from the inside or outside (22). With ECM verbs, the embedded domain gets a subject, but only a subject of sorts, since it is also or really an object of the matrix verb. A Case can penetrate the lower domain, as long as the clause is not fact-referential, yet the Case does not come from within its domain yet. Moreover, it lacks its own independent Tense (23):

(22) Mary seems *t* to be pretty.   RAISING
(23) I believe her to be happy (*tomorrow).   ECM

Next, with Control verbs, the embedded clause has its own independent subject, though it is still lexically non-overt. Temporal independence now becomes possible (24):

(24) I hope/try PRO to be at the door tomorrow.   CONTROL

It would make sense, therefore, too, that in a variety of languages, including Icelandic and Russian, PRO subjects can not only carry Case but carry their own *independent* one: At this level of complexity and referential independence,

the embedded clause has become its own Case domain. Thus, in Icelandic, the mechanism of Case assignment is arguably different in raising and control, with Case independence in the embedded clause only in control, and Case assignment arguably independent of A-movement (Sigurðsson 2008:420; see also Ndayiragije 2012; Wood 2012). For Russian, Landau (2008) has argued based on patterns of Case concord that PRO can be licensed by the head of the embedded clause. However, Landau argues that such Case independence in the embedded clause is limited to *tensed* infinitival contexts, namely contexts where an embedded clause can be modified by a temporal adverb like *tomorrow*, which indicates a different temporal anchoring from the one in the matrix clause. Only where embedded clauses are tensed is PRO case-licensed within the non-finite clause, illustrating a correlation between referentiality, finiteness, and morphological Case.

Why should Tense matter? Because Tense is essential to the referential anchoring of objects, events, and propositions. Whenever a clause is tensed so that it has its own temporal reference, it is to that degree referentially more complete and it needs and can take a subject – its phase can in this sense "close." As a phase completes and referentiality is established, argument DPs need to enter licensing relations with the heads that denote entities of which they become parts. High or NOM-case is associated with the establishment of propositional claims, which depends on the high left field of C, where speech features and force are checked (Sigurðsson 2004, 2008). Such checking ultimately requires finite Tense. Without it there is no full proposition and there is no complete speech event.

Consider, finally, an example from Uriagereka (2008:107). At first, (25a) and (25b) seem semantically identical in English, assuming that *that* replaces *to lose weight*. Yet, when we inspect their respective translations into Basque, we see very different patterns of Case assignment in the two cases (26):

(25) a. I tried [PRO to lose weight]
     b. I tried that.

(26) a. Ni   [PRO pisua   galtzen]   saiatu   naiz
        I.ABS   weight-ABS   lose-nominalizer-LOC try-PART   I.be
        'I have tried to lose weight'
     b. Nik   hori   saiatu   dut
        I.ERG   that-ABS   try-PART   I.have.III
        'I have tried that'

(26b) exhibits regular transitive Case typology. The transitive *saiatu* ('try') goes with the transitive auxiliary *dut*, which codes Agreement with both the ergative (ERG) subject *nik* and the absolutive (ABS) object *hori* ('that'). Where the syntactic argument of *try* is the clause, however, as in (26a), the auxiliary is *naiz*, which is unaccusative like English *be*, assigning no ACC. It now only agrees with the absolutive subject *ni*. In short, the regular Case/Agreement

system is not activated in (26a), and the embedded clause is treated as a domain invisible to Case assignment. No change of content seems to be involved. Or is it? Deictic *that* is paradigmatically referential in this context, whereas *PRO to lose weight* refers to no object, and is not even evaluable for truth and falsehood, failing to express a full proposition with its independent truth value.

Moreover, as Uriagereka (2008) notes, the switch in the Basque Case system in question is not confined to PRO complements but extends to other referentially weak clause types, such as subjunctives. Thus (27a) lacks PRO, yet still the matrix verb acts in the intransitive fashion, whereas, in (27b), which is a normal transitive with an indicative complement, the normal Case system appears again:

(27) a. Jon   [Mirenek   pisua   gal zezan]   saiatu   zen
        Jon-ABS Miren-ERG weight-ABS lose have-subj-LOC try-PART III.be
        'John tried that Mary lose weight'
     b. Jonek   [Miren   polita dela]   pentsatzen du
        Jon-ERG Miren-ABS pretty   is-COMP think-PART III.have.III
        'John thinks that Mary is pretty'

(27b) has a fully propositional complement, in the sense that the content of John's thought is either true or false. But no such propositional complement exists in (27a), and the clause as a whole is not recognized as an object of normal Case assignment, leading instead to the same curious locative Case specified on the clause that we see in (26a). The only element that activates the Case is the referential subject of this clause, which thus comes out unaccusative, being marked ERG. The fact that, nonetheless, we find *some* Case in the non-finite or subjunctive clauses concerned suggests, moreover, that *whenever* there is an argument, the Case system is activated in some way. Which Case is involved depends on the referentiality of the argument, with null Case reserved for referentially low-key elements like non-referential clauses or PRO, and canonical definite DPs marked positively for Person as the canonical candidates for structural Case, as opposed to indefinites, verbal predicates, or clauses, which carry no personal interpretations (cf. Uriagereka 2008:110, 124–126).

This line of thought extends to the Case called *partitive* in Belletti (1988), which she argues is assigned by unaccusative verbs as well and locally at the VP level, corresponding to indefinite and impersonal nominals:

(28) a. Poeydaellae on kirjoja.
        on the table is (some) books(PART, PL)
        'There are some books on the table.'
     b. Helsingistae tulee   kirjeitae.
        from Helsinki comes (some) letters(PART, PL)
        'There come some letters from Helsinki.'

The lack of licensing of definitely referential nominals through such Cases has effects on what kind of event is referenced. The matter has been classically described in terms of verbal Aspect, as in Kiparsky's (1998:1) statement that, "in its aspectual function, partitive case is assigned to the objects of verbs which denote an *unbounded* event," as illustrated in (29) (Kiparsky 1998:3):

(29) a. Ammu-i-n   karhu-a/   kah-ta   karhu-a/   karhu-j-a Finnish
        shoot-PAST-1Sg bear-PART / two-PART bear-PART/ bear-Pl-PART
        'I shot at the (a) bear / at (the) two bears / at (the) bears.'   (activity)

    b. Ammu-i-n   karhu-n /kaksi karhu-a /   karhu-t
        shoot-PAST-1Sg bear-ACC/two.ACC bear-PART/bear-Pl.ACC
        'I shot the (a) bear / two bears / the bears.'   (accomplishment)

In Finnish, predicates which are inherently unbounded almost always assign PART to their complements, which is part of a more general typological trend (Travis 2010:136). Prima facie, the difference between (29a) and (29b) relates to *reference*: A specific single bear or several specific bears are said to be shot and killed in the latter, but not the former. As a result also a specific event is being referenced, involving one or more specific bears, all of which end up shot (and possibly dead), reflecting a *state* in which the event in question pans out. In the former case, no specific bear is referenced, and any bear involved may have escaped unscathed. ACC-marking in this sense reflects a shift in reference: An object is licensed to an event in both cases, as part of a V-DP dependency. But the progression from PART to ACC suggests an increase in referentiality, analogously to the case of Romance clitics above, with ACC assigned by *v*. In a similar spirit, de Hoop (1996) takes *v* to assign ACC to arguments specified positively for Person, while V assigns impersonal null Case to indefinite arguments. This is a related progression, from indefinite to definite/personal, reflecting both a progression in referentiality and a grammatical progression within the verbal phase (see also Uriagereka 2008:124).

In sum, while it does not seem hopeful to rationalize Case in either lexical semantic or thematic role terms, the recognition that there is another kind of meaning, which is uniquely referential and uniquely organized grammatically, has the potential to make patterns of Case assignment appear in a quite different, novel, and more rational light. The generalization is that an increase in the *formal-ontological complexity* of meaning and relevant part–whole relations entailed by it is tracked by an increase in *grammatical complexity*, as reflected by morphological Cases.

5   Conclusion

As grammar is universal in neurotypical humans and a boundary that the animal mind has only crossed once in evolution, a general grammar in the traditional sense remains one of the most intriguing of scientific enterprises

around. But what is its content, if we abstract from what is language-specific? The hierarchies that show up everywhere the moment we look at structure-building in language are not of a purely generic sort but are deeply contentful. They may provide the formal ontology as such that is an intrinsic element of human-specific referential thinking and inseparable from the specific meaning that grammatical organization yields (Hinzen & Sheehan 2015). We cannot but use language referentially – to think or talk about the world, no matter what other functions we also use language for. As grammar starts acting on lexical concepts, phasal units arise that come with referential potentials depending on their respective complexity. Licensing referential arguments involves the crossing of phasal boundaries when nominals enter event- and proposition-denoting phrases. The resulting cross-phasal dependencies come with inter-pretive correlates in the formal ontology of semantics that has to be in place in order for a rational mind to exist. This ontology is reflected in normal Case-assignment patterns, which become non-normal or exceptional when the full referential potential of phasal units fails to arise, or grammatical arguments are non-object-referential. Insofar as it is so reflected, Case is rational and part of the substantive content that grammar has as a scientific domain.

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9   The Warped Forge

Pablo Bustos and Juan Romero[1]

1   Categories and Porous Modularity

In this chapter we argue that our concepts, in a pretheoretical sense, have some properties that are (i) independent of the cognitive module that makes use of them, and (ii) expressed in a format such that they can be used by any cognitive module. We will refer to the concept format as its category. We will argue that this format is structural in nature. Consider, for instance, an orange. The fact that it is edible is not relevant from a visual or linguistic point of view (although it is definitively important; see Heinrich 2015); being orange, on the other hand, is visually important, but linguistically it is not. The fact that it is a noun has linguistic consequences, but not visual ones. All of these properties, as important as they are, are module specific: they are not categorial in the sense argued for in this chapter. On the contrary, having a form or being a mass has consequences for the whole system. As a noun, there is some specific syntax for each of them (*many–much*); for vision, both kinds of objects (mass versus form) require different detectors. When planning, an orange can be picked up and a container is not needed; but water needs one. In this chapter we propose that general properties of this kind, to which we will return, are a by-product of the categorization procedure. Categorization allows concepts to be used by cognitive modules in a bare-phrase-structure fashion, i.e., categorial properties are fully interpretable by all modules.

Historically, language provides prototypical examples of categories. However, as observed by several scholars (Uriagereka 1996; Baker 2003), linguists do not really know too much about them, up to the point that for

many researchers, especially in the Distributed Morphology field, grammatical categories have actually become a nuisance, redundant features in the computational component.[2] According to this prevalent view, items in the lexicon are roots, whose category is specified when they are related to categorization heads. These heads serve the purpose of mediating between a root and a certain functional architecture. When a root $\sqrt{}$ is inserted under a node *n(oun)*, it is going to be also related to definiteness, number, gender, mass, etc.; but if it is inserted under a *v(erb)* node, it will relate to tense, person, etc. In its more radical (and coherent) interpretation, lexical information is not accessible at all by the computational component (see Borer 2004 or Embick 2015 for a detailed implementation). This view finds support in the fact that for most authors grammatical categories do not seem to play any specific role either in the syntax, or in the semantic component, and it is furthermore consistent with the idea that morphological operations take place along the syntactic computation.

Following seminal ideas proposed by Uriagereka (1996), we argue, on the contrary, that categorization is an inherent property of concepts in a broad sense. We understand categories as kinds of affordances that encode those properties of objects that allow us to conceptualize them. In other words, the categorization problem is to ascertain how we, as sensorimotor systems, *manage to detect those kinds that we can and do detect* (Harnard 2005). Furthermore, the solution we give to this problem has to be compatible with the fact that information is an input for the different modules in our mind/brain (vision, language, motor, etc.), and what each module does is an output to all the others, therefore affecting how concepts behave globally. In other words, objects get in and out of the different modules in our mind/brain, and the way they are changed and shaped by each of them has to be encoded in a format understandable by the rest of the modules. Each module contributes to our cognition, supplying the information it is able to compute. One elegant solution to this problem is the idea that modularity is *porous*:[3] The format defined by categorization allows objects to get in cognitive modules essentially in the same way as defined in Chomsky's Bare Phrase Structure. According to this Minimalist hypothesis, there are no specific interface conditions because interfaces are only permeable to certain properties. On the other hand, it is not that categorization has to be sensitive to interface conditions, but interface conditions are derived from categorization. In this sense, the categorization procedure conforms to the general architecture of the cognitive system.

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[2] See Embick (2015) and references therein. The content of this chapter refers, in Embick's words, to those "significant universal constraints on what could be a possible root in human language; particularly with respect to what kinds of meanings could be associated with a root" (p. 8).

[3] Although focusing on somewhat different aspects of cognition, this notion somehow relates to *fluidity* in the sense of Hofstadter (1995).

A modular architecture of this kind could be engineered with the necessary computational dynamics to show basic representational capabilities (Bustos *et al.* 2015). Objects would be instantiated by the modules creating a graph of entities and relations representing the internal (self) and external (world) states. Its basic functioning can be readily explained if we imagine it as a large dynamical system in which the existing modules struggle to keep a synchronized, predictive representation of the self and the world, against the unavoidable drift caused by non-ideal measurement devices and limited available knowledge. Modules create objects to anticipate changes occurring in the world, and information from sensors validate or correct these cognitive hypotheses. Both *forces* interact to keep the whole system close to an equilibrium, active and expectant at the same time, and always adapting and learning new representations (configurations of concepts) that minimize the prediction error (Hohwy 2013).

Since they have to be readable by systems that serve very different purposes, and they work with different kinds of objects, we assume that interface conditions are structural in nature. Consider, for instance, the multiple spell-out model as a purely structural condition (Uriagereka 1999 and subsequent work): once a structure cannot be ordered by asymmetric c-command, it has to be handed over to PF. This property, asymmetric c-command, can be derivationally determined, and essentially corresponds to a situation where a complex XP (a non-trivial maximal projection) is inserted as a specifier of a head-complement relation. In other words, if the structure does not satisfy this condition, it is not readable by those components in charge of its articulation/perception. Note that this condition restricts the range of possible syntactic objects and therefore has obvious interpretive consequences.

According to this line of reasoning, we assume that categorization reflects the geometry required by our cognitive system to conceptualize objects, their dimensionality in Uriagereka's (1996) terms. As in the previous case, dimensional structure restricts both object's range (dimensionally discrete objects) and interpretation (dimensional structure conforms an implicational hierarchy). Regarding objects, categorization expresses the dimensions required to create a concept according to the way we relate to it: singularity (1D), extension (2D), form (3D), movement (4D), and will (5D). Labels assigned to each dimension in the structure are just as mnemonic devices relating to those labels used in physics (except for 5D). From a theoretical perspective, this geometry is understood as a common format that makes concepts usable by our highly modular cognitive system. In terms of learning, different affordances require different dimensional spaces in order to be represented. A *table* does not require a 4D representation because it is spatiotemporally stable, but a *horse* does, because it has autonomous movement and changes over time.

If correct, we expect that empirically this geometry can explain the way concepts operate in different cognitive systems and somehow determine how

these systems work and interact. This does not mean, in any way, that we are arguing for a general learning machine. Each domain is properly structured to solve its own problems, and there is a certain amount of information specific to it. In the case of the faculty of language, conceived as the species-specific ability to acquire any human language (Berwick & Chomsky 2016), it deals obviously with a specific task. Although we may share cognitive abilities with other species, this one is within our grasp alone, and in consequence it cannot be addressed, at least completely, with a general learning device. Consider, for instance, the categories previously defined. All of them are expressed by the faculty of language as nouns. As said, being a noun, with its specific functional architecture, is linguistic information with no obvious correspondence in other modules (what does it mean to be a noun for vision?). In part, this is so because among nouns there are items that do not seem to have been created according to the proposed categorization procedure; for instance, eventive deverbal nouns. In other words, being a noun or a verb is a linguistic, not a cognitive, property; it mostly matches the items with the dimensional structure proposed, but this is not a necessary condition for being a noun.

Although more compelling evidence is needed to translate this proposal to the perceptual or action modules, recent computational developments in inductive learning from massive data sets show that more complex categories, in this dimensional sense, are easier to recognize than simpler ones.[4] Putting it another way, low-dimension objects need more context to be recognized than higher ones. People can be detected and tracked in their full articulated form and even recognized quite robustly, but less featured objects, such as water, sugar, or dirt, need a surrounding context to pop up. In a similar fashion, objects in higher categories such as movement or will, having a more complex internal structure, require more sophisticated computational resources to *fill up*. For example, a person can be readily recognized from sensorial data, but to complete all the properties of its object representation (emotional state, gaze, activity, voice pitch, conversational attitude, etc.) a great deal of interaction among other modules is required. Even more sophisticated computations would be required to instantiate a concept belonging to the *will* dimension, since a change of perspective to the person's point of view is probably required. An interesting experiment would be to relate error recognition rates in state-of-the-art deep learning systems, such as Clarifai, to the dimension of the objects being recognized in the images. The dimensional hypothesis would predict a decrease in error with the increase of dimension. Returning to the porous modularity idea and its computational architecture, the instantiation of complex objects entails deeper perturbations in the system, with modules striving to

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[4] Try, for example, uploading images to the Clarifai website to test this assertion in a state-of-the-art deep learning network (www.clarifai.com).

complete the many empty facets of the object, while simpler categories might only require enough context previously represented so they can be essentially inferred.

Here we restrict ourselves to the analysis of 5D concepts that we have termed *will*. First of all, when we say that an object is a 5D object we mean it in a physical sense; that is, the affordances of certain objects, typically human beings, have to be expressed by our cognitive system in a five-dimensional space. Our way of approaching 5D is based on the *theory of mind*, as proposed by Baron *et al.* (1985). That is, this "warp," as it is put by Uriagereka, is required to explain how we impute beliefs to others and predict their behavior. This is something we do with humans, but that, putting our pet aside, we do not do in general with other species. We have termed it *will* because once we are able to compute alternatives, we are in principle free to follow any of them. Therefore, this fifth dimension has deep cognitive consequences related on the one hand to consciousness and freedom and, on the other hand, to cultural evolution (Heinrich 2015). Nevertheless, 5D objects are the more complex items, and therefore the more specific, which has important consequences for learning.

In sum, categorization aims to deal with interface problems within a modular system where information is perceived by different senses, each of them analyzing different kinds of physical signals (visual, tactile, etc.). In order to integrate this information in the brain, this categorizing procedure imposes format restrictions on the objects that our mind can manipulate. In other words, it determines the number of dimensions needed to represent each object or, more precisely, needed for our brain to implement a temporarily coherent representation of the external world. The purpose of this chapter is to show how this format affects linguistic and visual/planning systems. We focus on 5D objects because, as it has been mentioned, there is one obvious sense in which they require to be independently categorized: Speech modules are used only to address humans.[5] Therefore, for instance, a plan may include a linguistic interaction for which it is first necessary to identify a proper participant.

2   Cognitive Categories in Language: The Case of Animacy

According to what we have said, and putting aside derived words, category information cannot be determined in the syntax because it comes along with the concept: X is an N, a noun, not because it combines with an *n* head, but because (i) X has certain properties that are independent of its use in the computational component, and (ii) those properties are assigned to the nominal category by the faculty of language. The reason why language expresses morphosyntactical

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[5] In a much more limited sense, it can also be used with some domestic animals, a fact that can at least partly explain the fuzzy limits we find to define animacy.

categories such as noun, verb, or adjective is beyond the scope of this chapter. Several proposals have been made in the last fifteen years after Hale and Keyser's (1992) insights on this issue, each one focusing on different aspects of their use. We suspect that Hale and Keyser's proposal in relational terms is essentially right, but for the purposes of this chapter it suffices to say that it is an empirical fact for underived nominals. Once the syntactic machinery is set to on, it can, for instance, transform a noun in a relational adjective or in a verb, but its status as a noun in the first place, as a root, is independently achieved.

Consider the case of animacy in its more restrictive use, i.e., animacy as human. Animacy is a property of nouns; there are no human verbs or adjectives. There are verbs and adjectives that take, at least in its literal sense, human arguments (*murder*, *procrastinate*, *ambitious*),[6] but it would not make any sense to categorize these lexical items as [+human], because they do not behave in a particular syntactic way for this reason. However, here we are going to show that this is indeed the case for nouns: Animacy is relevant for the computational component when X is a noun, and, since animacy is an extralinguistic property, being an animate noun is therefore lexically determined. In other words, the inner workings of the computational component do not motivate the use of the label [+human] to any category other than noun.

We know animacy is involved in many different linguistic processes. Here we are going to briefly mention four different processes that arguably take place in the computational component and involve animacy: Differential Object Marking, strong pronouns, psych verbs, and denominal verbs.

2.1   *Differential Object Marking*

Consider first Differential Object Marking (DOM). In many languages DOM is sensitive to animacy: among objects, only those that are [+human] receive DOM. Ormazabal and Romero (2013) argue that DOM is determined in the syntax, and it is not a simple morphological disguise, as shown, for instance, by the fact that it triggers scope asymmetries (López 2012). Furthermore, while non-DOM NPs can raise to subject position in SE constructions, this option is not available for DOM NPs (see (1)–(2)).

(1) a. Quemó los barcos
         burned.he the ships
         'They burned the ships'
     b. Los barcos se quemaron
         the ships SE burned.3pS
         'The ships were burnt'

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[6] We do not intend to say that they *select* human arguments, but merely that they relate to human arguments as part of our encyclopedic knowledge.

(2) a. Quemó a los prisioneros
       burned.he DOM the prisoners
       'They burned the prisoners'
    b. Se quemó/*quemaron a los prisioneros
       SE burned.3sS/burned.3pS DOM the prisoners
       'Prisoners were burnt'

Traditionally, the contrast between (1) and (2) has been "solved" by naming those constructions differently: passive and impersonal. However, the belonging to one or other group depends on whether the object receives DOM or not, which, in turn, depends on its animacy.

2.2   Strong Pronouns

Among other properties, strong pronouns in Spanish are interpreted only as animates when they occur in a position where an empty pronoun is also licensed (Montalbetti 1984). Since strong pronouns are more complex than empty pronouns, it can be argued that they are assigned human interpretation because, according to our proposal, this interpretation is the more specific one (see (3)–(4)). Note that, as shown in (4), in Spanish the same pronoun is used for both animate and inanimate arguments; there is no *it* in Spanish.

(3) a. La piedra cayó
       the stone fell
    b. María cayó
       Maria fell
    c. Ella cayó
       she/*it fell

(4) a. Salieron de la tienda sin la piedra
       get.out.they of the shop without the stone
    b. Salieron de la tienda sin María
       get.out.they of the shop without Maria
    c. Salieron de la tienda sin ella
       get.out.they of the shop without her/it

However, this cannot be the whole story, since these data can be replicated in contexts where there is no silent alternative available, for instance in nominalizations (see (5)).

(5) a. La caída de María/la noche
       the fall of Maria/the night
    b. La caída de ella
       the fall of her/*it
    c. Su caída
       her/its fall

Independently of how we deal with (5), the fact that a silent pronoun cannot be inserted as P complement in (5b) forces us to reject an interpretive approach: although there are no silent alternatives to the strong pronoun, it can only be interpreted as animate. If, for instance, a Principle C violation has to be avoided, we have to resort to a prenominal possessive pronoun (5c). Since *ella* (3rd person feminine) may receive a [−animate] reading in (4c), the only way to constrain its interpretation to a [+animate] one is to assume that the pronoun is entering in a Case/agreement checking relation, maybe a genitive one, as in (3). Be that as it may, this checking relation has to be sensitive to animacy in order to explain the contrast in (5b).

2.3   *Psych Verbs*

The behavior of these verbs has attracted a lot of interest among those linguists working on argument structure. It has been generally argued that these predicates have a specific θ role in their thematic grid, an EXPERIENCER. EXPERIENCERS stand for the person that is psychologically affected by the event. In consequence, an inherent property of this thematic role is to be human. As shown in Ormazabal and Romero (2007, 2013), animate internal arguments trigger a panoply of syntactic effects, such as the Person Case Constraint. However we deal with contrasts as the one exemplified in (6), we need animacy to be active in the computational component, whether to define EXPERIENCER, or whether to explain the interaction between Case and thematic interpretation.

(6) a. Mary.EXP/SUJ likes chocolate.OBJ
     b. a Mary.EXP/IO le gusta el chocolate.SUJ

2.4   *Denominal Verb Formation*

Consider, finally, the case of derivational morphology. It is generally assumed that not every combination between a functional head and a root is possible (see, for instance, Embick & Marantz 2008). The way we can restrict it is unclear. In a survey of denominal verbs in Spanish, we have found only three instances of verbs derived from animate nouns: *carpintear* ('work as a carpenter'), *panadear* ('work as a baker'), and *capitanear* ('to captain'). Putting *capitanear* aside, the other two verbs are quite interesting. In both cases, the suffix used to derive animate nouns from inanimate ones, *-ero*, has been ripped off from the base: *carpint-ero* and *panad-ero*. The first example is especially interesting because *carpintero* is not a derived word, it comes from the Latin word *carpentarius* ('carpenter'). This fact can be related to the restriction observed in the literature about the inability of animate nouns to incorporate into the

verb in polysynthetic languages (see Baker 1996 and references therein). Note that this constraint argues both in favor of syntactic derivation for denominal verbs, since incorporation and denominal verb derivation are restricted in the same way, and in favor of lexical categorization, since animacy is the key factor involved in the constraint.

3   Conclusion

Following Uriagereka's insights about the way we structure our knowledge, we have argued for a "porous" modularity architecture where modules' interfaces are all transparent to certain properties of concepts. He shaped those properties in terms of dimensional structure. In this chapter we have shown that this hypothesis has quite interesting consequences, especially for linguistic categorization. Although in AI much work remains to be done, the kind of categories predicted by this model seems to be central to the way cognition is modeled when implemented in artificial systems. Some recent artificial cognitive architectures for robots are organized as a set of modules – also called *agents* – that share access to a common representational structure, usually implemented as a graph. These agents are designed to fulfill high-level functionalities such as visual interpretation, motor and movement control, or language processing, and the graph is designed to hold an updated and adaptable representation of the robot's internal state and the state of the world around it, including people. Porous modularity and the hypothesis of dimensionality can become a valuable tool to constrain the design space of these elements in artificial beings.

We have restricted ourselves to what looks like the more basic conceptual objects. In order to define events, we require relations between objects and their context: X being/doing Y, X in Y, X giving Y to Z, etc. These kinds of relations are essential for planning, and its definition is extremely sensitive to the interaction between the agent and the world. The problems posed by the need to anticipate changes in complex environments have been obscured by the fact that languages were there to interpret them, but they have become immediately apparent in artificial systems. Porous modularity is not only a conceptual solution but also a methodological one, because it provides us with tools to understand the way different cognitive modules are connected and can learn from each other.

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10   Limiting Semantic Types

Paul M. Pietroski

In a Minimalist spirit, Uriagereka and Pietroski (2001) wondered why human languages – the languages that children can naturally acquire – generate expressions that exhibit any substantive *hierarchies*, as opposed to expressions that are merely structured in a way that reflects some elementary combinatorial operation.[1] One can imagine a simple operation, UNIFY, that generates {α, β} given compatible expressions α and β; cf. Hornstein (2001, 2009). So if combining human expressions yields asymmetric phrases that are "labeled" in accord with a hierarchy of grammatical types, say with verbs dominating nouns, this calls for explanation. Likewise, if human expressions exhibit a thematic or Vendlerian hierarchy, one wants to know how and why our languages diverge from procedures that generate similar expressions that do not exhibit the higher-order patterns. Theorists are free to posit operations like MERGE, which generates *ordered* expressions: merging α and β yields either <α, β> or <β, α>; see Chomsky (1995, 2000). But even if other asymmetries can be reduced to this one, there remains the question of why mergeable things are instances of types that are *ranked* in a certain way.

In this chapter, I focus on an alleged hierarchy that would be hard to account for, except by abandoning the spirit of Minimalism and saying that the combinatorial properties of overt expressions reflect a prior and more powerful system of thought. Semanticists often suggest that human languages are like Frege's (1879) *Begriffsschrift* in having expressions of many semantic types, with names and sentences corresponding to the basic types of a recursively specified hierarchy. On this view, grammatical distinctions – between nouns and verbs, adjuncts and arguments, internal and external arguments, etc. – apply to expressions whose meanings exhibit an independent combinatorial typology. More specifically, the expressions of a human language are said to include *truth-evaluable sentences* of a basic type <**t**>, *entity designators* of a basic type <**e**>, and *unsaturated expressions* of types characterized by the recursive principle (R).

(R) if <α> and <β> are types, so is <α, β>

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[1] I am grateful to the first author of that paper for years of fruitful discussions and friendship.

I offer a sparer proposal according to which human linguistic expressions exhibit no such hierarchy, and almost no semantic typology, because meanings are only minimally relational. I end with a speculation about several respects in which human languages are a *little* more interesting than languages of an especially simple kind.

1   Concepts Before Meanings

When talking about semantics, it is important to distinguish several topics that are related in ways we don't yet understand: the meanings that human languages connect with pronunciations; the concepts naturally available to children, before and after they acquire such languages; and the concepts that (idealized) theorists use in formulating truth-evaluable thoughts.

I assume that many animals have concepts that can be combined to form thoughts. Mature humans may enjoy concepts that are unavailable to other animals; and even infants may often think about things in distinctively human ways. But in acquiring a lexicon, a child may connect pronunciations with at least some concepts that are available to our non-human cousins. As children acquire words, they may also acquire species-specific concepts; see Pietroski (2014, 2018). But it seems unlikely that humans are unique in having composable concepts.

The details presumably vary across species, and perhaps within individuals. But if only for initial exposition, let's suppose that *mental sentences* are evolutionarily ancient, and that at least many of these composite representations have Subjects and Predicates, as suggested by classical logics and grammars. Given a particular dog, Fido, a thinker might *think about it* in a certain way (e.g., as a dog that often barks at dusk) and *think that* it is hungry. Such acts of predication can be time-sensitive, and there may be many concepts of hunger, dogs, dusk, etc. But if only for simplicity, let's assume that, independent of human languages, biology supports Subject-Copula-Predicate thoughts like {FIDO IS HUNGRY} – or perhaps Subject-Predicate thoughts like {FIDO [IS HUNGRY]}, in which the Predicate comprises a time-indexing element and a classificatory concept like HUNGRY.[2]

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[2] Chomsky (1957, 1964) argued that the classical notion of *subject* plays no important role in characterizing the human languages he was talking about. And if expression labels are projected from lexical items, then it isn't clear that these languages generate *sentences* as such. (Projections of tense may be more like event-predicates, and so not truth-evaluable; projections of complementizers may be too perspectival, and not available for simple negation.) Frege argued that the sentences of an ideal language do not have Subject-Predicate structure. But many natural judgments may have such structure. Indeed, this may be the source of classical conceptions of sentences.

If thoughts are truth-evaluable representations of a special type **<t>**, then we can describe Predicates as (time-sensitive) representations that can combine with Subjects to form instances of type **<t>**. Abbreviating, we might say that Predicates are of type <Subj, **t**> or that Subjects are of type <Pred, **t**>. This choice invites a familiar cascade of questions concerning *conceptual* typology, even before we get to questions about how concepts are related to human linguistic expressions. Given thoughts like {[EVERY DOG] [IS HUNGRY]}, one wants to know if potential Subjects like FIDO and [EVERY DOG] exhibit a common type. Is FIDO a quantificational concept, akin to [EVERY FIDOISH-THING], or an *entity-designator* of type <e>? Is a Predicate an instance of type <e, t>? How should Predicates like [SEES FELIX] be accommodated? Do thoughts have constituents like [SEES [EVERY CAT]] and [EVERY [CAT THAT FIDO SEES]]? Or does grammar mislead us into thinking that each constituent of a sentential pronunciation indicates a concept?

Some of these questions bear on old discussions about how logic is related to arithmetic. The fifth positive integer is such that a suitably educated human can both *think about it* in a certain way (e.g., as the successor of Four) and *think that* it is prime. Humans can also entertain the thoughts that every integer has a successor, that there are infinitely many prime numbers, and boundlessly many other thoughts that exhibit logical relations not adequately characterized in classical Subject-Predicate terms. Motivated by such considerations, Frege (1879, 1884, 1892) characterized a space of concept types that would be available to an ideal thinker who had certain powers of *abstraction* in addition to the basic capacities required to think about particular things and (somehow) form thoughts about them. His leading idea was that formally new concepts can be abstracted from antecedently available thoughts.

If an ideal thinker can entertain the thought that Fido is hungry, then however she initially does so, she can – in part by using her capacity to think about Fido – form an "unsaturated" concept of being hungry; where by hypothesis, this concept exemplifies the abstract type <e, **t**>. If such a thinker can also form the thought that Felix is thirsty, then she can form an unsaturated concept of being thirsty; and this concept of type <e, **t**> can be combined with her singular concept of Fido to form the thought that Fido is thirsty, while her <e>-concept of Felix can be combined with her <e, **t**>-concept of being hungry to form the complete thought that Felix is hungry. The content of an <e, **t**>-concept can be represented as a function that maps entities to truth values, thus reflecting the role of "what remains" when an <e>-concept is abstracted from the content of a complete judgment that involved thinking about something via the <e>-concept.

Frege envisioned thinkers who can employ such abstraction in an open-ended way. When someone first entertains the thought that *every dog* is hungry, she may not use a concept of type <<e, **t**>, **t**>; there may be more natural

ways of thinking about the dogs as being among the hungry. But given the initial thought of type <**t**>, and an <e, **t**>-concept of being hungry, a Fregean abstractor can form an <<e, **t**>, **t**>-concept of universal-quantification over dogs. Given an <e, **t**>-concept of being a dog, or being doggish, she can also form a restrictable universal-quantification concept of type <<e, **t**>, <<e, **t**>, **t**>>; where the content of this doubly unsaturated concept can be represented as a higher-order function that maps ordered pairs of <e, **t**>-functions to truth values. Likewise, if a Fregean thinker can somehow entertain the thought that Fido *sees* Felix – perhaps by forming a tripartite representation that has a relational constituent – she can abstract an <e, **t**>-concept of seeing Felix, from which she can abstract an <e, <e, **t**>>-concept of seeing, where the content of this doubly unsaturated concept can be represented as a first-order function that maps ordered pairs of entities to truth values. Given the thought that Fido sees Felix, she can also abstract an <e, **t**>-concept of things that Fido sees.

Frege's focus on arithmetic and proofs by induction led him to develop a logic that imposed no parochial limits on abstraction; see Horty (2007) for discussion. Ideal thinkers can form concepts of the boundlessly many types that are characterized by the recursive principle (R),

(R) if <α> and <β> are types, so is <α, β>

given the basic types <e> and <**t**>. Church (1941) noted that this kind of abstraction can be encoded in his lambda calculus, which was designed to describe the full space of computable functions.[3] And for certain purposes, it may be useful to describe natural expressions as analogs of invented expressions that exhibit Fregean types. One can also pursue Montague's (1974) project of encoding algorithms that connect strings of English words with expressions of Church's calculus, subject to various stipulated constraints, perhaps with the goal of specifying "theories of truth" for human languages. But this hardly shows that human linguistic expressions have meanings that exhibit the types <e>, <**t**>, and the further types countenanced by (R). Yet even among those who view human languages as generative procedures, subject to natural constraints, Frege's model of an ideal mind is often taken to be a partial model of the linguistic competence that ordinary speakers enjoy; see, e.g., Heim and Kratzer (1998). I think this application of Frege's work is implausible.

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[3] But he also stressed the contrast between functions as *extensions* – sets of a certain sort – and functions as *intensions* or generative *procedures*. Church was mainly interested in the latter notion, given his focus on computability (and its relation to Frege's notion of sense). Chomsky's (1986) notion of "I-language," with 'I' for 'Intensional', is effectively Church's notion applied to functions that connect meanings with pronunciations.

2   Rapid Overgeneration

It's one thing to say that a human language generates boundlessly many expressions, endlessly many of which will never be formed. It's quite another thing to say that a human language generates expressions of boundlessly many types, only a few of which are ever exhibited by expressions that speakers can actually form. Syntacticians are rightly puzzled by the existence of multiple lexical categories; see, e.g., Baker (2003). Other things equal, we would not welcome a theory according to which every grammatical category begets many others. And it is worth being explicit about *how fast* the number of Fregean types grows beyond the first two.[4]

The basic types <e> and <t> can be described as constituting Level Zero of a hierarchy whose next level includes four types: <e, e>; <e, t>; <t, e>; and <**t**, **t**>. Each of these Level One types corresponds to a class of functions from things of a Level Zero sort – either entities in the basic domain, or truth values – to things of a Level Zero sort. Put another way, the <0> types are <e> and <t>, while the <1> types are the four <0, 0> types. At the next level, there are the new types that can be formed from those at the two lower levels:

eight <0, 1> types, including <e, <e, t>> and <**t**, <**t**, e>>;
eight <1, 0> types, including <<e, e>, e>> and <<**t**, **t**>, **t**>; and
sixteen <1, 1> types, including <<e, e>, <e, e>> and <<**t**, **t**>, <**t**, **t**>>.

So at Level Two, there are thirty-two types, each corresponding to a certain class of functions (from things of a Level Zero or Level One sort to things of a Level Zero or Level One sort). At Level Three, there are 1,408 new types that can be formed from those at the three lower levels:

sixty-four <0, 2> types, including <e, <e, <e, **t**>>>;
sixty-four <2, 0> types, including <<e, <e, **t**>>, **t**>;
one-hundred-and-twenty-eight <1, 2> types, including <<e, **t**>, <<e, t>, **t**>>;
one-hundred-and-twenty-eight <2, 1> types, including <<e, <e, **t**>>, <e, **t**>; and
one-thousand-and-twenty-four <2, 2> types, including <<e, <e, **t**>>, <e, <e, **t**>>>.

Level Four has over 2 million types: <e, <e, <e, <e, **t**>>>> and 5,631 more <0, 3> or <3, 0> types; 11,264 <1, 3> or <3, 1> types; 90,112 <2, 3> or <3, 2> types; and 1,982,464 <3, 3> types. (Compare the "iterative conception" of the Zermelo-Frankl sets; see Boolos 1998.) Let's not worry about Level Five, at

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[4] This section borrows from Pietroski (forthcoming).

which there are more than 5 x 10^{12} types. But it is worth thinking about Levels Three and Four.

Let 'e**t**' abbreviate '<e, **t**>', and consider the Level Three type <<e, e**t**>, **t**>. Functions of this type map functions like λy.λx.**Predecessor**(x, y) – i.e., λy.λx.T if Predecessor(x, y), and otherwise ⊥ – onto truth values. So following Frege, one can use invented expressions of type <<e, e**t**>, **t**> to encode various judgments concerning properties of first-order dyadic relations. For example, λy.λx.**Predecessor**(x, y) is not transitive, but λy.λx.**Precedes**(x, y) is; and these judgments can be reported with the invented sentences (1) and (2).[5]

(1)   ~TRANSITIVE[λy.λx.Predecessor(x, y)]
(2)   TRANSITIVE[λy.λx.Precedes(x, y)]

Fregean languages also support abstraction over dyadic relations: λ**D.TRANSITIVE**(**D**) maps λy.λx.**Precedes**(x, y) to T, while mapping λy.λx.**Predecessor**(x, y) to ⊥. Such languages also provide a logically perspicuous way of encoding judgments concerning relations among relations, and in particular, the judgment that precedence is the transitive closure or "ancestral" of the predecessor relation. Indeed, as Frege (1879, 1884) showed, the real power of his logic is revealed with expressions of the Level Four type <<e, e**t**>, <<e, e**t**>, **t**>> as in (3).

(3)   **ANCESTRAL-OF**[λy.λx.**Precedes**(x, y), λy.λx.**Predecessor**(x, y)]

Note that λ**D′**.λ**D.ANCESTRAL-OF**(**D**, **D′**) is like λ**D.TRANSITIVE**(**D**) in being second-order, and like λy.λx.**Predecessor**(x, y) in being dyadic; compare λ**D**.ANCESTRAL(**D**), which maps λy.λx.**Predecessor**(x, y) to λy.λx. **Precedes**(x, y). In providing this kind of symbolism, Frege thought he was offering a *new* way of representing relations among relations. One can use a human language to say, long-windedly, that the relation of precedence is the transitive closure of the smallest relation that one number bears to another if and only if the first is the predecessor of the other. In this sense, we can get at the "content" of (3) with naturally generable locutions. But this requires circumlocution, in which we talk about relations as "things"; and prima facie, the nominalizations fail to reflect certain logical relations among the relations and relata. By contrast, we can imagine minds that naturally generate (1–3) and pronounce them as we would pronounce (1a–3a), using verb-like words of types <<e, e**t**>, **t**> and <<e, e**t**>, <<e, e**t**>, **t**>>.[6]

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[5] Crucially, **Predecessor**(2, 3) is a truth value, and Predecessor(3) is a number. Similarly, **Prime**(2) is a truth value. In this sense, λx.**Prime**(x) and λx.Predecessor(x) are on a par. For simplicity, let's ignore Frege's talk of functions themselves being unsaturated.

[6] Such words would differ from verbs that can combine with *names* of relations, and perhaps correspond to "events/states" of being transitive (or being the transitive closure of a certain relation).

(1a) Predecessor doesn't transit.
(2a) Precedes transits.
(3a) Precedes ancestrals predecessor.

Theorists can still posit a competence that is partly characterized by (R).

(R) if <α> and <β> are types, so is <α, β>

Perhaps limitations on memory or other cognitive resources keep us from naturally employing expressions of types above Level Three, even if our (I-) languages generate expressions of types like <<e, <e, e**t**>>, <<e, <e, e**t**>>, **t**>>. As an analogy, one might note that human languages generate "unparsable" expressions like (4).

(4)   The rats the cats the dogs chased chased fight bulldogs bulldogs fight.

And many expressions of lower types like <**t**, <e, <**t**, e>>> might correspond to functions (i.e., intensions) that thinkers find unnatural, even if such expressions are available in principle. But my concern is not merely that endlessly many Fregean types are unattested in human languages. The more important point is that, with a little help, we can *and do* grasp the thoughts indicated with formalism like (1–3). So why can't we pronounce these thoughts simply and directly, using expressions like (1a–3a), if human languages generate expressions of Fregean types?

Here is another way of getting at the point; cf. Chierchia (1984). Abstraction on the subject or object position of (5), as in (5a) and (5b), is easy. So why isn't (5c) equally available,

(5)   The plate outweighs the knife.

(5a) The plate is something *which outweighs the knife*.

(5b) The knife is something *which the plate outweighs*.

(5c) *Outweighs is something *which the plate the knife*.

with the italicized phrase understood as a relative clause of type <<e, e**t**>, **t**>? (If 'something' or 'which' imposes a type restriction, why can't we have 'is somerel whonk the plate the knife'?) And why can't we use (6) to say that λy.λx.**Precedes**(x, y) is a relation that three bears to four?

(6)   *Precedes is something *that three four*.

This question has a second-order analog. It is often said that words like 'every' and 'most', as in (7) and (8), are instances of the Level Three type <e**t**, <e**t**, **t**>>.

(7)   Every cat ran.

(8)   Most cats ran quickly.

The idea is that, modulo niceties of tense and agreement, a determiner combines with an "internal argument" of type <e, **t**> and an "external argument" of the same type, much as 'precedes' can combine with two arguments of type <e>. On this view, 'every' and 'most' indicate relations that hold between functions of type <e, **t**>. Correlatively, <e, <e**t**>> and <e**t**, <e**t**, **t**>> instantiate the abstract pattern <α, <α, **t**>>. But <<e, e**t**>, <<e, e**t**>, **t**>> also exhibits this pattern. So given (R),

(R) if <α> and <β> are types, so is <α, β>

one would expect human languages to generate expressions of type <<e, e**t**>, <<e, e**t**>, **t**>> if they generate expressions of type <e, e**t**>. And even if *verbs* cannot have meanings of this type, for some reason, one wants to know why humans can't naturally generate expressions like (9);

(9)   Ancestral predecessor precede.

where 'Ancestral predecessor' is a constituent of type <<e, e**t**>, **t**>. In short, what precludes (9) if 'Every cat' is a constituent of type <e**t**, **t**> in (7)?

    This bolsters other reasons for suspecting that quantificational determiners *do not* have meanings of the Level Three type <e**t**, <e**t**, **t**>>. Note that (10) does not have a sentential reading.

(10) every cat which ran

    If 'which ran' exhibits any Fregean type, it is presumably <e, **t**>. But if the relative clause is an instance of this type, why can't (10) be understood as a sentence roughly synonymous with (7)?

(7)   Every cat ran.

One can say that, for some syntactic reason, 'every' cannot take a relative clause as its external argument and must instead take a smaller clause of the same semantic type. But why think that, in (7), the determiner's external argument has the requisite meaning of type <e, **t**>?

    We can specify the meaning of (7) as follows: for every cat, there was an event of it running. And I am happy to say that the quantifier 'Every cat' raises, with the result that the determiner's external argument is a sentential expression akin to (11).

(11) It ran.

But then one needs an ancillary assumption to maintain that 'every' is of type <e**t**, <e**t**, **t**>>.

Heim and Kratzer (1998) are admirably explicit about this. On their view, (7) has the form shown in (7a), with the *indexed trace* of displacement interpreted like the pronoun in (11);

(7a) $[[\text{every cat}]_{<et,\,t>} [1 [t_1 \text{ ran}]_{<t>}]_{<et>}]_{<t>}$

where the *index* '1' is syncategorematic, not an expression of the unhelpful type <t, et>. The idea is that when the index is copied into a higher position, it converts the sentential expression of type <t> into an expression of type <et>.[7]

Like Heim and Kratzer, I think we need to posit a syncategorematic operation of abstraction, corresponding to Tarski-style quantification over ways of assigning values to indices; see Pietroski (2018, forthcoming). So my concern is not that (7a) includes an element that is not an instance of any Fregean type. But (7a) posits an element that effectively converts the external/sentential argument of 'every' into a relative clause, even though quantificational determiners cannot take such clauses as external arguments. That seems odd, especially in the context of view that emphasizes the importance of semantic types, since (10) *cannot* have the meaning of (7). On the Heim and Kratzer view, 'every' abhors relative clauses, and yet its external argument is converted into an expression of the same semantic type as a relative clause.

If words like 'every' indicate second-order dyadic relations, one also wants to know why these relations are invariably *conservative* in Barwise and Cooper's (1981) sense; see also Higginbotham and May (1981). In a domain of sets, a first-order relation **R** of type <e, et> is conservative if and only if $\forall s'\forall s[\mathbf{R}(s', s) \equiv \mathbf{R}(s \cap s', s)]$. For example: s' is a (perhaps improper) *superset* of s – if and only if the intersection of s and s' is a (perhaps improper) superset of s. So letting '**Superset***(X, Y)' abbreviate '**Superset**(Extension[X], Extension[Y])', we can say that $\lambda Y.\lambda X.\mathbf{Superset}^*(X, Y)$ is a conservative function of type <et, <et, t>>. By contrast, $\lambda Y.\lambda X.\mathbf{Subset}^*(X, Y)$ is not conservative.

I take it as given that the first word in (12), which can be inserted at any point in (13),

(12) Only dogs think they like cats.

(13) Dogs think they like cats.

is not a determiner whose meaning is $\lambda Y.\lambda X.\mathbf{Subset}^*(X, Y)$; see, e.g., Herburger (2000). But this raises the question of why kids *don't* acquire a determiner 'Ryev' that is the semantic converse of 'Every'. And for each asymmetric

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[7] More generally, Heim and Kratzer posit a rule of interpretation according to which, if a sentence S contains a trace with index *i*, and S combines with a copy of *i*, the result is an expression of type <et>; and *relative to any assignment function* A, *i*^S indicates a function that maps each entity e to T iff S denotes T *relative to the minimally different assignment* A* that assigns e to *i*.

conservative relation, there is a corresponding nonconservative relation. The symmetric relations **Identical**(s′ s) and **Equinumerous**(s′ s) are also nonconservative. So if 'every' is of the same semantic type as 'λY.λX.**Superset***(X, Y)', we need some explanation for the absence of determiners – call them 'ident' and 'equi' – that indicate the functions λY.λX.**Identical***(X, Y) and λY.λX.**Equinumerous***(X, Y).

The relevant asymmetry, between *internal/nominal/restrictor* and *external/sentential/scope* arguments of determiners, can be described in many ways. But why should there be any such asymmetry if determiners are of type <e**t**, <e**t**, **t**>>?[8] One can posit a filter on otherwise admissible meanings. But prima facie, this is a manufactured solution to a problem for the idea that determiners instantiate a type of the abstract form <α, <α, β>>.

Moreover, puzzles remain, even if some natural limitation precludes dyadic abstractions across dyadic relations – like λ**D′**.λ**D**.ANCESTRAL-OF(**D**, **D′**) – while still allowing for types like <e**t**, <e**t**, **t**>>, and <e, e**t**>. The many Level Four types include <e**t**, <e**t**, <e**t**, **t**>>>, and <e, <e, <e, <e**t**>>>>. So if these types are unattested, one wants to know why.

It isn't hard to imagine "ditransitive" quantificational determiners like 'Glonk' in (14).

(14) Glonk dogs cats are brown.

Such words would combine with three predicates, yielding a meaning like that of (14a) or (14b).

(14a) The brown dogs outnumbered the brown cats.

(14b) There some brown dogs or some brown cats.

Nor is it hard to imagine a "tritransitive" verb that appears in sentences like (15),

(15) A dog sald a cat a car a dollar.

with the meaning indicated in (15a) and (15b).

(15a) A dog sold a cat a car for a dollar.

(15b) A dog sold a car to a cat for a dollar.

For these purposes, let's not worry about the indefinite descriptions. Suppose that 'sald' would be of type <e, <e, <e, <e**t**>>>> and not the Level Five type <e**t**, <e**t**, <e**t**, <e**t**, **t**>>>>. For now, let's also ignore adverbial modification as in (16) and the need for an event variable.

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[8] One can say that 'Every cat ran' has the structure [[every cat]_{<et, t>} [one [which₁ [t₁ ran]<t>]<et>]<et>]<t>. But then it is even harder to explain why 'every cat which ran' cannot mean that every cat ran.

(16) Yesterday, a dog happily sold a cat a car for a dollar in Boston.

The important point is that we seem to have a concept of selling that differs in adicity from the corresponding concept of giving: a seller gets something back, as part of the *exchange*. So why don't we have a verb whose type matches that of the tetradric Fregean concept SOLD(X, Y, Z, W)? String (17) is anomalous, not a simpler way of saying that Fido sold a car to Felix for a dollar.

(17) *Fido sold Felix a car a dollar.

But why use the prepositional phrase '*for* a dollar' if verbs can be of type <e, <e, <e, <e**t**>>>>? And note that (18) has the meaning(s) indicated with (18a).

(18) Fido bought Felix a car for a dollar.
(18a) Fido bought a car for (the benefit of) Felix (in exchange) for a dollar.

One can speculate that limitations on the use of human languages somehow preclude expressions of *any* semantic types from above Level Three, while also blocking nonconservative meanings of type <e**t**, <e**t**, **t**>>, and the Level Three type <<e, e**t**>, **t**>. One can say that while <e, e**t**> and <**t**> are attested types, some performance limitation blocks further abstraction as in λ**D.TRANSITIVE**(**D**). But at this point, the question is whether appeal to (R)

(R) if <α> and <β> are types, so is <α, β>

and the requisite ancillary assumptions is any better than appeal to a *list* of attested types. Moreover, various facts suggest that <e, <e, <e**t**>>> – arguably the simplest Level Three type – is unattested. I assume that children can acquire triadic concepts like BETWEEN(X, Y, Z). Given this assumption, one might expect sentences like (19),

(19) Fido betweens Garfield Harriet.

with 'betweens Garfield' as a constituent of type <e, e**t**> that combines with 'Harriet' to form a constituent of type <e**t**>. But instead, we have the circumlocutory (20),

(20) Fido is between Garfield and Harriet.

as if children abhor lexical analogs of triadic concepts. Similarly, we seem to have a triadic concept of *jimmying* that relates a jimmier to both a thing jimmied and an instrument. Yet we resort to prepositional phrases, as in (21),

(21) A thief jimmied a lock with a screwdriver.

instead of introducing a verb of higher adicity as in (22); see Williams (2007, 2015).

(22) *A thief jimmied a lock a screwdriver.

Examples like (23) may initially suggest that some words are of type <e, <e, e**t**>>.

(23) A dog gave a cat a car.

But verbs in ditransitive *constructions* need not be semantically triadic; cf. (24).

(24) A woman kicked a dog a bone.

With regard to meaning, and perhaps with regard to syntax, "indirect objects" seem like the prepositional phrases in (23a) and (24a); see Larson (1988) and Baker (1997).

(23a) A dog gave a car to a cat.

(24a) A woman kicked a bone to a dog.

So while some verbs may have Level Three meanings, the absence of evidence is striking.

3   Events and Minimal Relationality

Following Davidson (1967), theorists might describe the meaning of (25) with (25a).

(25) A dog chased a cat.

(25a) ∃e:**Past**(e)[∃x:**Dog**(x)[∃y:**Cat**(y)[**ChaseByOf**(e, x, y)]]]

Correlatively, one might say that 'chase' is of type <e, <e, e**t**>>, where the italicized '*e*' connotes *events*. But there are other options, like (25b),

(25b) ∃e:**Past**(e)[∃x:**Dog**(x)[**DoneBy**(e, x)] **&** ∃y:**Cat**(y)[**ChaseOf**(e, y)]]

in which the ampersand conjoins expressions of type <e**t**>; and '**ChaseOf**(e, y)' might be replaced with '**Chase**(e) **& DoneTo**(e, y)'. That is, the verb may fail to reflect at least one of the "participant variables." Kratzer (1996) speaks of severing Agent-representations from verb meanings. Schein (1993, 2002) urges more general thematic separation; see also Pietroski (2005), Williams (2007) and Lohndal (2014). Here, let me note just one cluster of considerations that motivate at least Kratzer-style severing.

The passive (26) presents familiar difficulties if 'chase' is semantically triadic.

(26) A cat was chased.

There is no evidence of a covert analog of the subject in (27).

(27) Something chased a cat.

And a "passivizing" morpheme of type <<e, <e, *et*>>, <e, *et*>> would have a Level Four meaning. By contrast, suppose 'chase' is of type <e, *et*>. Then combining 'chase' with one argument, corresponding to a thing chased, yields a phrase of type <*et*> – a predicate of chases. On this kind of view, transitive constructions have two verbal heads, each supporting *one* argument; see also Borer (2005).

This suggests an explanation for why (28) *doesn't* have the reading indicated with (28c).

(28) A dog saw a cat with a telescope.

(28a) A dog saw a cat that had a telescope.

(28b) A dog saw a cat by using a telescope.

(28c) #A dog saw a cat and had a telescope.

If the verb meaning has no variable for whoever did the seeing, then (29)

(29) see a cat with a telescope

can be understood as (29a) or (29b), but not as (29c).

(29a) ∃y:**Cat**(y)[**SeeingOf**(e, y)] **&** ∃z:**Telescope**(z)[**With**(y, z)]

(29b) ∃y:**Cat**(y)[**SeeingOf**(e, y)] **&** ∃z:**Telescope**(z)[**With**(e, z)]

(29c) #∃y:**Cat**(y)[**SeeingByOf**(e, x, y)] **&** ∃z:**Telescope**(z)[**With**(x, z)]

This assumes that two expressions of type <et> can be conjoined. But accommodating the adjunction is more complicated if 'see a cat' is of the relational type <e, *et*>. We then need a new "restriction" rule for dyadic predicates, as in Chung and Ladusaw (2003), absent a covert element of type <*et*, <<e, *et*>, <e, *et*>>>. But more importantly, if the verb meaning has a variable for the seer, why *must* the adjunctive predicate pass over it to modify the event variable?

If (29) is an event predicate of type <*et*>, then one wants to know how the verb phrase combines with an external argument like 'Fido' or 'a dog'. Kratzer appeals to a covert voice head of type <*et*, <e, *et*>>. But this appeal to Level Three *functional* vocabulary seems like imposition of Fregean typology on human languages, not an independently plausible hypothesis. Given the option of treating agent-specifiers on a par with adjuncts, as in (25b),

(25b) ∃e:**Past**(e)[∃x:**Dog**(x)[**DoneBy**(e, x)] **&** ∃y:**Cat**(y)[**ChaseOf**(e, y)]]

why invoke an otherwise unattested type that may be from an otherwise unattested level?

Imagine a language, Monadish, that only permits atomic sentences with one or two indexable positions, as in 'Cat(_)' and 'ArrivalOf(_, _)': one-placers exhibit a basic type <M>; two-placers, which permit expression of dyadic relations, exhibit a basic type <D>. There are no other types. Every complex expression of Monadish is an instance of type <M>.

Two expressions of type <M> can be combined to form a third via "M-junction," a simple combinatorial operation: 'Grey(_)^Cat(_)' applies to something if and only if both 'Grey(_)' and 'Cat(_)' apply to it. Fregean field semanticists might think that 'Cat(_)' indicates a function **C** of type <e**t**>, 'Grey(_)' indicates a function **G** of the same type, and 'Grey(_)^Cat(_)' indicates $\lambda x.T$ iff **G**(x) = T **&** **C**(x) = T. But expressions of type <M> do not indicate functions. Fregean apparatus overintellectualizes Monadish. Note that this apparatus could also be used to describe a language in which combining 'Grey(_)' with 'Cat(_)' forms a phrase that indicates a *dyadic* function: $\lambda y.\lambda x.T$ iff **G**(x) = T **&** **C**(y) = T. But by hypothesis, speakers of Monadish cannot understand 'grey cat' as an expression of type <D>.

On the contrary, they understand 'arrive cat' as an expression of type <M>, akin to the English 'arrival of a cat'. An expression of type <D> can combine with an expression of type <M>, via the operation "D-junction," which yields another expression of type <M>. Combining 'ArrivalOf(_, _)' with 'Cat(_)' yields '∃[ArrivalOf(_, _)^Cat(_)]', which is understood as follows: the existential closure applies to the *monadic* predicate, which must be linked to the *second* position of the dyadic predicate. The mandatory construal is indicated in (30),

(30) ∃[ArrivalOf(_, _)^Cat(_)]

which is an analog of (30a), as opposed to (30b) or (30c).

(30a) ∃x[ArrivalOf(e, x) & Cat(x)]

(30b) #∃e[ArrivalOf(e, x) & Cat(x)]

(30c) #∃x[ArrivalOf(e, x) & Cat(y)]

But '∃[ArrivalOf(_, _)^Cat(_)]' is not disambiguated by inserting variables; it applies, unambiguously, to e if and only if e is an arrival of a cat.

If it helps, think of '∃' as skipping over 'Arrival(_, _)' – since neither position can be targeted by a variable-free closer – and think of the second position in 'Arrival(_, _)' as one that needs some link to independent content, since the

first position is for events in which something arrives. In general, an instance of '∃[D(_, _)^M(_)]' applies to e if and only if e bears the dyadic relation to *something* that has the monadic property. So an expression of type <M> can have an atomic constituent of type <D> whose second position was restricted and closed via D-junction.[9]

4   Doing Without Level Zero

Monadish provides a model for how a language can allow for a minimal degree of relationality – namely, locally bounded first-order dyadicity – but no expressions of Fregean types. Obviously, <M> and <D> are analogs of <e**t**> and <e, e**t**>. But the former are basic types, not abstract types from Levels One and Two of a hierarchy that starts with <e> and <**t**>.

We know how to invent languages whose expressions exhibit *no* typology. Indeed, Tarski (1944) showed how to provide a truth theory for a first-order predicate calculus that only generates sentences. These "well-formed formulae" differ with regard to how many unbound variables they contain. But (31) and (32) are not instances of distinct types,

(31) Pxy & Nx

(32) ∃y[Pxy & Ny]

even if they can be classified as dyadic and monadic.[10] And while "closed sentences" like (33)

(33) ∀x[Nx ⊃ ∃y[Pxy & Ny]]

are true or false, they are not special expressions that denote truth values. All sentences of a Tarskian language have satisfaction conditions, recursively specified in terms of sequences of domain entities, with truth/falsity characterized in terms of satisfaction by all/no sequences.

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[9] D-junction can be viewed as a special case of Higginbotham's (1985) posited operation of *theta-marking*, which allowed for polyadicity. M-junction is the analog of what Higginbotham called *modification*. It is also worth remembering that 'a cat' may be of the same type as 'cat'; cf. Kamp (1981) and Heim (1982). From a Fregean perspective, this seems odd. Why say that 'a cat' combines with 'arrive' in a conjunctive way that involves covert existential closure, instead of treating 'a cat' as a quantifier of type <e**t**, **t**>? But in languages without indefinite articles, the closure is covert either way.

[10] To ease reading, I use 'y', 'z', and 'w', instead of 'x′', 'x″', and 'x‴'. Constants can be added as special cases of variables. But a variable is not an expression, much less an expression of a special type; neither is '′'. And since there is no upper bound on the number of variables that a sentence can contain, the ampersand in (32) is not an instance of any Fregean type.

Monadish is not quite this spare. It doesn't permit expressions of type <e> or type <t>. But it does allow for proprietary predicates of type <M> – e.g., FIDOISH(_) – that apply to at most one thing. Monadish also permits (34),

(34) Demonstrated(_)^∃[CalledWith(_, _)^Sound-of-'Fido'(_)]

which would apply to e in context C if and only if e is both demonstrated in C and (properly) called with the sound of 'Fido'. These expressions have Fregean analogs of type <et>. But the question is not whether Monadish has expressions of type <et>; it doesn't. The question is whether human languages have expressions of the basic Fregean types <e> and <t>.

I can't review here the many reasons for thinking proper nouns are *not* expressions of type <e>. But the history of this topic is one of considering alternatives. A quantificational analysis, *à la* Russell/Montague, would be attractive if phrases like 'a/the/every cat' are of type <et, t>. Though as Quine (1963) suggested, in discussing 'Pegasus', predicative analyses have their own attractions. Burge (1973) and Katz (1994) offer insightful proposals that can be formulated in Monadish-friendly terms. Deictic pronouns and traces of displacement can also be described as instances of type <M>; see Pietroski (2014, 2018). I don't know of good reasons, independent of (R), for saying that human languages generate type <e> expressions:

(R) if <α> and <β> are types, so is <α, β>

But one can easily imagine a language that forbids expressions like (35).

(35) The three Tylers at the party included that nice Professor Tyler Burge.

So if kids could become adults who treat 'Tyler' as an instance of type <e>, why don't they? And if we don't need (R), we can eschew <e> in favor of <M>.

Likewise, given <M>, we can eschew appeal to <t> as a semantic type. Applying Tarski's characterization of truth/falsity in terms of satisfaction to the special case of monadic predicates, we can posit a pair of operators – ⇑ and ⇓ – that combine with expressions of type <M> to form "polarized" expressions of the same type. For any expression '…' of type <M> and any entity e: '⇑…' applies to e if and only if '…' applies to something; '⇓…' applies to e if and only if '…' applies to nothing. If there is at least one cat, then '⇑Cat(_)' applies to each thing in the domain, and '⇓Cat(_)' applies to nothing. If the domain is catless, then '⇑Cat(_)' applies to nothing, and '⇓Cat(_)' applies to each thing. In effect, '⇑Cat(_)' and '⇓Cat(_)' are the predicates 'is such that there is a cat' and 'is such that there is no cat'. Truth tables can be reconstructed in these terms. So we can do without <t, t> and <t, <t, t>>.[11]

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[11] Partee (2006) – prompted by Carstairs-McCarthy's (1999) discussion of sentences and noun phrases – asked whether we to need to posit *two* basic semantic types. I share Partee's view that "tradition" explains much of the current reliance on appeals to type <t> in studies of human linguistic meaning. But I think that much the same can be said about reliance on appeals to type <e>.

This doesn't show that tensed expressions are *not* instances of type **<t>**. One can hypothesize that tense morphemes are restricted existential quantifiers of type **<e t, t>**; cf. '$\lambda\Phi.\exists e$:Past(e)[$\mathbf{\Phi}(e)$]'. But on this view, a single morpheme does two very different jobs: it makes its own contribution as a temporal *restrictor* of an event predicate; and it *closes* that predicate, creating an expression of type **<t>**. This does not seem better than treating tensed expressions as instances of type **<M>** and posit a covert polarizer. I have argued elsewhere that the usual range of textbook examples, along with various puzzling cases, can be plausibly accommodated in these terms; see Pietroski (2005, 2014, 2018).[12]

5   Summary and Conjecture

Let me end with a brief summary and final speculation. I have suggested that human languages allow for expression of a *little* more relationality than classical Subject-Predicate systems. But permitting limited dyadicity can be viewed as a minimal departure from a fundamentally monadic system whose only mode of semantic combination is the simple operation of M-junction. I have also suggested that human expressions exhibit a *little* more typology than Tarskian sentences, though far less relationality, and vastly less typology than Fregean languages. Human languages seem to be a *little* more expressive, in some respects, than purely first-order languages. All this is reminiscent of Chomsky (1957) describing three conceivable types of grammars, characterized in terms of increasingly powerful kinds of recursion, and noting that human languages seem to be generative procedures of some other sort.

One can say that children naturally acquire languages whose combinatorial operations go beyond those of "context-free" systems, but only in highly constrained ways; or following Joshi *et al*. (1990), one might say that human languages permit only "mild" context sensitivity. As Chomsky stressed, the fundamental questions concern the natural combinatorial operations and lexical items, as opposed to any corresponding sets of generable expressions. Still, it can be useful to think about human languages as generating complex pronunciation-meaning pairs via some operation (or cluster of operations) that is a little more powerful than those in one independently specified class of computational procedures, yet much less powerful than those in another independently specified class of such procedures. One can try to characterize a corresponding notion of "minimally interesting syntax" and defend the hypothesis that human languages are minimally interesting in this sense. But one wants to know if this hypothesis requires appeal to more substantive typology and/or

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[12] If copied indices can be devices of abstraction, as discussed above, then it is a small step to allowing for the clausal expression 1-⇑Past(_)^∃[ArrivalOf(_, _)^1(_)]; where this expression of type <M> applies to an entity e if and only if e is such that *there was an arrival of* e.

combinatorics, when it comes to characterizing the pronunciations and meanings that human languages connect, or whether positing a minimally interesting syntax makes it possible to accommodate the facts with even less interesting conceptions of the relevant interfaces.

Idsardi (this volume) explores and defends the very attractive idea that the phonological patterns may well be computationally (and logically) simpler than patterns observed in syntax; see also Heinz and Idsardi (2011, 2013). If his conception of how phonology relates to syntax is correct, then an analogous conception of how semantics relates to syntax would be an optimal consummation. Instead of positing a substantive "syntax–semantics" interface, in addition to a typologically rich semantics, we could posit a minimally interesting syntax as that which mediates *less* complicated pronunciations and meanings. This outcome, devoutly to be wished, would invite further speculation. For if these ideas are on the right track, perhaps there is a unifying explanation for the various respects in which human languages seem to be just a *tad* more interesting than languages of some independently characterized kind. If human languages turn out to be minimally interesting not "just" with regard to syntax and phonology but also with regard to semantic typology, non-first-order-ness, and relationality, then it would seem unlikely that these features are accidentally related.

A bold conjecture, in the spirit of what Chomsky has long suggested, would be that a single evolutionary tweak to a simple combinatorial device led to a new way of recursively combining concepts and connecting them with pronunciations – with the various observed "minimal complexities" of human languages being by-products of minimally interesting syntax.

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11   Why Is Phonology Different? No Recursion

William J. Idsardi

1   Introduction

Large-scale architectural issues regarding the human language faculty were brought back onto the front burner by Hauser, Chomsky and Fitch (2002, HCF).[1] Their succinct proposal is quoted in (1).

(1) "In fact, we propose in this hypothesis that FLN [the narrow faculty of language, WJI] comprises only the core computational mechanisms of recursion as they appear in narrow syntax and the mappings to the interfaces" (HCF: 1573).

One can certainly quibble about whether phonology and semantics lie within "the mappings to the interfaces," but the tack I take here is that they do not (cf. also Pietroski 2011, 2012, this volume). This hypothesis, then, has as a direct corollary an answer to the question "Why is phonology different (from syntax)?" (*pace* Bromberger & Halle 1989), namely because phonology has no recursion. This claim, however, will require a bit of unpacking.

2   Kinds of "Recursion": Definition, Computation, Structure

As pointed out in several of the chapters in van der Hulst (2010), the term "recursion" means different things to different people. We must be careful to distinguish recursion from iteration (Uriagereka 2008; Karlsson 2010; Kinsella 2010), and to distinguish recursive structure from recursive computation (i.e. processes) (Tiede & Stout 2010) and recursive functions (Rogers 1967; Boolos, Burgess & Jeffrey 2002: 63–72). And structures and computations must also be distinguished from (mere) definition (Reuland 2013). Let us take the Fibonacci series (1, 1, 2, 3, 5, 8, 13, …) as an example to clarify these distinctions (see Uriagereka 1998 for examples from various fields; and Idsardi 2008 and Idsardi & Uriagereka 2009 for occurrences of the Fibonacci series in

metrical phonology). The Fibonacci series is defined in (2); the definition is recursive (also termed "inductive") because some cases (2b) are defined in terms of other cases, but eventually the definitions "bottom out" at the base cases (2a); see also Cormen (2013: 22–24).

(2) Fibonacci series definition
    a. Fib(1) = Fib(2) = 1   (the base cases)
    b. Fib(n) = Fib(n – 1) + Fib(n – 2)   (the recursive case)

As Wirth (1986: 135) puts it, "[a]n object is said to be *recursive*, if it partially consists or is defined in terms of itself." Wirth goes on to give examples of recursive mathematical *definitions*, tree data *structures* and function *computations*. Just because we have defined the Fibonacci series recursively in (2) does not mean either that we have to compute Fibonacci numbers recursively, or that we will build recursive data structures in the course of their computation (though we could do either, or both).

    In discussing computations, we will distinguish between recursion and iteration, as in (3).

(3) **Recursion:** Call of a procedure or a function by itself …

    Iteration: Calculation inside a **loop**, using the values calculated in the previous loop cycle. (Harris & Stocker 1998: 908)

Returning to our Fibonacci example, if asked to compute Fib(5), we can calculate the answer by iterating up to the answer (4a) (see Skiena 1998: 55), or by (lazy) recursive calls "downwards" (4b).

(4) a. Fib(1) = 1, Fib(2) = 1, Fib(3) = 1 + 1 = 2, Fib(4) = 2 + 1 = 3, Fib(5) = 3 + 2 = 5
    b. Fib(5) = Fib(4) + Fib(3)
             = [Fib(3) = Fib(2)] + [Fib(2) + Fib(1)]
             = [[Fib(2) + Fib(1)] + [Fib(2)] + [Fib(2)] + Fib(1)]
             = [[1 + 1] +1] + [1 + 1] = 5

The "call tree" in (4b) is also an example of a recursive data *structure* if we expand out all of the recursive calls before evaluating any base cases. Since the recursive definition (2) is a constant linear recurrence relation, there is also a closed form solution to the problem (Cameron 1994: 50–54; Uriagereka 1998: 72–73), (5), which allows a direct calculation of the value *without calculating any other values of the Fibonacci series along the way* (albeit at the cost of exponentiation and irrational numbers, and against the potential future advantages of memoization to the subsequent calculations of other values of the series).

(5) $\mathrm{Fib(n)} = \dfrac{\varphi^n - (-\varphi)^{-n}}{\sqrt{5}}$ where φ is the Golden Ratio, $(1 + \sqrt{5})/2$

Merge systems (Chomsky 1995, 2000, 2007, 2008; Uriagereka 1998, 2008, 2012) aim to provide recursive definitions for the (infinite) set of form–meaning pairs (π, λ) in which complex expressions can be iteratively constructed from the base cases, often with recursive intermediate syntactic representations (through phases and spell-out).

3   Unary Numerals

The unary numerals (hash or tally marks [Flegg 1983], also as used in Optimality Theory [Prince & Smolensky 2004], where * is used to count constraint violations) provide a simple toy system to explain the basic ideas of Merge systems. A recursive definition is offered in (6) (cf. Reuland 2013: 210). (We will deal here only with external Merge.) The Unicode tie ⁀ denotes concatenation (Chomsky 1975: 105), and the dot denotes access to the named member of a data structure (as in C++, Stroustrup 2013).

(6) a. (|, 1) is an expression (for convenience, call this I)
     b. If x, y are (π, λ) expressions, then so is Merge(x, y) = (x.π⁀y.π, x.λ + y.λ)

That is, the Merge combination is constructed using string concatenation in the phonology and integer addition in the semantics. This system, given that it is associative (and commutative, given only the one π symbol), gives many derivations resulting in the same complex item. Take, for example, (|||, 3) which is a valid (π, λ) pair under (6). This can be derived by Merge(I, Merge(I, I)) or by Merge(Merge(I, I), I). If spell-out is immediate (i.e. not evaluated in a lazy manner, or every Merge a phase), then even the syntax (such as it is in this example) does not generate interesting structures, for the new (π, λ) expression can always be fully calculated (evaluated) immediately in both the phonology and the semantics.

We can enhance (6) in several ways to make it more reminiscent of existing practices. For instance, we could add another lexical item, O = $(\varepsilon, 0)$, where ε is the empty string, and then (|, 1) would be infinitely derivationally ambiguous, being both a base case, and the result of Merge(O, I), Merge(I, O), Merge(O, Merge(O, I)) and so on. But since concatenation is not in general commutative (being so only in the degenerate case of a one-symbol alphabet), we could also add other lexical items, such as B = (_, 0) (the equivalent of "white space"), which would yield "synonyms" such as (||, 2), (|_|, 2) and (_|__|__, 2), etc.

Or we could add a bit of destructive phonology to make the system slightly more reminiscent of crossing the hash marks, a change in form without any effect on meaning, (7):

(7) a. (|, 1) is an expression
     b. If x, y are (π, λ) expressions, then so is Merge(x, y) = (p(x.π⁀y.π), x.λ + y.λ), where p(|||||) = ||||/, otherwise p(π) = π

Now, Merge(I, (||||, 4)) = (||||/, 5), with the fifth line now slanted, a notational proxy for crossing the previous four lines, ⑅. (Note that adding new phonological symbols such as _ or / renders the phonology non-commutative, and that the "phonology" p(·) will require additional definitions to really work as desired; this is left as an exercise for the reader. Of course, Optimality Theory did not develop special symbols to mark larger quantities but instead used Arabic numerals; see, for example, Kirchner 1997: 104.)

   We could also change the definition of the recursion step (6b), to "mark up" the form with brackets, as in (8); this "trick" will become important in assessing "recursion in phonology," below.

(8) a. (|, 1) is an expression
     b. If x, y are (π, λ) expressions, then so is Merge(x, y) = ([⌢x.π⌢y.π⌢], x.λ + y.λ)

Under (8) Merge(I, Merge(I, I)) would now be ([|[||]], 3), whereas Merge(Merge(I, I), I) = ([[||]|], 3). Irrelevant details about "|" aside, (8) defines a sub-type of the Dyck language (see Liberman 2006; the full Dyck language is the Kleene closure of (8)). As with the similar convention in Chomsky and Halle (1968: 13), updated in (9), the phonological object is now a string, with no recursive *structure* itself, but wearing some of the traces of the recursive calculation on its sleeve.

(9) If x, y are (π, λ) expressions, then so is Merge(x, y) = (#⌢x.π⌢y.π⌢#, x.λ + y.λ)

Parallel considerations hold even more strongly for the rudimentary semantics here, as + is both associative and commutative. If we prefer, however, we can give a different version of semantics that does build recursive structures, as in (10).

(10) a. (|, 1) is an expression
      b. If x = (|, 1) and y = (π, λ) are expressions, then so is Merge(x, y) = (|⌢π, s(λ)), where s(λ) is the successor of λ

Now, Merge(I, Merge(I, I)) yields (|||, s(s(1))) with a (trivial) recursive semantic structure as a result (one which should be familiar from the axioms of Peano 1889; see also Chomsky 2008: 139). (The generalization of (10b) to accommodate arbitrary expressions for x is left as an exercise for the reader.)

   The take-home message from the toy examples with unary numbers is simple: recursively defined Merge is agnostic about the resulting phonological and semantic structures. All that is needed is effective definitions for the resulting values for (π, λ). If phonological combination is (primarily) concatenation (*pace* Idsardi & Raimy 2013) and semantic combination is (primarily) conjunction (following Pietroski), then no recursive structures need to be built in

either the phonology or the semantics. And, in the case of apparent recursive structure, we must ask if the relevant effects can arise instead via the recursive Merge calculation.

4   Phonological Recursion?

From Ladd (1986) through Ito and Mester (2012) (among many others) to Elfner (2015) and Elordieta (2015), the principal claims for recursion in phonology have been for recursive structures for phonological and intonational phrases in order to capture certain prosodic effects (though see van der Hulst 2010b for recursive syllables and Ito & Mester 2003 and 2012 for recursive prosodic words). Both Elfner and Elordieta argue for recursive phonological phrases, with particular pitch melodies occurring at the beginning of non-minimal phonological phrases (those phonological phrases that dominate at least one other phonological phrase). So, one understanding of this generalization would be that what we have in the non-minimal phrase case is phonological adjunction to an already spelled-out phrase (or phase); that is the pitch marking is added at Merge(x, y) when y is itself already complex, that is, when y is the product of a previous instance of Merge. As Elfner says:

(11)   "Notably, Wagner (2005, 2010) develops a theory of prosodic domain formation that is based on a cyclic spell-out model of syntactic structure: in this way, the recursion of prosodic domains emerges organically from underlying syntactic structure." (Elfner 2015)

This organic emergence from syntax (i.e. Merge) is mostly pure phonological concatenation, but with a few little twists here and there. An approximate version to get the Elfner and Elordieta effects would be along the lines of (12).

(12)   a. any lexical item $L = (\pi, \lambda)$ is an expression
      b. For any lexical items x, y, Merge(x, y) is an expression $= (x.\pi \frown y.\pi, \ldots)$
      c. For any expressions x, y, Merge(x, y) is an expression $= (T \frown x.\pi \frown y.\pi, \ldots)$, where T is the special boundary tone marking the relevant pitch accent

Clause (12b) takes precedence over and excludes (12c) (as in the pattern matching conventions in Haskell [Lipovaca 2011], or the Elsewhere Condition [Kiparsky 1973]) so that only non-minimal phrases will receive the special boundary pitch accents. Alternatively, we could see (12c) as sub-classing and including the simple concatenation present in (12b), as an object-oriented "call super" anti-pattern (see the "Call super" Wikipedia entry). Either way, the price we pay is the split in definitions between lexical and phrasal Merge and having to "special case" one of them to ensure that lexical Merge does phonological concatenation without tonal boundary marking (see Uriagereka 2008: 209 for

a somewhat similar dissection of Merge cases by lexical status, albeit for different purposes; the concepts of "first merge" in Chomsky 2007 and Martin & Uriagereka 2015 and of "bare merge" in Boeckx 2015 make similar cuts). Proposals such as (12) eliminate the need for recursive structure within the phonology, accomplishing the necessary marking within the recursive Merge calculation while maintaining non-recursive phonological structures.

5   Speculations

Merge systems build (infinite) sets of form–meaning (π, λ) pairs. As Berwick *et al.* (2011) emphasize, this confers a distinct advantage to language learners, (13).

(13) "language acquisition is not merely a matter of acquiring a capacity to associate word strings with interpretations. Much less is it a mere process of acquiring a (weak generative) capacity to produce just the valid word strings of a language. Idealizing, one can say that each child acquires a procedure that generates boundlessly many meaningful expressions, and that a single string of words can correspond to more than one expression." (Berwick *et al.* 2011: 1212)

Nevertheless, we can (perhaps stubbornly) persist in examining the weak generative capacity of the π forms, and, more generally, ask about the relative complexity of generalizations and patterns in phonology, syntax and semantics. Heinz and Idsardi (2011, 2013) review word and sentence patterns, and conclude (consistent with many other researchers) that phonological patterns are all subregular (Heinz & Rogers 2013) while sentence patterns can be mildly context-sensitive (Joshi, Vijay-Shanker & Weir 1990). Liberman (2006) demonstrates a similar point through a Language Log Breakfast Experiment™ for Dyck languages, translating left and right brackets into musical tones, and concluding that "[i]t's no easier for humans to keep track of a Dyck language in acoustic rather than textual form." So non-regular (non-finite-state) patterns seem to be beyond the auditory pattern recognition abilities of humans (see Kershenbaum *et al.* 2016 for a general review of animal abilities), and non-regularity constitutes a reasonable operational diagnostic for recursion in HCF terms (similar to exponential growth as a diagnostic for computational unfeasible problems, Cobham 1965). Likewise, birdsong patterns seem to be well characterized by regular patterns, suggesting that the birds' abilities are analogous to human language phonology rather than syntax (Berwick *et al.* 2012; Berwick & Chomsky 2016; Okanoya 2013; Rogers & Pullum 2011; Samuels 2015a, b). It is probably worth noting that in order to practice comparative cognition (Olmstead & Kuhlmeier 2014) and find relevant animal models for human language, we may need to continue to examine weak generative capacity, as it is difficult to ask birds or other animals what an expression means.

As is well known (Hopcroft & Ullman 1979; Savitch 1982; Uriagereka 2008: 225–236), these patterns occupy different spots in the Chomsky hierarchy, shown in expanded form in (14), including the sub-regular patterns, adapted from Rogers and Hauser (2010: 229); embedded push-down automata are defined and characterized in Vijay-Shanker (1988), and further developed into the Weir hierarchy (Weir 1992, 1994).

(14)

Class	Memory or logic type	Cognitive significance
Turing machine	infinite tape	any recursively enumerable set
Context sensitive	linearly bounded tape	any recognizable set
Mildly context sensitive	embedded PDA	syntactic patterns upper bound
Context free	push-down automata	$a^n b^n$
Regular	finite-state automata, MSO	count modulo n
Non-counting	FO($<$)	phonology patterns upper bound
Locally threshold testable	FO($\triangleright$)	culminativity (one a)
Locally testable	propositional logic	existence (some a)
Strictly local	set of k-factors	n-grams

Once we allow for the use of different data structures in phonology, syntax and semantics, then we see a tantalizing convergence on the computational or logical power required to capture the regularities across all three systems, landing just at or below monadic second order (MSO) (Pullum 2013: 498–501; Rogers 2003). MSO over strings defines exactly the regular languages (Büchi 1960); Pietroski (2003, 2011, 2012, this volume) has developed a comprehensive MSO semantic theory based on conjunction; and Graf (2014, 2015) and Graf and Heinz (2015) show that MSO (or possibly even first order with transitive closure of succession ($\triangleright$*), FO($<$), *pace* Graf 2009) suffices for phonological patterns and minimalist derivation trees in syntax.

This convergence near MSO also suggests a possible evolutionary story (see Hornstein & Idsardi 2014 for another) that seems consistent with HCF, fits with the scenario (15) envisioned by Chomsky (2000: 94) and resonates with some other proposed evolutionary accounts of neural and cognitive functions.

(15) "Imagine some primate with the human mental structure and sensorimotor apparatus in place, but no language organ … Suppose some event reorganizes the brain in such a way as, in effect, to insert FL." (Chomsky 2000: 94)

The evolution of trichromacy in primates required not only the biochemical innovation of a new long-wavelength (L) receptor but also required the existing blue-yellow opponent process circuit to be copied and modified to provide both the new red-green opponent response, all while still maintaining the original blue-yellow opponent response, which now requires summing the L and M receptor outputs, and in so doing also copies and modifies the former white response as well (see the diagrams in Surridge, Osorio & Mundy 2003: 199; Hurvich 1981: 132). So the wild speculation for human language (building on Graf & Heinz 2015) is that the FO($<$) system over strings and the near-MSO($\&$) logic for semantics are the pre-existing systems, still found in phonology, semantics and animals. What was innovated was the change from string concatenation and set intersection to treelets (whatever that change may turn out to be in detail), and therefore we expect two consequences: (1) syntactic patterns should be at most MSO or FO($<$) over trees (where $<$ in trees is c-command or something similar, Frank & Vijay-Shanker 2001); (2) syntax cannot look at strings or precedence ($<$ in strings), having traded strings for trees. This is the strongest possible version of the *structure-dependence* hypothesis (Berwick *et al.* 2011), namely that precedence-based generalizations cannot even be stated in the syntax, because syntax lacks the relevant representational resources (as we haven't added something to concatenation, we've traded concatenation in for a new model, but see Berwick & Chomsky 2016 for a different view).

In addition, the systems developed above in section 3 might be more than mere toys. Bones with systems of tally marks are among the artifacts surviving from the Upper Paleolithic, and they have survived better than knotted fabric or hide (Camps & Uriagereka 2006; Balari *et al.* 2011) and are much older than any extant records of language (at least 40,000 years ago, Beaumont & Bednarik 2013: 38). Inductive definitions, such as those provided by Merge systems above, are necessary to define counting systems and seem to have developed alongside human linguistic abilities (Carey 2001), perhaps with the subitizable numbers as the "lexical entries." So maybe then, FLN created the integers, and all else is cultural history (with my apologies to Carey, Leopold Kronecker and God).

If these speculations are anywhere near correct, then we should really reformulate the question we began with to "Why is syntax different?" This seems to be more in line with HCF, (15), and with the evolutionary novelty of syntax.

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12 Nothing in Syntax Makes Sense Except in the Light of Change

David W. Lightfoot

1 Introduction

My title riffs on Dobzhansky's famous "nothing in biology makes sense except in the light of evolution" (1964: 449), later the title of his 1973 paper in *American Biology Teacher*. He followed the Jesuit Teilhard de Chardin, who had used similar phraseology. Their position was that biologists can EXPLAIN properties of organisms by showing how they might have arisen through evolution, a stance taken by proponents of Minimalist explanations of properties of Universal Grammar (UG). Minimalists argue that the rich information postulated in government-and-binding approaches to UG is evolutionarily implausible – hence the goal of attributing minimal information to the linguistic genotype. There is much to be said about this reasoning, including its consequences for our understanding of acquisition, but here I show that there is a parallel line of argument, explaining language-specific properties – but not properties of UG, of course – through historical change.

Any I-language-specific property must have arisen as a result of historical change and, I argue, at least in the domain of syntax, this can happen only through language acquisition by young children. Here I examine three peculiarities of English, where we know enough about when and how they arose to be able to provide good explanations for them. Given that very few of the world's languages have a richly recorded history, we will not be able to develop equivalent explanations in a pervasive way, but it will be helpful to think through what it would have taken for language peculiarities to have arisen at some point in history. A key to the whole approach is to link changes in E-language with changes in I-languages.

2 Explaining Change Through Acquisition and Learnability

In work on syntactic change, one needs good hypotheses for the early stage of the language under investigation and for the late stage, after the change has taken place; one needs a good synchronic analysis at both ends of any changes to be considered. That means that one needs all the ideas marshaled by

synchronic syntacticians. However, there is more to describing and explaining changes through time: questions arise that do not typically impinge on synchronic work, different research strategies are called for, and certainly there are different research traditions. Under an approach linking syntactic change to acquisition, work on change casts light on the idealizations used in synchronic work and is instructive for synchronic syntacticians, as I aim to make clear.

Over recent decades an approach has developed that links explanation of syntactic changes to ideas about language acquisition, learnability, and the (synchronic) theory of grammar. One way of making this linkage construes change as always externally driven.

Baker and McCarthy (1981) identified the "logical problem of language acquisition" as one of identifying the three elements of the triplet of (1).

(1) Primary linguistic data (Universal Grammar → Grammar)

Children are exposed to primary linguistic data (PLD) and, as a result, their initial state characterized as UG develops into a mature state characterized by a particular individual, internal grammar or, these days, "I-language" (I use grammar/I-language interchangeably). The solution to the logical problem lies in identifying the three items in such a way that links a particular set of PLD to a particular grammar, given particular ideas about Universal Grammar (UG). Children seek the simplest and most conservative grammar compatible with both UG and with the PLD that they encounter (Snyder 2007).

Under that approach, there can only be one way to explain the emergence of a new grammar: a new grammar will emerge when children are exposed to new PLD such that the new PLD trigger the new grammar. In that sense, it is new PLD that CAUSE the change; UG certainly does not cause changes, but it provides the outer limits to what kinds of changes may occur.

Crucial to this approach is Chomsky's 1986 distinction between internal and external language, I-/E-language, both of which play an essential role in explaining change. E-language is the amorphous mass of language out in the world, the things that people hear. There is no system to it, but it reflects the output of the I-language systems of many speakers under many different conditions, modulated by the production mechanisms that yield actual expressions. Internal languages, on the other hand, are mental SYSTEMS that have grown in the brains of individuals and characterize the linguistic range of those individuals; I-languages are represented in individual brains and are, by hypothesis, biological entities.

PLD consist of structurally simple things that children hear frequently, robust elements of their E-language (in fact Degree-0 simple; see Lightfoot 1999). Work in diachrony, therefore, makes crucial use of the E-language/I-language distinction and keys grammatical properties to particular elements of the available PLD in ways that one sees very rarely in work on synchronic syntax.

Successful diachronic work distinguishes and links two kinds of changes: changes in PLD (part of E-language) and changes in mature I-languages. The changes are quite different in character, as we will see when we consider some well-understood changes below.

Work explaining language change through acquisition by children has been conducted now for decades, and there have been surprising results that lead us to re-think the relationship between PLD and particular I-languages. Diachronic syntacticians have ideas quite different from those common among their synchronic colleagues about which PLD trigger which particular grammars.

3   Models of Acquisition

Work in synchronic syntax has rarely linked grammatical properties to particular triggering effects, in part because practitioners often resort to a model of language acquisition that is flawed and is strikingly unilluminating for work on change. I refer to a model that sees children as EVALUATING grammars globally against sets of sentences and structures, matching input, and evaluating grammars in terms of their overall success in generating the input data most economically (e.g. Clark 1992, Gibson and Wexler 1994). A fundamental problem with this approach is that I-languages generate an infinite number of structures, and, if children are seen as setting binary parameters, they must, on conservative assumptions that there are only thirty or forty parameters, entertain and evaluate billions or trillions of grammars, each capable of generating an infinite number of structures. For discussion, see Lightfoot (2006: 73–77).

Beyond these overwhelming issues of feasibility, the evaluation approach raises further problems for thinking about change, because work usually fails to distinguish E-language and I-language changes and encounters problems of circularity: the new grammar is most successful in generating the structures of the new system, but that presupposes that the new structures are already available in order to explain the emergence of the new grammar. This is part of a larger problem: if one asks a syntactician how children can learn some grammatical property, she will point to sentences that are generated in part through the effects of the relevant grammatical property, taking those sentences to be the necessary PLD. This circularity will become clear when we discuss specific changes.

A discovery approach (Dresher 1999, Lightfoot 1999) is not subject to the feasibility problems of global grammar evaluation and treats children as looking for structures EXPRESSED by PLD, the structures needed in order to parse sentences. There may be a thousand or more possible structures, provided by

UG, but that does not present the feasibility problems of evaluating the success of thirty or forty binary parameters against corpora. Children posit structures that are required to analyze what they hear and that parsing is the key to language acquisition. Once children have an appropriate set of structures, the resulting I-language generates what it generates and the overall set of structures generated plays no role in triggering or selecting the grammar. This model of acquisition, essentially a DISCOVERY procedure in the sense of Chomsky 1957 (see my introduction to the 2002 second edition of *Syntactic structures*), keys elements of grammar to particular elements of the PLD and provides good explanations for diachronic shifts and the emergence of new grammars. Under this model, we can link an element of I-language structure with the PLD that express that structure, and this yields some surprising results that force us to think about triggering experiences differently.

So a person's internal language capacity is a complex system that depends on an interaction between learned operations and principles that are conveyed by the genetic material, directly and indirectly. It grows in children in response to the E-language that they encounter, the source of the I-language structures, and becomes part of their mature biology. If language growth in young children is viewed in this way, then we can explain language change over generations of speakers in terms of the dynamics of these complex systems; new I-languages are driven entirely by children responding to new E-language. In particular, we explain how languages shift in bursts, in a kind of punctuated equilibrium, and we explain the changes without invoking principles of history or ideas about a general directionality or dis-preferred grammars, as in much modern work on diachronic syntax (e.g. Heine & Kuteva 2007, Givon 2009). The three I-language innovations to be discussed here are completely contingent on new E-language.

Under this approach, there is no separate theory of change. Sometimes there are changes in E-language such that children are exposed to different PLD that trigger a different I-language. New I-languages, in turn, yield another new set of PLD for the next generation of children in the speech community; that new E-language, stemming in part from the new I-languages, helps to trigger another new I-language, with further consequences for E-language. In this way we can understand domino effects in language change.

This chapter examines a sequence of three reanalyses in the I-languages/grammars of English speakers, three phase transitions introducing unusual properties, which are not shared by closely related languages. In all cases, children are computationally conservative, acquiring the simplest I-language consistent with principles of UG and the ambient E-language and PLD (Snyder 2007); we do not need special principles to weed out dis-preferred I-languages.

4   First Reanalysis

Modern English has forms like (2–6a) but not (2–6b).

(2)   a. He has understood chapter 4
      b. *He has could understand chapter 4
(3)   a. Understanding chapter 4, …
      b. *Canning understand chapter 4, …
(4)   a. He wanted to understand
      b. *He wanted to can understand
(5)   a. He will try to understand
      b. *He will can understand
(6)   a. He understands music
      b. *He can music

However, earlier forms of English had the b forms, which occur in texts up to the writings of Sir Thomas More in the early sixteenth century. More used all the forms of (2–6) and the b forms occur in nobody's writing after him. (7–9) provide examples of the latest occurrences of the obsolescent forms, (7) corresponding to (2b), (8) to (4b), and (9) to (5b).

(7)   If wee **had mought** convenient come togyther, ye woulde rather haue chosin to haue harde my minde of mine owne mouthe (1528, More, *Works* 107 H6), 'if we had been able to come together conveniently, ...'
(8)   That appered at the fyrste **to mow** stande the realm in grete stede (1533, More, *Works* 885 C1), 'appeared at first to be able to stand the realm in good stead.'
(9)   I fear that the emperor will depart thence, before my letters **shall may** come unto your grace's hands (1532, Cranmer, *Letters*)

There is good reason to believe that there was a single change in people's internal systems such that *can*, *could*, *must*, *may*, *might*, *will*, *would*, *shall*, *should*, and *do* were once categorized as more or less normal verbs, but then they were re-categorized as Inflection or T elements in all known grammars of English speakers after the time of More. Before More, verbs like *can* MOVED to a higher Inflection position, as in (10), and after More they were generated directly as Inflection elements and occurred in structures like (11), a single shift in the system, which was manifested by the simultaneous loss of the phenomena in (2–6), the phase transition; sentences like (2–6b) are not compatible with a system with structures like (11) (if perfective and progressive markers are generated in the Specifier of VP, then they will never occur to the left of I as in 2b and 3b; if there is only one I in each clause, then 4b and 5b will not be generated). The SINGULARITY of the change explains the PARALLELISM in the loss of phenomena.

(10)

```
                    IP
                   /  \
                 /      \
              Spec       IP
                        /  \
                      /      \
                    /          \
                   I            VP
                   ↑           /  \
                   |         /      \
                   |_____ V        VP
                           can    see stars
```

(11)

```
                    IP
                   /  \
                 /      \
              Spec       IP
                        /  \
                      /      \
                     I        VP
                    can      /  \
                           /      \
                          V        VP
                         see      stars
```
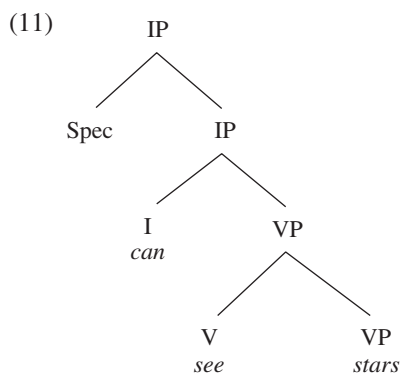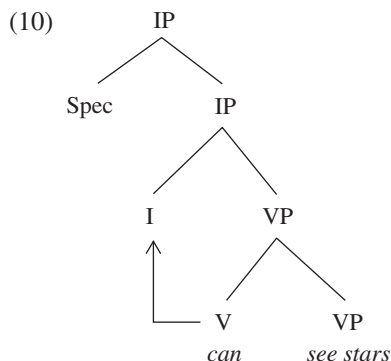
This change occurred only in Early Modern English and nothing compara-
ble happened in any other European language, so it is not satisfactory to say
that this change is to be explained by a "general tendency" to grammaticalize
or to re-categorize modal verbs as members of a functional category. If there is
a general tendency, why has it not yet affected any other European language?
Positing a general tendency enables researchers to unify some phenomena,
which provides a level of explanation. The change of category membership
for the English modals is a parade case of grammaticalization, but saying that
it results from an internal drive or a UG bias gives no explanation for why it
happened when it did nor under what circumstances and does not explain why
the change hasn't happened in other European languages.

A critical property of this change is that it consisted entirely in the LOSS of
phenomena (2–6b), and there were no new forms emerging. Since children
converge on their I-language in response to ambient simple expressions and
not in response to "negative data" about what does not occur, the new, more
limited data need to be explained by a new abstract system that fails to generate

(2–6b). There were no new forms in which the modal auxiliaries began to occur, so the trigger for the new system must lie elsewhere. In this case, the new PLD cannot be the new output of the new grammars, because there are no new forms. Changes like this, which consist only in the loss of expressions, make up a kind of poverty-of-stimulus argument for diachrony: there appear to be no new forms in the PLD that directly trigger the loss of those.

If we ask why this or any other I-language change happened, there can only be one answer under this approach: children came to have different PLD as a result of a prior change in external language. We have a good hypothesis about what the prior E-language change was in this case.

Early English had complex morphological properties. For example, we find *fremme*, *fremst*, *fremþ*, *fremmaþ* in the present tense and *fremed*, *fremedest*, *fremede*, *fremedon* in the past tense of 'do'; *sēo*, *siehst*, *siehþ*, *sēoþ* in the present tense for 'see'; and *rīde*, *rītst*, *rītt*, *rīdaþ* for the present tense of 'ride', and *rād*, *ride*, *rād*, *ridon* for the past tense. There was a massive loss of verbal morphology in Middle English, beginning in the north of England and due to intimate contact with Scandinavian speakers and widespread English–Norse bilingualism. Again I skip interesting details (see Lightfoot 2017a), but external language that children heard changed such that the modern modal auxiliaries like *can*, *shall*, etc. came to be morphologically distinct from other verbs, because, as the members of the small preterite-present class, they lacked the one surviving feature of present tense verb morphology, the *-s* ending of the third person singular. This made them formally distinct from all other verbs, which had the *-s* ending. Furthermore, their "past tense" forms (*could*, *would*, *might*, etc.) had meanings that were not past time, reflecting old subjunctive uses (12).

(12) They might/could/would leave tomorrow.

The evidence indicates that these modal verbs were re-categorized in people's internal systems, because they had become formally distinct from other verbs as a result of the radical simplification of morphology (Lightfoot 1999). More parsed his E-language and had elements like $_I[_V$can] in his I-language, while after him speakers had $_I$can. So we see domino effects: changes in what children heard, the newly reduced verb morphology, led to a different categorization of certain verbs, which yielded systems (11) that were compatible with (2–6a) but not (2–6b).

More was the last known speaker with the old system. For a period, both systems coexisted: some speakers had (10) and others had (11), the former becoming rarer over time, the latter more numerous. A large literature is now devoted to this kind of sociological variation, changing over time, and we will return to this matter in section 8.

5   Second Reanalysis

A later major change was that English lost (13–15a), another phase transition. Such forms occurred frequently in texts up through the seventeenth century, although diminishing over a long period in favor of the *do* forms of (13–14b).

(13) a. *Sees Kim stars?
     b. Does Kim see stars?
(14) a. *Kim sees not stars
     b. Kim does not see stars
(15) a. *Kim sees always stars
     b. Kim always sees stars

Again we can understand the parallelism of the three changes in terms of a single change in the abstract system, namely the loss of the operation moving verbs to a higher Inflection position, as in (16).

(16)

```
              IP
             /  \
          Spec   IP
                /  \
               I    VP
               ↑   /  \
               | V     N
               see    stars
```
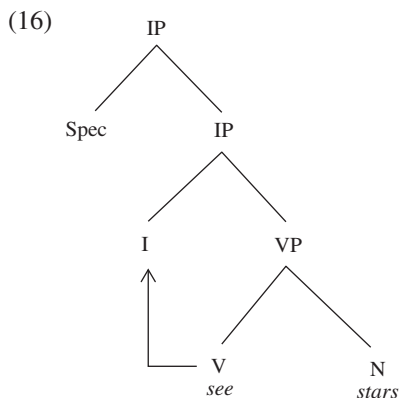
This is another change that did not affect other European languages, whose systems have retained the verb movement operation (apart from Faroese and, perhaps, some Scandinavian systems; see Heycock et al. 2012 and their references). Present-day English verbs do not move to the higher position and therefore cannot move to clause-initial position (13a), to the left of a negative (14a), or to the left of an adverb (15a). The equivalent movements continue to occur in French, Italian, Dutch, and German systems. Again a contingent explanation is required: what was it about English at this time that led to this shift in I-languages? In particular, what were the new PLD that children were exposed to that helped to trigger the new grammar?

It is plausible that this shift was due to two prior changes and we see another domino effect. The first was the new I-language that we just discussed, involving the re-categorization of modal verbs (which are very frequent in typical speech); given that words like *can* and *must* were no longer verbs but I items, no sentence containing one would have a $_I[V]$ structure. The second change was the emergence of "periphrastic" *do* forms as an alternative option for expressing past tense: *John did leave*, *John did not leave*, etc., instead of *John left* and *John left not*. Given that *do* forms were instances of I, any sentence containing one would not have the $_I[V]$ structure. As a result of these changes, the Inflection position came to be occupied by modal auxiliaries and by *do* in internal systems and was not available as a target for verb movement. Thus, lexical verbs did not occur in that position as often as before the days of periphrastic *do* and before modal auxiliaries were no longer verbs, and as a result, the $_I[V]$ structure was expressed much less and apparently fell below the threshold that had permitted its acquisition by children. More parsed his E-language to have $_I[V]$ structures, reflecting the movement of verbs to Inflection, but after the eighteenth century, speakers had no such structures, instead $_V[V+I]$, reflecting the attachment of inflectional endings on to a lower, unmoved verb.

As with the first reanalysis, the two systems coexisted for a while, in fact for a longer period than with the re-categorization of the modal verbs: Shakespeare and other writers alternated easily between the coexisting old and new systems, sometimes using the old V-to-I forms and sometimes the new *do* forms, even within the same sentence (17).

(17) a. Where **didst thou** see her? – O unhappy girl! – With the Moor, **say'st thou**?
   b. I **like not** that. **//** What **dost thou** say?
   c. Alas, what **does this gentleman** conceive? – How **do you**, madam?

Again this is too brief an account (see Lightfoot 2017b), but it is clear that prior changes in external language, some due to a shift in I-languages, had the effect of reducing enormously children's evidence for the $_I[V]$ structure, triggering a new internal system, and that simultaneous but apparently unrelated changes were a function of a single change in the abstract system.[1]

6   Third Reanalysis

There is a third phase transition, resulting in part from the two changes just discussed, observed, and analyzed by Warner (1995). It involves very peculiar properties of the verb *be*, which have no equivalent in familiar European

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[1] Many people have contributed to our current understanding of these two phase transitions. Roberts (2007) gives a detailed textbook account of both changes in I-languages.

languages that are closely related to English. One way of characterizing the change is that different forms of the verb *be* came to be listed in the mental lexicon as atomic or "mono-morphemic," as Warner puts it.

VP ellipsis is generally insensitive to morphology and one finds cases where the understood form of the missing verb differs from the form of the antecedent (18).

(18) a. Kim slept well, and Jim will [sc. sleep well] too.
b. Kim seems well-behaved today, and she often has [sc. seemed well-behaved] in the past, too.
c. Although Kim went to the store, Jim didn't [sc. go to the store].

There is a kind of SLOPPY identity at work here, since *slept* and *sleep* in (18a) are not strictly identical. One way of thinking of this is that in (18a) *slept* is analyzed as [$_v$*sleep+past*], and the understood verb of the second conjunct accesses the verb *sleep*, ignoring the tense element.

However, Warner noticed that *be* works differently: *be* occurs in elliptical constructions but only on condition of STRICT identity with the antecedent (19). In (19a,b) the understood form is strictly identical to the antecedent but not in the non-occurring (19c,d,e).

(19) a. Kim will be here, and Jim will [sc. be here] too.
b. Kim has been here, and Jim has [sc. been here] too.
c. *Kim was here and Jim will [sc. be here] too.
d. *If Kim is well-behaved today, then Jim probably will [sc. be well-behaved] tomorrow.
e. *Kim was here yesterday and Jim has [sc. been here] today.

This suggests that *was* is not analyzed as [$_v$*be+past*], analogously to *slept*, and forms of *be* may be used as an understood form only when precisely the same form is available as an antecedent, as in (19a,b).

Warner goes on to note that the ellipsis facts of modern English *be* were not always so, and one finds forms like (19c,d,e) in earlier times. Jane Austen was one of the last writers to use such forms, and she used them in her letters and in speech in her novels, but not in narrative prose (20a,b). These forms also occur in eighteenth-century writers (20c), and earlier, when verbs still moved to I (20d).

(20) a. I wish our opinions were the same. But in time they will [sc. be the same]. 1816, Jane Austen, *Emma*, ed. R. W. Chapman (London: Oxford University Press, 1933), 471.
b. And Lady Middleton, is she angry? I cannot suppose it possible that she should [sc. be angry]. 1811, Jane Austen, *Sense and Sensibility*, ed. R. W. Chapman (London: Oxford University Press, 1923), 272.

c. I think, added he, all the Charges attending it, and the Trouble you had, were defray'd by my Attorney: I ordered that they should [sc. be defrayed]. 1741, Samuel Richardson, *Pamela* (London, 3rd edn.), vol. 2, 129.

d. That bettre loved is noon, ne never schal. *c*. 1370, Chaucer, *A Complaint to His Lady*, 80, 'So that no one is better loved, or ever shall [sc. be].'

These forms may be understood if *were* in (20a) was analyzed as [ᵥ*be+subjunctive*], and the *be* was accessed by the understood *be* in the following *But* clause. That is, up until the early nineteenth century, the finite forms of *be* were decomposable, just like ordinary verbs such as *sleep* in present-day English.

Warner goes on to show, in addition, that present-day English shows quite idiosyncratic restrictions on particular forms of *be*, which did not exist before the late eighteenth century or early nineteenth century. For example, it is only the finite forms of *be* that may be followed by a *to* infinitive (21); only *been* may occur with a directional preposition phrase (22); and *being* is subcategorized as not permitting an *-ing* complement (23).

(21) a. Kim was to go to Paris.
     b. *Kim will be to go to Paris.
(22) a. Kim has been to Paris.
     b. *Kim was to Paris.
(23) a. I regretted Kim reading that chapter.
     b. I regretted that Kim was reading that chapter.
     c. *I regretted Kim being reading that chapter.

Restrictions of this type are stated in the lexicon, and these idiosyncrasies show clearly that *been*, *being*, etc. must be listed as individual lexical entries in order to carry their own individual subcategorization restriction. However, these restrictions did not exist earlier, and one finds forms corresponding to the non-occurring sentences of (21)–(23) through the eighteenth century (where 24a is equivalent to 21b, 24b to 22b, and 24c to 23c):

(24) a. You will be to visit me in prison with a basket of provisions ... 1814, Jane Austen, *Mansfield Park*, ed. J. Lucas (London: Oxford University Press, 1970), 122.
     b. I was this morning to buy silk. 1762, Oliver Goldsmith, *Cit W*: 158 (meaning 'I went to ...,' not 'I had to ...').
     c. Two large wax candles were also set on another table, the ladies being going to cards. 1726, Daniel Defoe, *The Political History of the Devil* (Oxford: Talboys, 1840), 336.

So there were changes in the late eighteenth/early nineteenth century whereby the ellipsis possibilities for forms of *be* became more restricted and particular forms of *be* developed their own idiosyncratic subcategorization restrictions.

I-languages perform computational operations on items stored in a mental lexicon, and both the operations and the items stored may change over time. There is good reason to believe that decomposable items like [$_v$*be+subjunctive*] or [$_v$*be+past*] ceased to be stored in that form, replaced by un-decomposed, atomic forms like *were*, *was*, *been*, each with its own subcategorization restrictions. The phenomenon has no parallel in closely related languages, but we can explain it by showing how it may have arisen in the I-languages of English speakers.

It is natural to view this change as a consequence of the changes discussed in sections 4 and 5. After the loss of rich verb morphology and the loss of the $_I$[V] structures, the category membership of forms of *be* became opaque. If they were instances of V, then why could they occur where verbs generally cannot occur, to the left of a negative or, even higher, to the left of the subject DP (*She is not here*; *Is she happy?*)? If they were instances of I, then why could they occur with another I element such as *to* or *will* (*I want to be happy*; *She will be here*)?

In earlier English, forms of *be* had the same distribution as normal verbs. After the two phase transitions discussed earlier, they had neither the distribution of verbs nor the distribution of Inflection items. The evidence is that, from the late eighteenth century, children developed I-languages that treated forms of *be* as verbs that have the unique property of moving to higher functional positions and being un-decomposed, atomic elements, unlike other verbs.

7   Domino Effects

We see domino effects and we understand them through language acquisition. English underwent massive simplification of its verb morphology, initially under conditions of bilingualism in the northeast. The new primary linguistic data led to a new I-language with about ten former verbs now categorized as Inflection items. As a result, the primary linguistic data changed again and, along with new periphrastic forms with *do*, this led to new I-languages where verbs ceased moving to higher I positions. That, in turn, led to new PLD in which the categorical status of forms of *be* became opaque, leading to the re-analysis of section 6.

Amorphous external language and internal SYSTEMS are different in kind, and the modern distinction between external and internal language is crucial; both contribute to explaining change (Lightfoot 2006). We see an interplay between changes in E-language (new PLD) and changes in I-languages, and

changes in both E-language and I-languages are crucial to our account. New E-language leads to new I-languages, new I-languages lead to new E-language, and sometimes we see sequences of changes, domino effects, which we can understand through language acquisition.

When a new I-language$_p$ develops in one individual, that changes the ambient E-language for others, making it more likely that another child will acquire I-language$_p$; likewise for the next child and so on. As a result, the new I-language spreads through the speech community quickly; Niyogi (2006) provided a computational model of new language systems spreading through speech communities quickly.

8   Variation

Children are exposed to speech, and their biological endowment, a kind of tool-box, enables them to parse their external linguistic experience, thereby growing a private, internal system that defines their linguistic capacity.

The systems involve particular abstractions, categories, and operations, and these, not the behaviors themselves, constitute the real points of variation and change. Phenomena do not change in isolation, but they cluster, depending on the abstract categories involved. As a result, change is bumpy and takes place in "punctuations" that disrupt general equilibrium. We explain the bumps, the clusters of changes, in terms of changes in the abstract system, as illustrated in the three phase transitions in the history of English. If we get the abstractions right, we explain why phenomena cluster as they do.

Everybody's experience varies, and people's internal systems may vary, but not linearly. I-languages change over time, and sometimes variation in experience is sufficient to trigger the growth of a different internal system. Children are sensitive to variation in initial conditions, in the terminology of chaos theory. In general, we understand change in internal systems through the acquisition process, by virtue of children experiencing different E-language. We explain changes where we can identify changes in the external language that children experience, such that the new experiences trigger different internal systems with different categories and operations. For example, after the comprehensive morphological changes of Middle English, young children had different experiences that led them to categorize words like *may* and *must* differently from verbs like *run* and *talk*. Assigning these words to a different category, Inflection or T, explains why (2–6b) all disappeared in parallel. Similarly, new structures resulting from modal verbs being treated as Inflectional items and new structures with periphrastic *do* entailed that the $_I$[V] structure was expressed much less robustly and fell out of use, entailing the obsolescence of (13–15b). Finally, as a result of these two phase transitions, forms of *be* were reanalyzed as mono-morphemic and no longer as a verb with an affix.

Under this approach, change is contingent, dependent on particular circumstances, and we explain why English underwent at this time changes that other European languages have not undergone at any point. English had particular morphological properties that were affected in particular ways by contact with Norse speakers and that led to the new categorization. Other European languages were not affected in that way. If change is contingent like this, then there is no general direction to change and there is no reason to believe that languages all tend to become more efficient, less complex, etc. There are no general principles of history of the kind that nineteenth-century thinkers sought and which modern diachronic syntacticians continue to invoke. Explanations are local (Lightfoot 2013), and there is no reason to revive historicism or invoke principles of history or UG biases.

This approach to syntactic change also provides a new understanding of synchronic variation, along the lines of Labov's 1972 discussion of sound change in progress. When a phase transition takes place, it does not happen on one day, with all speakers changing in unison. Rather, a new I-language emerges in some children and spreads through the population, taking over from the old I-language, sometimes over the course of a century or more (but typically not for a very long period). Competing grammars (Kroch 1989) explain the nature of certain variation within a speech community: in this context, one does not find random variation in the texts but oscillation between two (or more) fixed points, two I-languages. In general, writers have either all the forms of the obsolescent I-language or none. Not all variation is to be explained in this way, of course; only variation in I-languages. There is also variation in E-language that has little if anything to do with I-language. In amorphous E-language, variation is endemic, and it does not come in the structured form of variation in I-languages: no two people experience the same E-language and, in particular, no two children experience the same PLD. Since E-language varies so much, there are always possibilities for new I-languages to be triggered.

9   Identifying Triggers

So the major contributions of diachronic work in syntax lie in explaining one kind of variation, due to coexisting I-languages, and in revealing what the E-language trigger might be for any particular property of I-languages.

It is surprising how little discussion there has been among synchronic syntacticians of what triggers what properties, given the generally accepted explanatory schema of (1). Reducing hypothesis space is an essential part of the enterprise but is not sufficient.[2]

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[2] Lightfoot (2006: 57–61) discusses the binding theory, a vast improvement on earlier analyses, but one that nonetheless raises (solvable) learnability issues that had not been addressed in the literature.

We should allow for the possibility that the PLD that trigger a grammatical property may not have any obvious connection with that property. Indeed, our discussion of the re-categorization of modal verbs was triggered by new morphological properties.

Niko Tinbergen (1957: ch. 22) once surprised the world of ethologists by showing that young herring gulls' behavior of pecking at their mothers' mouths was triggered not by the fact that the mother gull might be carrying food but by a red spot. Mothers typically have a red spot under their beak and Tinbergen devised ingenious experiments showing that this was the crucial triggering property. So chicks would respond to a disembodied red spot and not to a bird carrying food but with the red spot hidden. Similarly, grammars may have certain mechanisms and devices because of properties in PLD that are not obviously related to those mechanisms, as we saw in our first case study.

Speakers have their own internal system, a grammar, which grows in them in the first few years of life as a result of an interaction between genetic factors common to the species and environmental variation in PLD. Such a grammar represents the person's linguistic range, the kind of things that he/she might say and how he/she may say them. If they hear different things, children may converge on a different system, a new grammar, perhaps the first instance of a particular, new I-language. We want to find out what triggers which aspect of a person's I-language, and therefore how new I-languages might emerge.[3]

People have claimed that we can discover things about grammars by seeing how they change. In particular, by looking at change, one can generate productive hypotheses about what PLD trigger particular properties of I-languages, thereby explaining the I-language properties.

10   Conclusion

We may have achieved ideal explanations for certain syntactic changes in terms of how children acquire their I-language: we can identify shifts in I-languages along with prior shifts in the ambient E-language that plausibly triggered the new I-languages. If that is along the right lines, then we explain diachronic changes in I-languages in terms of language acquisition, distinguishing I-languages and E-language, where each plays a crucial role in our account. This provides a model for explaining other unusual properties that occur in mature syntactic systems.

Linking matters of acquisition and learnability to matters of syntactic change permits deep explanations of particular changes and illuminates what experience it takes to trigger elements of I-languages. Under this approach, there is

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[3] It should be noted that a particular structural element might be triggered by quite different PLD in different I-languages. For discussion, see Lightfoot (2006: 123–136).

no independent theory of change and change is an epiphenomenon. Children acquire their own internal, private I-language when exposed to the ambient E-language and not influenced directly by any ambient I-language. No two children experience the identical E-language and therefore there is always the possibility of a different I-language emerging, but nothing is actually transmitted and there is no object that changes.

We explain peculiarities in I-languages by showing how they arise through language acquisition taking place when E-language changes for a generation of children, i.e. through language change. We therefore explain the peculiarities in ways that are broadly similar to the ways in which biologists explain properties of organisms by showing how they might have evolved in the species. All I-language variation stems from change and, where we have insufficient data to tell rich stories like the ones documented here, we should nonetheless be able to imagine plausible scenarios, just as the imagination of biologists was provoked by Dobzhansky.

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13   Neurology and Experience: The Language Organ and Externalization

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1   Introduction

A basic assumption of generative grammar since its very beginning has been that much of the knowledge speakers have of their respective languages is innate: Since there is only one human genotype, in a non-trivial sense "there is only one human language," i.e., "only one computational system and one lexicon" (i.e., a universal lexicon of functional elements), "apart from idiosyncratic lexical properties" (more generally, externalization properties such as sound and sign sequences) in Noam Chomsky's view, a conjecture that "remains controversial" (1993: 3).[1] The underlying differences between any two languages are taken to be reducible, in scientific terms, to values in a set of parameters and a lexicon (a set of "lexical entries"); there is no variation in the LF component or in overt syntax. As stated in *Aspects of the Theory of Syntax* (1965: 160), "The very notion 'lexical entry' presupposes some sort of fixed, universal vocabulary in terms of which these objects are characterized, just as the notion 'phonetic representation' presupposes some sort of universal phonetic theory." What is a "lexical item"? Here is how Chomsky put it more than two decades ago:

> You'd raised some time back a question about the "atoms" in the minimalist program. I had said "lexical items," but you're right about the intention. By a "lexical item" I mean nothing more than a feature complex, and there are some feature complexes without much content, for example AGR, which you mention, which I suppose is just a collection of phi-features. Tense on the other hand has at least some semantic content – though it's not entirely obvious that this is true of the Tense position as well as the feature on the verb that ends up matching it. About the status of more complex owrds [words], and morphology generally, I think there are a lot of murky areas, and am not trying to stake out a clear position just yet.
>
> (p.c., September 1, 1993)

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[1] I'm indebted to Noam Chomsky for bringing to my attention an uninvited word and some of the advantages of bisyllabic writing.

As is well known, in the post-1980s biolinguistics, a particular human language, as represented in the mind/brain (in other words, in its psychoneurological representation, like other systems of human knowledge), from Arabic to Zulu, including of course languages of the Germanic branch of the Indo-European, such as English, and the Romance languages, such as Spanish, is the collection of choices (parameters) that define one of a limited number of genetically permitted selections from the narrow universal-grammar menu of grammatical options (head-initial/final, null/nonnull subject, and so on) together with parochial idiosyncratic facts of the vocabulary of that particular language. Children internalize this effortlessly, in sharp contrast to adults, who need to recur to drills that facilitate the demanding process of learning both a set of vocabulary items (or signs, in the case of the deaf) and at least essentials of the grammar, and that often aim to integrate the four competencies (listening, speaking, reading, writing). The innate universal word-level units provide the fundamental fabric of syntax (cf. Katamba 2005), while a particular subset of the vocabulary-level units, which are the raw materials of speech, have to be memorized, one after another, by each individual learner. Specific examples would be the fact that English *tree*, Spanish *árbol*, and German *Baum* mean 'tree', that English *house*, German *Haus*, and Spanish *casa* mean 'house', or that *single-family house*, *Einfamilienhaus*, and *casa para una familia* mean 'single-family house'.

The mental word-level units add up to the fabric or structure of syntax, while the vocabulary-level units (the sound-level units) are the raw materials of speech. To put it in more general terms: The word-level units innately in the mind/brain of every healthy human being at an early age provide the fabric of the syntax (the mental lexicon), as the title of Aitchison (2003) suggests (cf. Emonds 2001: 105; Kayne 2010; Wunderlich 2006), while the vocabulary-level units or the sign-level units are the raw material of speech or signing, respectively, and differ not just from language to language but from idiolect to idiolect, and within idiolects, from style to style (formal, casual, and so on). Not surprisingly, the basic difference between a variety of Spanish and a variety of Spanglish is to be found in the vocabulary (cf. Stavans 2003). (On misleading cognates, e.g., *library* 'biblioteca' and *librería* 'book store', *exit* 'salida' and *éxito* 'success', and so on, see Prado 1998, 2001.)

Once the grammatical parameters for a particular language, say an individual variety of Spanish or of American Sign Language, are fixed and a set of the vocabulary items or of the signs are learned (the rate of children's vocabulary or, presumably, sign acquisition in peak periods of language growth is maybe a dozen a day), the whole system is in place. From there on the general principles genetically programmed into the language organ just churn away to yield all the particular facts about the particular language. Given the focus of generative

grammar, which has always been the biology or, more precisely, the psycho-neurology of language, such a perspective was to be expected.

2   Mental Entities Externalized

It goes without saying, doesn't it, that every speaker knows what, say, the vocabulary-item for 'house' means in their language. Actually, that's not far off the mark if we add "unconsciously," but it is completely off the mark if we mean that every speaker is a conscious mind reader when it comes to their own mind. The fact that no speaker is a mind reader as a user of a particular vocabulary item of a language they speak natively is a familiar fact for those who have read Chomsky on the topic (and an often unknown one otherwise). As he has made clear, a simple, everyday English term like *house* (*Haus*, *casa*, or the corresponding term in another human language) that is used to refer to a concrete object (from the standpoint of special human interests and goals) actually has surprisingly curious properties when it is explored carefully, as Chomsky has done. Here are some: A house not only can be destroyed, but it can be rebuilt; if someone sees a house or is painting a house, we all understand that it is its exterior that's being seen or painted, not its interior, so if the house is being painted white, then the paint is being applied to its exterior surface, not its interior surface. And so on. As Chomsky points out, these facts appear to be true of all I-languages (hence a feature of Universal Grammar) and hold of broad categories of container words, not only those referring to artifacts (e.g., *airplane*, *igloo*, *lean-to*) but also those referring to non-artifacts (e.g., *cloud*, *tree*) and even impossible objects (e.g., *spherical cube*). As he has written, "the most elaborate dictionaries do not dream of such subtleties"; in fact, they do not go beyond providing hints that enable a speaker who already has the intended concept (at least, in essential respects) to identify it. Thus, "a lexical item provides us with a certain range of perspectives for viewing what we take to be the things in the world, or what we conceive in other ways; these items are like filters or lenses, providing ways of looking at things and thinking about the products of our minds" (Chomsky 1992; 2000, ch. 2).

Not long before, answering a question by an interviewer, he had pointed out that in the "radically different" post-1900s theories, "The variety of languages may be a matter of a number of lexical options, where those lexical options probably leave out a large part of the substantive vocabulary, meaning nouns and verbs and so on." In fact, one can reasonably speculate that "there may be only one computational system and in that sense only one language," so once a speaker has learned the vocabulary items and fixed the grammatical parameters for a particular language (English, Spanish, ..., Zulu), "the general principles genetically programmed into the language organ just churn away to

yield all the particular facts about English grammar" (Chomsky 1991: 32) – or any other grammar, as the case may be.

When we turn our attention to language externalization, in particular to the sound or sign sequence units that are taken to be intertranslatable (the units memorized by a speaker or signer in the process of learning a language), we find that a relevant meaningful part of a lexical item can be represented in each particular system as a vocabulary item or as a visual gesture, each internalized system having specific properties of its own. From a slightly different perspective: A vocabulary item or a visual gesture are alternative ways of turning mental entities involved in the use of a particular language into transmissible signals, which in turn may be represented by means of a variety of writing systems or of gestural systems, e.g., the graphemes of the Greek or the Latin alphabets, the characters used to represent Chinese, or the Sign Writing of American Sign Language (ASL or Ameslan), or of other signed or spoken languages. So if we read that injuries to Broca's area can cause patients to have trouble when they attempt to express speech by producing "words" (a sometimes ambiguous English vocabulary item, since it is sometimes used to mean "a mental lexical item" and at other times to mean a sequence of sounds – or something else, as in the chapter title "A Final Word"), we understand "words" in this case to mean terms or vocabulary items, i.e., *vocables* (for some reason a term less natural in English than *vocablos*, its cognate, is in Spanish); with the understanding that, for example, *give*, *gave*, *given* are all words, but it is only *give* that we take to be a vocabulary item (cf. Pinker 2000).

When we read, for example, that Goethe believed that a speaker doesn't know his language well if he doesn't know any other language, we understand that a crucial part of the knowledge Goethe is referring to is the speaker's knowledge of the vocabulary of that particular language. We may add that "other things being equal, there is no doubt that language teaching will be facilitated to some extent by an intelligently designed curriculum making use of texts that introduce new vocabulary and structures at a reasonable rate and with adequate repetition" (Chomsky 1969).

3   Vocabulary and Creativity

The main goal of this chapter is to show that some aspects of a particular language externalization (oral or committed to writing) are not without consequences for the range of expressions available to its speakers, and hence for the range of possibilities open to a particular speaker (in fact, an individual may be judged by others on the basis of his or her vocabulary) and, more generally, to a speaking community. This, in turn, has an arguably crucial bearing on the cultural creations of those communities along several fundamental dimensions,

particularly with respect to the success of their systems of education and their direct impact on the level of achievement within reach of the general population at a variety of levels. It goes without saying that a human being is a richer person if she/he has some more diverse kinds of experience, so knowledge of several languages and immersion in various cultures no doubt adds a certain richness to life, which has a highly positive value.

In what follows the focus will be on a comparison (intended to be representative) between items of the English vocabulary of everyday use and the items of the Spanish vocabulary they are usually matched with in oral or written rendition. It should be kept in mind that the number of sounds is relatively small (usually around 20 to 40 per language) in comparison with the great variety of syllables across languages. English (a language with a comparably large keyboard because of its rich ancestry, Germanic and Romanic – plus extended borrowing) is represented, in all its varieties, with 26 letters, like other Western languages, even though the sounds represented add up to close to 50 different ones, including an exceptionally high number of vowel shadings. In sharp contrast, daily reading and writing of Chinese by an educated speaker is said to involve at least 2,000 symbols, out of an inventory of some 60,000 symbols required for its written representation by scholars – no wonder mass literacy became possible in China only in 1949 (cf. Sacks 2003: 4–5). This is in fact the reason why in some ways syllabic writing is no match for alphabetic writing, although it has its own advantages, as Noam Chomsky points out (p.c.).

Our concern here will not be the vocabulary used during a particular century (cf. Ayto 2006) or the vocabulary used by a single individual during his or her lifetime, that is, the set of words a speaker of a particular language is familiar with and able to use. A comparison of the properties of representative English vocabulary items with the Spanish vocabulary items generally used to translate them shows that a high percentage of English vocabulary items are shorter, often by several syllables, than their Spanish counterparts. Shakespeare's sonnets would have been far less rich in content if he had been born and raised in Burgos or Toledo. Needless to say, we will not be concentrating on the notions that English expresses succinctly and Spanish does not; rather, we will attempt to select a representative sample of the two vocabularies, and we will ignore other of their properties. For example, a literal translation into English of the following lines loses its punch because "jewelry" does not suggest what the sound sequence "joyería" suggests in the last line:

> Con la hija de un joyero,
> yo sí que me casaría:
> Me gastaría el dinero
> y además la joyería.

The most relevant book-length study to this discussion is George A. Miller's *The Science of Words* (1991), and the most relevant of its chapters are chapter 7 ("The Mental Lexicon") and chapter 12 ("The Growth of Vocabulary"). In chapter 7 it is explained (misleadingly) that in English the word "lexicon" has three senses: (1) dictionary; (2) the abstract lexicon; (3) a person's word knowledge, which is but a subset of the abstract lexicon, the lexical component of the language of a particular speaker (no one knows every word of general use, but somebody is likely to know a particular one). This does not exclude the possibility of a speaker being able to think of a new concept or thought for which there are no words in the language, as Chomsky has repeatedly emphasized. (Needless to say, the output and input of an individual's vocabulary must be closely related.) The process of retrieval is unavailable to introspection. (On intricacies of the words for colors, see Deutscher 2010, Appendix. Cf. Berlin and Kay 1869 and Hardin and Maffi 1997.)

4   Two Vocabularies Side by Side

Consider the following (selected, but not unrepresentative) paired terms, many of them drawn from those listed at the end of *The Sound Pattern of English*, some of which have to be paraphrased in Spanish. They are ordered alphabetically within their grammatical category, beginning with some common truncated forms:

ad[vertisement]s	anuncios comerciales
click	clic
dem(ocrat)s	demócratas (as in the headline *Dems should slam GPO*)
exam(ination)	examen
exec(utive)	ejecutivo
fest(ival)	festival
fridge (for *refrigerator*)	refrigerador
grad(uate)	graduado
limo(usine)	limusina
match	fósforo, cerilla
pot	olla; a slang term for *cannabis* (*marijuana*)
prep(aratory)	preparatorio
pres(ident)	presidente
pro(fessional)	profesional
prom(enade)	alameda
pulp	revista de poca categoría
purple	púrpura
rec(reation)	recreación, pasatiempo

sane	cuerdo, sensato
show biz [business]	farándula, teatro
stat(istic)s	datos estadísticos
tact	tacto; discreción
title	título
ton	tonelada
tramp	vagabundo
vase	florero
vet(eran)	militar jubilado

The considerable number of English vocabulary items borrowed by other languages (e.g., *click*) appears to be an indication of not just the cultural impact of English all over the world but also the hard-to-match richness of the English vocabulary. The following is a representative sample of those used in Spanish that have been adopted by the Spanish Academy (see Prado 2001):

(mental) *stress* (1984); *show*, *slip* (1989); *puzzle, slogan* (1992)

Nouns

bat	murciélago
brick	ladrillo
coin	moneda
coo	arrullo (de una paloma)
coy	tímido, cohibido; coqueto
cue	señal
den	madriguera; guarida; estudio
fan	ventilador
film	película
hen	gallina
hole	agujero
hope	esperanza
horse	caballo
hot	caliente
huge	enorme
inn	posada
job	empleo; puesto de trabajo; ocupación
kin	pariente; familiar
law	ley; derecho
lazy	perezoso; holgazán
loss	pérdida
lungs	pulmones
mood	estado de ánimo
morbid	enfermizo

mum	(orden/mandato de permanecer) silencioso; no verbalizar
owl	lechuza
palm	palmera
peek	ojeada
poll	encuesta
prime	primo; primordial
quill	pluma de ave / púa de erizo
range	sierra; cordillera
reign	reinado
rent	alquiler
road	carretera
rubble	escombros
saw	sierra
scalp	cuero cabelludo
search	búsqueda
seed	semilla
sin	pecado
slip	enaguas
sloth	perez-a/-oso, indolencia, desidia
	Braz. *bicho-preguiça* 'lazy animal'; Ecuador *rit(to)*, *ridette*
snood	redecilla
sole	lenguado
sponge	esponja
state	estado
stream	corriente
stress	acento
tax	impuesto
tilt	inclinación
tree(s)	árbol(es)
width	anchura
wild	salvaje
wit	inteligencia; ingenio; gracia, agudeza
wits	razón, buen juicio
work	trabajo; obra

Untranslated borrowings:

aligátor(es)
chip(es)
eslógan(es) (for slogan(s))

> *flashback(s) (cf. analepsis)*
> *gánster(es)*
> *iceberg(ues)*
> *pullover*
> *rímel(es)*
> *tráiler(es)*

(Terms like *Machiavellianism*, *prestidigitation*, *plenipotentiary*, and so on are obvious borrowings rarely used.)

Some of the rare counterexamples in which the Spanish term is shorter:

egregious	atroz
faith	fe
inseminate	cubrir
nickname	apodo, mote
partridge	perdiz
recreation	recreo
reputation	fama/reputación
strawberry	fresa
turkey	pavo

Verbs

beam	sonreír satisfecho
bungle	echar a perder; equivocarse
chip	desportillar(se), desconchar(se), astillar [madera]; descascararse [e.g., pintura]
contact	ponerse en contacto con
cue	darle la señal a
exploit	explotar, aprovecharse de
fret	preocuparse
fume	echar humo; estar furioso
furlough	dar permiso a, dar licencia a
howl	aullar
hurl	lanzar; botar (un barco)
keep	retener; guardar; quedarse con
leave	marcharse
mum	deja de hablar (literally, stop speaking)
nickname	apodar
perch	posarse
quit	abandonar [un trabajo], dimitir [de un puesto]
quote	citar/entrecomillar

shell	desvainar (garbanzos/chícharos), pelar (nueces, etc.); bombardear
sit	sentarse
slam	tirar o dejar caer de golpe
sort	dividir en grupos; clasificar
sort	ordenar, seleccionar
sort out	poner en orden; resolver
squint	mirar con los ojos entornados
start	iniciar, empezar
stem the tide	contener (el curso de) la marea
stew	estofar, guisar; preocuparse (cf. *to fret* above)
swish	mover (produciendo un sonido)
tear	desgarrar
vex	molestar, fastidiar
warn	avisar
wean	destetar

Representative pairs:

act now	actúa ahora
art beat	tema periodístico actual sobre arte
beam lights	luces largas
blank slate	pizarra en blanco
boat sinking	hundimiento de un barco
class war	guerra de clases
dead last	absolutamente último
dry-clean	limpiar en seco
last hope	última esperanza
left wing	de izquierdas
media matters	asuntos relativos a los medios de comunicación
sort of	de cierto modo
teach-in	asamblea pública en la que se discute cuestiones políticas de actualidad
tight-lipped	con los labios bien cerrados
train tracks	raíles del tren/ferrocarril
turnstile	torniquete (de acceso)

In the following pairs, some of the English pairs are in the relation of alliteration or of assonance, some in both alliteration and assonance:

big chill	gran escalofrío
boat sinks	un barco se hunde
book launch	lanzamiento de un libro
bubble burst	reventón de una/la burbuja

car care	cuidado del coche/automóvil
crying wolf	!que viene el lobo!
endless slump	bajón/declive económico sin fin
food first	alimentación por encima de todo
coast guard	guardia costera; guardacostas
jazz jam	una actuación musical sin preparación ni arreglo detallado
lame duck	persona sin poder (e.gr. un presidente saliente)
poop scoop	cucharón para excrementos
red shift	desplazamiento hacia lo rojo
rock greats	grandes del rock; grandes éxitos de la música rock
tax cuts	reducciones de los impuestos
tiny bubbles	burbujas diminutas
the real deal	una verdadera ganga
tooth paste	pasta para los dientes (o dentrífica)
toys for tots	juguetes para niñ-o/a-s pequeñ-o/a-s

Representative triples:

a f(l)at tax	un impuesto alto (lit. obeso)/plano
a flat refusal	una negativa categórica
all things art	todo lo que tiene que ver con al arte
a good/bad boy	un niño/muchacho bueno/malo
all things art	todas las cosas referentes (todo lo referente) al arte
bard beats bond	bardo evita fianza
big bubble burst	gran reventón de una burbuja / reventón de una gran burbuja
deep freeze soon	congela hondamente pronto
fair or foul	atractivo o repugnante
flash with cash	destellar con dinero efectivo
help hope grow	ayuda a crecer a la esperanza
hot or cold	caliente o frío
green job search	búsqueda de ocupaciones no dañosas para el medio ambiente
healthcare NOT warfare	seguro de enfermedad NO beligerancia
a lightning logician	un especialista en lógica (un "lógico") con la rapidez de un relámpago
the economy is tanking	la economía se está hundiendo
more rain soon	más lluvia en el horizonte
press a point	recalcar un punto
put down (money)	adelantar un depósito (de dinero)
wired for life	cableado para toda la vida

Longer strings of monosyllables (with one bisyllable), some also linked by alliteration, assonance, or both:

Bush-era tax cuts.	La reducción de impuestos de la era de Bush.
Can you chip in ten?	¿Puedes contribuir diez [dólares]?
Click here for more.	Haz **clic** aquí y encontrarás más.
Diet tips and hints.	Sugerencias e indicios dietéticos.
Take a deep breath.	Ingiere una inhalación profunda (Inhala profundamente).
Fluff up the pillows.	Mullir las almohadas.
Where are the green jobs?	¿Dónde están los empleos "verdes"? (los que favorecen el medio ambiente)?
We must clear out now.	Tenemos que dejar libre el local ahora.
Is to leap to jump?	¿Es brincar dar saltos?
Is to strut to walk?	¿Es pasear pavoneándose andar?
Long live the web.	Que la Red tenga una larga vida.
People can get loans at low rates.	Todo el mundo puede conseguir préstamos a intereses bajos.
Ways to quell the debt crisis.	Maneras de sofocar la crisis de la deuda.
The right hip, but not the left one.	La cadera derecha, pero no la izquierda.
Life springs from the soil.	La vida brota de la tierra. [There is no Spanish word for **soil**.]
No tax cuts for the rich.	Ninguna reducción de impuestos para los ricos.
Banks should not break the law.	Los bancos no deben incumplir la ley.
Small plates for large palates.	Platos pequeños para paladares grandes.
Stand up, fight back.	Defiénd-ete/-ase, repel-a/-e el ataque.
No pain, no gain.	Sin pena (esfuerzo) no hay ganancia (aumento).
The focus hocus-pocus.	El foco/enfoque en una palabra mágica (e.gr. *abracadabra*).
The year cars fly!	¡El año en que los coches vuelen!
Spend real time with my son.	Pasar tiempo significativo con mi hijo.

> *A gun lay on the table by the guard*.
>> Había una pistola sobre la mesa junto al guarda.
>
> *All dems switched sides and moved to the far right*.
>> Todos los demócratas cambiaron de lado y adoptaron una posición de extrema derecha.
>
> *Black hole may offer clues to more than three*.
>> Un/el agujero negro puede ofrecer indicios para más de tres.
>
> *Dive into PDA with your eyes open*.
>> Echate a bucear en el PDA [personal digital assistant] con los ojos abiertos.

Give gifts with heart and hope.
   Da regalos con corazón y esperanza.
Help us launch a new new deal.
   Ayúdanos a lanzar un "acuerdo nuevo" nuevo.
*How even just one puff harms one's lungs and leads to big health ills
   down the road.*
   Cómo aún una sola inhalación le daña a uno los pulmones y más adelante
lleva a grandes males de salud.
It's serving us well as our field site.
   Nos está siendo muy útil en nuestro sitio de campo.
More of what you want.
   Más de lo que usted quiere.
News wrap: Now comes the hard part.
   Envoltura de noticias: Ahora viene la parte difícil.
No one can put a price on the guts of your laptop.
   Nadie puede asignar un precio a las entrañas de tu/su "laptop" [lit. "parte
superior del regazo"]
Now is the time to rein in the costs.
   Ahora es el momento de contener los gastos.
Our brains store each face in "face space."
   Nuestros cerebros almacenan cada una de las caras/rostros en el "espacio
de las caras/rostros."
Save this file on to a hard drive, a flash drive, or a CD [compact disc].
   Guarda este archivo en un disco duro, un "flash drive," o un "CD" [disco
compacto].
Some masks bore the craggy visage of the guy.
   Algunas máscaras llevaban el escarpado rostro del tipo.
Tax deal has been reached. Did the Pres(ident) back down?
   Un acuerdo en lo que respecta a los impuestos ha sido alcanzado. ¿Dio el
Presidente marcha atrás?
*The dems didn't come even close to slam the Grand Old Party
   (GOP).*
   Los demócratas ni siquiera se aproximaron a triturar al Gran Viejo Partido
(GOP).
They're thrilled to work for wages that a pro would sneer at.
   Están encantados trabajando por salarios de los que un profesional se
mofaría.
We'll serve the people best by doing that.
   Serviremos mejor a la gente haciendo eso.
We'll take them off your hands for free.
   Te las quitaremos de las manos sin cargo.
What does the tax cut deal mean for most of the people?
   ¿Qué significa el acuerdo de reducción de impuestos para la mayoría de la
población?
What happy people know: The good life? It's close to home.
   Lo que la gente feliz sabe: La buena vida? Está cerca de casa.

Possibility of adding up modifiers within a phrase:

> *Protect Spawning Atlantic Bluefin Tuna!* (V, 3 modifiers, N)
>   Protege el atún de aletas azules del Atlántico que están desovando.

In writing, some expressions are ingeniously reduced to a minimum as in the following:

iContact	contacto de miradas
sole4soul	lenguado para el alma/espíritu
U-turn	cambio de sentido
W is for war-monger	W. [Bush] significa supervillano belicoso

Some representative expressions:

brain gain, not brain drain	aumento (del número) de cerebros, no desagüe de cerebros
bring the troops home	trae las tropas a su país de origen (repatría las tropas)
drunk as a skunk	más borracho que una cuba (lit. que un zorrillo / una mofeta)
hard as a rock	más duro que una piedra
make or break day	el día de completar con éxito o fracasar
treat or trick	invitación o treta/artimaña
top ten tags	(las) diez mejores etiquetas
big fools blame game	la diversión de los superidiotas/idiotazos de echar culpas
this ain't over	esto no está acabado
lame duck session	sesión con diputados/congresistas salientes (sin poder de decisión)
getting lifesaving care	conseguir atención médica salvavidas
cheer and roar with glee	aplaudir y reírse a carcajadas con júbilo
neck-and-neck	cuello a cuello
stand and fight	mantenerse firme y luchar
weak and meek	débil y sumiso
clockwise from left to right	de izquierda a derecha como las agujas del reló
the great risk shift	la gran transferencia del riesgo

> *on-the-spot cash for use in the store*
>   dinero contante y sonante en el acto para usar en la tienda
> *an easy math quiz and what you can do to help solve it*
>   un problema de matemáticas fácil y lo que uno puede hacer para ayudar a resolverlo

Representative phrases:

A run-down house.	Una casa destartalada.
All that we share: A field guide.	Todo lo que compartimos: Una guía de la esfera de actividades.
A new way to roll.	Una nueva manera de rodar.
Art/decline of the West.	El arte (/ la decadencia) de occidente.
Be the change: Save a life.	Sé el cambio: Salva una vida.
Bring joy to people.	Da alegría a la gente.
Do not vote yes on a bad tax deal.	No vote sí en un mal acuerdo respecto a los impuestos.
Fund jobs not war.	Financia puestos de trabajo, no guerra.
Green shoots or false hopes.	Retoños/vástagos verdes o esperanzas falsas.
The hard part will take a little while.	La parte difícil llevará un poco de tiempo.
Let's change the way we live here.	Cambiemos la manera de vivir aquí.
Long live the web!	¡Que la Red tenga una larga vida!
One way not to trim growth.	Una manera de no recortar el crecimiento.
People at the high end.	La gente en la cumbre de la escala social.
The death and birth of real news.	La muerte y renacimiento de noticias auténticas.
The urge to splurge.	La compulsión de derrochar dinero.
Ten cheap eats that have been a treat.	Diez bocados baratos que han resultado ser una suculencia.
We can take to wait or to fail.	No podemos aceptar esperar o fracasar.
Will you cross the line?	¿Estás dispuesto a cruzar la línea (divisoria)?
What the far right wants.	Lo que quiere la ultra-derecha.
*When push comes to **shove***.	Cuando de **empujar** se pasa a **empujar bruscamente**.
Don't just do what you can, stand there.	No te limites a hacer lo que puedes, mantente ahí. [Ironía]
Tea and friends make a great blend.	Té y amigos hacen una gran mezcla.

Their human rights come out on top.   Sus derechos humanos acaban por estar por encima de todo.

No time to waste.   No hay tiempo que perder.

Night soon gives way to day.   La noche pronto cede el paso al día.

The lies of our times.
Las mentiras de nuestro tiempo [e, implícitamente, de nuestro (NY)Times].
The names have been changed.
Los nombres han sido cambiados.
The way we live/were.
Nuestra manera de vivir / La manera de la que éramos.
A storm claimed the lives of four people.
Una tormenta se llevó las vidas de cuatro seres humanos.
As a mom with little kids, I think that we need laws that ban the breed.
Como mamá con niños pequeños, creo que necesitamos leyes que prohiban esa variedad de raza de animales.
Do not bring the Fed to an end; change it the right way.
No llevemos la Reserva Federal a su fin; cambiémosla de la manera apropiada.
Don't pass tax cuts for the rich and then tell me you couldn't not do it.
No aprueben reducciones de impuestos para los ricos y después me dicen que no podían no hacerlo.
Few new jobs as the rate of the jobless rises to 9.8%.
Pocos nuevos puestos de trabajo, mientras que el porcentaje de los sin puestos de trabajo sube a 9.8%.
Fowl is better than beef for your health.
La carne de ave es mejor que la carne de vacuno para la salud de uno.
Good for you, good for me, good for girls, good for boys, good for all.
Bueno para ti/usted, bueno para mí, bueno para las jóvenes, bueno para los jóvenes, bueno para todos.
No meat? No fish? No big deal, even for kids.
¿Nada de carne? ¿Nada de pescado? No es un gran problema, incluso para los niños.
See how you can find the home loan that's right for you.
Vea como puede encontrar la hipoteca que es adecuada para usted.
Share your toys and get a free toy doll.
Comparte tus juguetes y recibe sin cargo una muñeca de juguete.
You don't get bubbles if you do not spend the wrong way.
No se obtiene burbujas si no se gasta de manera equivocada.

We have not been there for more than five years.
　No hemos estado allí desde hace más the cinco años.

They know what is like to have no food.
　Saben (bien) lo que es no tener nada para comer.

They rode a wave of cash from shadowy front groups.
　Cabalgaron una ola de dinero contante y sonante procedente de grupos frontales sospechosos.

Is it just a dream or just a lie if it doesn't come true, or could it be both of them at once?
　¿Es sólo un sueño o sólo una mentira si no resulta verdad, o podría ser ambas cosas a la vez?

We cannot let us be held back by a few rich people.
　No podemos dejarnos retener por unos pocos ricos.

We want to help build a state health care core for people's needs.
　Queremos ayudar a construir un núcleo de seguro de enfermedad para las necesidades del pueblo.

People at the high end should be paying a lot more taxes.
　Los que están en el extremo más alto [de recursos] deberían estar pagando muchos más impuestos.

Six months after the largest oil spill ever, the leak has been plugged.
　Seis meses después del derramamiento de petróleo más grande de todos los tiempos, el agujero ha sido obturado.

The US dropped any call for a real freeze.
　Los Estados Unidos abandonaron todo llamamiento a favor de un congelamiento auténtico.

They've got it nice while the rest of us have it not-so-nice.
　Lo tienen a pedir de boca mientras que todos los demás no lo tenemos tan a pedir de boca.

Most are having it better than they've ever had it.
　La mayor parte están teniendo la situación más favorable que han tenido nunca.

All stretched their reach to the North, where armed groups reign.
　Todos extendieron su alcance hacia el Norte, donde grupos armados campean por sus fueros.

This is a make-or-break point in the fight to let the Bush tax cuts for the rich to end as planned at the end of this year.
　Este es el momento de hacer-o-dejar-de-hacer en la lucha en favor de dejar expirar las reducciones-de-impuestos-para-los-ricos de Bush a fines de este año tal como-había-sido-planeado.

Unbossed and unbought news and information you can use.
　(Organization motto.)
　Noticias e información no supervisada ni comprada que puede ser usada.

Similar alternative succinctness is also found in personal first names and last names, respectively (Al is a short form of Albert and other names beginning with Al):

> Al (cf. Albertito), Bill (Guillermito), Bob (cf. Robertito), Clint, Craig, Cris, Dee, Don, Drew, Fritz, Greg, Jim, Joan, Jon, Karl, Ken, Lynn, Mark, Phil, Rich, Tom, Trent.
>
> Barden, Bash, Bowles, Burns, Burge, Casey, Clowes, Cook, Cote, Cray, Doyle, Dreier, Dyer, Gage, Gibbs, Gore, Grant, Hale, Hein, Holt, Hume, Hunt, Jay, Jones, Junn, Kirk, Kirsh, Krick, Kroll, Kuhn, Locke, Ohm, Pelz, Rush, Sapps, Scott, Shane, Shats, Smith, Stern, Walsh, Wills, Wren

Compare the possible Al Dyer, for example, with a real name such as Diego Rodríguez de Silva y Velázquez or with a conceivable contemporary name such as Anunciación Fernández de Henestrosa y Antolínez. (Fernández, derived from Fernando – in turn derived from Germanic Fredenand, introduced in Spain by the Visigoths, the most common in Spain after García – is the first last name of almost 1 million Spaniards.)

5   Counted Syllables Grouped in Pairs or Triplets

Why this focus on the number of syllables of a vocabulary item? Because poems are not written with ideas but with pronounceable words ("ce n'est point avec des idées que l'on fait des vers . . . C'est avec des mots"), as a celebrated poet (Mallarmé) famously put it. Since every vocabulary item has one or more syllables, the number and distribution of syllables grouped in pairs or triplets in a line written in a particular language is not without consequences for the poetry written in the language. As a medieval Hispanic poet once put it (in the *Libro de Alexandre*), not without bragging, writing poetry with precisely counted syllables – and with the appropriate number and distribution of stressed syllables, it must be added – requires "great mastery" ("*e silabas cuntadas, ca e gran maestria*"). Evidence for this relevance will be provided directly.

As a point of entry, consider this stanza from Shelley's celebrated *Song of the Men of England*:

> The seed you sow, another reaps;
> The wealth ye find, another keeps;
> The robes ye weave, another wears;
> The arms ye forge, another bears.

Except for the reiterated *another*, all the words are monosyllabic, as is often the case for the common words of English. The contrasting reiteration

of *another*, the only non-monosyllable, arguably contributes to bringing out the class division and the implicit contrast between the two classes (recall "Ye are many; they are few", the closing line of *The Mask of Anarchy, Written on the Occasion of the Massacre at Manchester* – where *anarchy*, as is often the case, is taken in the sense of disorder rather than in its etymological sense of 'no (hier)archy', more in line with anarchism as "the anarchist variety of libertarian socialism" (Chomsky, e.g., 2001)). The predominance of monosyllabic words exemplified in Shelley's stanza is a defining characteristic of the English language that has no doubt contributed to its becoming "Globish" (as Robert McCrum has suggested; cf. Crystal 1997), that is, a sort of world language, despite the fact that English has more sounds than other languages (between 44 and 48 depending on regional pronunciation) – a richness partly due to its heritage, which includes roots from two different Indo-European branches (Germanic and Romance) – and that nearly half of them are shadings of vowel sounds that enrich the keyboard and are challenging for most non-English-speaking people.

These and other properties of English underlie English literature, which arguably culminates in the writings of Shakespeare, widely regarded as the greatest writer in the English language (and the world's pre-eminent dramatist and, arguably, sonnetist), to whom we owe some of the most memorable literary creations in the English language. Not surprisingly, his sonnets are among the most famous within the rich treasure of English poetry, with no less than twenty being included in the *Oxford Book of English Verse*, a measure of their perceived relative prominence in English literature. Published in 1609, *Shakespeare's Sonnets: Never Before Imprinted* (in modern spelling), including all 154 sonnets, was the last of Shakespeare's non-dramatic works to be printed. It is usually assumed that most of the sonnets were written in the last decade of the sixteenth century. Needless to say, if he had been born and grown up in Burgos or Bilbao, even Shakespeare, with all his genius, would not have been the author of comparable sonnets (or plays). A single representative line may be sufficient to suggest what the English language contributes: The Spanish poet Miguel de Unamuno closes one of his sonnets with a literal translation of the second hemistique (minus *of*) of the first line of Shakespeare's Sonnet 30 (*of sweet silent thought*) and the translation takes the whole line:

> *el dulce silencioso pensamiento*

As is to be expected, in the creation of his sonnets Shakespeare was influenced by the Italian sonnet, which had been popularized by Dante and Petrarch and refined in Spain and France. (See Otero 1966.) Exploiting the sonority of the vowel-rich Romance language, the Italian poets gave preference to the Italian form of the sonnet – two groups of four lines, or quatrains (always rhymed a-b-b-a-b-b-a), followed by two groups of three lines, or tercets

(variously rhymed c-c-d e-e-d or c-c-d e-d-e), a rhyme scheme that is less natural in English. Presumably to adjust to this difference between Romance and English, with some exceptions, Shakespeare chose to follow a rhyme scheme where the rhymes are interlaced in two pairs of couplets to make three four-line stanzas (called quatrains) and a final couplet, all lines being iambic pentameters (a meter used extensively in Shakespeare's plays) with the rhyme scheme abab cdcd efef gg, a form now known as the Shakespearean sonnet.

Here the collection of his sonnets can only be sampled, and a concise way of doing it is to examine briefly three of them (arguably representative). We will begin by considering Sonnet 18, one of the best-known and most widely admired of all 154 (for some it is Shakespeare's greatest love poem), in part perhaps because it is one of the most straightforward in language and intent. Its theme is the stability of love and its (presumed) power to immortalize both the poetry and the subject of that poetry. It is reproduced directly below, along with Agustín García Calvo's rendition into Spanish, to facilitate the comparison of the English original with the translation, in particular the two vocabularies. These glosses might be helpful:

> *temperate* 'constant'; *darling* 'beloved'; *all too* 'far to';
> *Sometime too hot the eye of heaven shines* 'at times the sun is too hot';
> *often is his gold complexion dimm'd* 'often goes behind the clouds';
> *every fair from fair sometime declines* 'everything beautiful sometime
>   will lose its beauty';
> *By chance or nature's changing course untrimm'd* 'by misfortune or
>   by nature's planned out course';
> *thy eternal summer* 'your eternal youth';
> *lose possession of that fair thou owest* 'will you lose the beauty that
>   you possess';
> *brag thou wander'st in his shade* 'brag that you strayed into its shade';
> *When in eternal lines to time thou growest* 'when in my eternal verse
>   you will continue to live';
> *So long lives this and this gives life to thee* 'as long as this lives on
>   and gives you life'.

Sonnet 18

> Shall I compare thee to a summer's day?
>   ¿A un día de verano habré de compararte?
> Thou art more lovely and more temperate:
>   Tú eres más dulce y **temperado: un ramalazo**
> Rough winds do shake the darling buds of May,
>   **de viento** los capullos de Mayo **desparte**,

And summer's lease hath all too short a date:
   y el **préstamo** de estío **vence a corto plazo**;
Sometime too hot the eye of heaven shines,
   tal vez **de sobra** el ojo de los cielos **arde**,
And often is his gold complexion dimm'd;
   tal vez su tez de oro **borrones empañan**,
And every fair from fair sometime declines,
   y toda gracia gracia pierde **pronto o tarde**,
By chance or nature's changing course untrimm'd;
   que ya accidente o cambio natural **la dañan**.
But thy eternal summer shall not fade
   Mas tu verano eterno **ni jamás se agosta**
Nor lose possession of that fair thou owest;
   ni pierde prenda de esa **gracia en que floreces**,
Nor shall Death brag thou wander'st in his shade,
   ni Muerte ha de ufanarse que **a su negra costa**
When in eternal lines to time thou growest:
   vagues, que cara al tiempo en línea eterna creces.
So long as men can breathe or eyes can see,
   En tanto aliente **un hombre** o ver el **ojo pida**,
So long lives this and this gives life to thee.
   vivo estará este verso, y te dará a ti vida.

The level of creativity exhibited by García Calvo's version, in this and other cases, is really extraordinary in itself. However, his Spanish rendition of Sonnet 18 (aside from the last line), because of properties of Spanish out of anyone's control, has, arguably, little in common with Shakespeare's sonnet, even putting aside the fact that he doesn't render Shakespeare's lines in iambic pentameters, the meter of the English original, but rather in hexameters (alexandrines), thus adding four more syllables per line – as other translators have done before him (see Pujante 2009). One reason for this shortcoming appears to be that most common English vocabulary items, many of them monosyllabic, are usually shorter (in some cases considerably shorter) than their Spanish counterparts (Catalan fares better than Spanish – cf. Montoriol 1928), e.g., *rough winds* 'ramalazos de viento'; *summer's lease* 'préstamo de estío'; *the eye of heaven* 'el ojo del cielo'; *shall not fade* 'jamás se agostará'; *fair thou owest* 'gracia en que floreces', and so on, in García Calvo's rendition, which in a number of cases differs from the modern English paraphrases listed above. (The words in bold are not translations of the English words.)

Consider now two other sonnets (neither of which are usually included among his best) for which we have two extant published versions: Sonnet 138 (in a slightly different form) and Sonnet 144, both of which had already

appeared ten years earlier in *The Passionate Pilgrim* (1599). The two are reproduced below (as printed in 1609), selected here for comment not just for that reason, or because they stand out in the level of achievement they exemplified, but because they provide a little window on what Shakespeare took to be improvements. Both are reprinted below, again with García Calvo's version of each. (A vocabulary item, *forgeries*, is no longer current. It means 'subtleties' in present-day English.)

The following expressions might need clarification:

> *made of truth* 'truthful'
> *untutor'd* 'inexperienced'
> *Unlearned in the world's false subtleties* 'ignorant of all the deceit that exists in the world'
> *vainly* 'foolishly'
> *Simply I credit* 'foolishly I give credit'
> *wherefore* 'why'
> *unjust* 'dishonest' (about her infidelity)
> *best habit is in seeming trust* 'best disguise is the pretense of truth'
> *lies* both 'tell lies' and 'lies (has sex) with other men'

Sonnet 138

> When my love swears that she is made of truth
>   Cuando jura mi amor que su fe es **como el cielo**
> I do believe her, though I know she lies,
>   **de firme**, yo la creo, bien que sé que miente,
> That she might think me some untutor'd youth,
>   **para que** ella me crea un **infeliz** mozuelo,
> Unlearned in the world's false subtleties.
>   del mundo y sus **perversidades** inocente.
> Thus vainly thinking that she thinks me young,
>   Así, creyendo en vano que ella me cree joven,
> Although she knows my days are past the best,
>   bien que sabe que es ida la flor de mis años
> Simply I credit her false speaking tongue:
>   yo, simplemente, de su lengua bebo los engaños.
> On both sides thus is simple truth suppress'd.
>   **y** sufre la verdad **que aquí y allá la roben**.
> But wherefore says she not she is unjust?
>   Pero ¿por qué ella no declara que ella es falsa?
> And wherefore say not I that I am old?
>   **Pero** ¿por qué no digo yo que yo soy viejo?

O, love's best habit is in seeming trust,
    Ah, **que** en amor **la pura fe** es **la mejor salsa,**
And age in love loves not to have years told:
    Y edad **no quiere amor contar en su cortejo**
Therefore I lie with her and she with me,
    Conque **ella en mí, yo en ella, así con trampa entramos,**
And in our faults by lies we flatter'd be.
    Y **nuestras faltas con embustes adobamos**.

    The crucial ambiguity of *lie*, which can be understood as either *acostarse* or *mentir*, is, of course, not available to a Spanish translator. No less crucial is what, arguably, the sonnet takes for granted, which, to my knowledge, does not seem to have been pointed out: The sonnet can be fully understood only in the light of one of the stories of Boccaccio's *Decameron* (Third day, Tenth tale), generally considered to be its most obscene and bawdy one by far. It is told by Dioneo ('Dio nuovo'), who always speaks last at the end of each day. Boccaccio's initial summary of the story is this: "Alibech turns hermit, and is taught by Rustico, a monk, how the Devil is put in hell. She is afterwards conveyed thence, and becomes the wife of Neerbale." ("Alibech diviene romita, a cui Rustico monaco insegna rimettere il diavolo in inferno; poi, quindi tolta, diventa moglie di Neerbale.") A naive young woman, Alibech wanders into the forest in an attempt to attain a closer unity with God and she meets the monk Rustico, who seduces her under the pretense of teaching her how to better please God by putting Rustico's "devil" in her "hell."

    A few clarifications may be in order:

of comfort and despair	'one comforting, the other despairing'
do suggest me still:	'do urge me on:'
a man right fair	'a beautiful man'
a woman colour'd ill	'a woman of dark complexion'
Wooing his purity with her foul pride	'seducing him and his purity with her repulsive pride'
But being both from me, both to each friend	'but both being away from me, and each friendly toward the other'
I guess one angel in another's hell	'I guess one angel is in the other's hell'
Till my bad angel fire my good one out	'until my bad angel drives away my good angel'

    A number of pairings between the English original and García Calvo's Spanish version, including those underlined below, don't seem to be quite

on target, and more so if the tale of the *Decameron* is as relevant as it, arguably, is:

Sonnet 144

> Two loves I have of comfort and despair
>> Dos tengo amores de **catástrofe y amparo(?!)**
>
> Which like two spirits do suggest me still:
>> como dos **genios que me inspiran hora a hora**
>
> The better angel is a man right fair,
>> mi mejor ángel es un hombre blondo claro,
>
> The worser spirit a woman colour'd ill.
>> **mi genio malo** una mujer **morena mora(?!)**
>
> To win me soon to hell, my female evil
>> Para **echarme** al infierno **ya**, (?!) mi **diablo** hembra
>
> Tempteth my better angel from my side,
>> tienta a mi ángel **bueno a abandonar mi bando(?!)**
>
> And would corrupt my saint to be a devil,
>> y **en** mi santo **malicias de demonio siembra(?!)**
>
> Wooing his purity with her foul pride.
>> su pureza con vil soberbia cortejando.
>
> And whether that my angel be turn'd fiend
>> Y si **se hará mi diablo o no, conmigo(?!)**
>
> Suspect I may, but not directly tell;
>> **temerlo** puedo, **mas** no decirlo **a lo derecho**;
>
> But being both from me, both to each friend
>> mas siendo míos ambos y uno de otro amigo,
>
> I guess one angel in another's hell.
>> un ángel en [**el**] infierno del otro me sospecho.
>
> Yet this shall I ne'er know, but live in doubt,
>> Pero eso nunca lo sabré, y en duda **peno**
>
> Till my bad angel fire my good one out.
>> hasta que el malo **a purgatorio arroje (?) al bueno**.

6   Coda

If it is true that Greek architecture, English poetry, and German music are three of the, if not *the* three, greatest creations of humankind, and that Shakespeare is "a poet who does not have an equal in any other language," as the outstanding twentieth-century Spanish poet Luis Cernuda was inclined to believe (1994: 255, 647), it is, arguably, due, to a not inconsiderable extent, to the crucial contribution of the English vocabulary. If so, it suggests that, when it comes to the creative aspects of language use, the mental lexicon and the (externalizable) vocabulary go together like a horse and carriage, as in the song introduced in the United States in 1955 (the year *Language Structure and Linguistic Theory (LSLT)* was completed) and popularized in the 1960s; when a language is used

for intercommunication and creative expression, "you can't have one without the other": You cannot externalize some of the main artistic uses of the mental lexicon without making crucial use of the carriage provided by the vocabulary, and, as the preceding considerations are meant to suggest, some vocabularies are far more helpful than others for some significant creative purposes, the conciseness of the English vocabulary being hard to match.

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Part III

Linguistics and Other Sciences

14 My Head's in Knots: On Uriagereka's Generalization and the Knot-Sentence Connection

Sergio Balari, Antonio Benítez-Burraco, Marta Camps, Víctor M. Longa, and Guillermo Lorenzo

In 2005 and 2006 Juan Uriagereka coauthored two seminal papers where an intriguing connection was established between the Faculty of Language and the human ability to make knots (Piattelli-Palmarini and Uriagereka 2005; Camps and Uriagereka 2006), for both seem to rely on sequential operations exhibiting "context-sensitivity," a term borrowed from the Chomsky hierarchy of languages (Chomsky 1956, 1957, 1959, 1963).[1] The fact that language and knot-tying abilities seem to be specifically human capacities and the seeming exceptionality of context-sensitivity, in sharp contrast with the behavior of other species, were further used in these papers to argue that the said connection is not accidental. The conclusion paved the way for an innovative methodological proposal at the service of evolutionary linguistics, which we like to call "Uriagereka's Generalization":

Uriagereka's Generalization

Absence of material evidence of knotting in the fossil record of different human species should also be read as evidence of the absence of (full-blown) language at the corresponding stages of human evolution.

After its original formulation, the authors of this chapter have made sporadic contributions aiming at clarifying, amending, and extending the generalization, sometimes in joint efforts with Uriagereka (Balari *et al.* 2011), sometimes in different parallel projects (Balari *et al.* 2012; Balari and Lorenzo 2013: ch. 7;

Longa 2013). This chapter summarizes the main conclusions of this collective effort and reflects about the strengths and weaknesses of the idea.

1   Searching for the Grammar of Knots

Uriagereka's Generalization entails the attribution of language-like properties to knots. At first sight, this might seem a surprising contention, but terminology is misleading here and asks for some clarification: "Language-like," in the intended sense, does not mean derivative from (or parasitic on) some specific properties observed in the productions of natural languages (sentences and so on). The expression is used as in formal language theory (FLT), a mathematical framework where "languages" are sets specified as collections of strings (or sequences) made up of symbols taken from finite alphabets (or inventories), and "symbols" are items of any kind capable of being part of any such alphabets and any such strings (Hopcroft and Ullman 1979; Lewis and Papadimitriou 1981; Webber 2008). Another key concept of the theory of formal languages is "grammar" (also a potentially misleading one, given its historical connotations), which refers to the method for specifying languages under some rule format. This is an advantageous method because languages in themselves, consisting of (possibly infinite) sets of strings, incorporate no direct record of their complexity; grammars, on the contrary, compress these sets into tractable finite devices (rule systems), where different degrees of complexity may obtain from the different types of constraints imposed on the format of the rules. FLT makes use of a third key notion, namely the concept of "automaton," which introduces a further descriptive method based on the abstract characterization of machines capable of implementing the recognition of strings belonging to a language by handling the required rule equipment. Within this perspective, types of constraints corresponding to different degrees of complexity match the "memory" resources (abstractly characterized) associated to the corresponding automata. The perspective of automata is crucial when FLT is used in enterprises with empirical import, as it sanctions the physical feasibility of properties identified in the abstract. This statement requires some clarification, as the applicability of FLT to the study of cognition has sometimes been called into question on different grounds (Lobina 2012; Lobina and Brenchley 2012; Boeckx 2013; Benítez-Burraco and Boeckx 2014) based, in our opinion, on a misunderstanding of what FLT can actually do for us.

   The crucial point here is that FLT is a tool with which we can assess *structural* complexity. That is to say, symbols in the strings of a language are arranged following some regular pattern, and these patterns are based on different kinds of dependencies established between symbols within the string, as illustrated in (1):

(1) a.   aaaaabbb
    b. $a_i a_j a_k a_l b_l b_k b_j b_i$
    c. $a_i a_j a_k a_l b_i b_j b_k b_l$

Thus, in (1a) the presence of the last two *b*s in the string just depends on the transition defined by the substring *ab*, that is, as soon as we are able to determine that we have found the last instance of symbol *a* and the first instance of the symbol *b*, we know that only an arbitrary number of *b*s can follow. In (1b) things are a bit different because, while the substring of *b*s must follow the substring of *a*s, as in (1a), here we require that the numbers of *a*s and *b*s be the same *and* that the dependency relation between *a*s and *b*s in each substring be the one indicated by the subindices, giving rise to a center-embedded structural pattern. Finally, (1c) is almost identical to (1b) with the exception that the structural pattern is crossed. Now, the abstract patterns observed in (1) can serve as models of actual structural patterns observed in natural languages. These results are well known and come down to the conclusion that natural languages appear to exhibit a degree of structural complexity that does not go beyond that of mildly context-sensitive languages, with a limited number of crossed-dependencies like (1c) (Joshi 1985; Joshi *et al*. 1991; Vijay-Shanker and Weir 1994). Context-free patterns like (1b) are also observed, as it is also the case of patterns of the regular kind like (1a), with one interesting qualification: Regular patterns appear to be exclusive of phonological structure, while context-free and mildly context-sensitive patterns are exclusive of syntax/semantics (Heinz and Idsardi 2011, 2013). This is an interesting result, but one of little import to our arguments here, so we will not come back to it anymore.

This is then one area in which FLT finds an application, since it provides a frame of reference against which we can assess degrees of structural complexity. Moreover, to the extent that similar abstract patterns can be identified in other areas of cognitive activity apart from natural language, it also offers us the possibility of comparing degrees of structural complexity not only in different cognitive activities in humans, but also between humans and other nonhuman species, as in the case of human phonology and birdsong (Berwick *et al*. 2011, 2012; Bolhuis *et al*. 2010). This last point will be of importance later when we turn to knots and knotting activities, but for the time being let us stay focused on the case of natural language and the kinds of inferences we can draw from the use of FLT as a modeling tool.

As noted above, FLT makes use of two different, but equivalent, mathematical constructs to determine the degree of structural complexity of a language: grammars and automata. Complexity is therefore determined by how constrained are the rules of the grammar or the operation of the automaton: The more constrained the rules or the operation, the less complex is the language generated by any of these devices. Let us concentrate on automata and forget about grammars for reasons that should be clear presently.

Automata are machines, abstract computing devices, capable of determining whether an input string is a member of a language or not. The minimal structural specifications for an automaton are a control unit with a reading head pointing at an input tape where the string we want to compute has been

inscribed. It is assumed that the control unit implements a set of rules that determine the actions the automaton must perform as a function of the symbol it is currently reading, so the computation consists of going through the input string until a halting state is reached or the machine gets stuck without actually being able to reach the end of the string. In the first case, we say that the automaton has accepted the string. Now, how does the structural complexity of a language relate to the structural complexity of an automaton? A standard way of looking at this is by attending to two parameters: (i) the presence/absence of an external memory device; and, if external memory is available, (ii) its degree of sophistication. Structurally simple languages like those of the regular type can be computed by an automaton with no external memory, while languages beyond the regular type all require that the automaton has access to external memory to perform the computation. This is the second area in which FLT finds an application in cognitive modeling, since it provides the *minimal structural specifications* a computational device must comply with to be able to deal with patterns of a certain degree of structural complexity: A computational engine with or without access to external memory and, in the latter case, an external memory with a higher or lesser degree of complexity. To the extent that cognitive activity is assumed to be computational activity, the analogy is a valid one, but with limitations. To avoid misunderstandings of the kind we referred to above, it is also important to know what FLT *cannot* tell us.

First and foremost, to claim that some automaton, say a pushdown automaton (PDA), can be used as a model for some natural computational system is not the same as claiming that the natural computational system *is* a PDA. In other words, the claim cannot be an identity claim. There are several reasons for this. One is that automata cannot be taken to be full-fledged models of processing systems, because processing systems are necessarily much more complex structurally than an automaton. As pointed out above, however, automata give us some minimal specifications over which more realistic processing models can be built. A second reason has to do with the actual concerns of FLT. Let us insist that FLT is interested in structural complexity or, to put it differently, in computability. When we determine that some structural pattern falls within the space defined by the Chomsky hierarchy, we are simply saying that it is computable or, in other words, that there is some algorithm capable of computing it. Crucially what we are *not* saying is that it can be computed *efficiently*: Some problems can be solved computationally, but not necessarily in an efficient way; there are even problems for which no computational solution exists – this is the essence of Alan Turing's results. Thus, to the extent that FLT is concerned only with structural complexity and not with efficient computation, automata can only be used as models of natural computational devices in the sense pointed out above: i.e. as providing the minimal structural specifications for such a device. But in order to approach more realistic models, other

considerations need to be taken into account. Here is where computational complexity enters.

The theory of computational complexity deals with sets, like FLT, but looking at them as if they were problems (Papadimitrou 1994; Arora and Barak 2009). The theory relies on the assumption that any problem that we may think of can be represented as a language and aims at establishing whether there are any solutions forthcoming for it in the near future and how hard it is to get them. The complexity that is at stake now is not "structural complexity," which is what one can assess with FLT, but, complementarily, "computational complexity," defined as the amount of time and/or space resources spent by a Turing machine in order to solve a problem (with "time" defined as the number of steps, and "space" as the number of cells in a tape that the machine visits during the computation). Problems can thus be sorted as belonging to different classes: For example the **P** class, comprising those problems that can be solved efficiently in polynomial time by a k-string (input and output) Turing machine working in deterministic mode;[2] the **NP** class, comprising those for which a nondeterministic Turing machine will reach a solution following some path (i.e. by a procedure close to brute-force search) and the correctness of the solution can be verified through a succinct certificate (or polynomial witness) in polynomial time;[3] or the **PSPACE** class, which is the deterministic class of problems resolvable by a Turing machine using a polynomial amount of space, a more costly resource than time. Classes are related by inclusion (not known to be proper, so some classes may turn to be equivalent), describing a hierarchy with **PSPACE** at the top and the **P** class at the bottom ($\mathbf{P} \subseteq \mathbf{NP} \subseteq \mathbf{PSPACE}$). Problems in **P** are those with "feasible" decision procedures, while as we go up in the hierarchy we come to problems that, although being computable, verge into intractability. Natural computational systems are, necessarily, finite, so if we do not want to give up the idea that certain aspects of cognitive activity like language are computational, we'd better find out whether this can be done efficiently.[4] Thus, while formal language theorists are concerned only with structural complexity and computability, they are happy to assume that automata have unlimited amounts of time and space to work. Computational complexity theorists, on the other hand, actually impose constraints on the

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[2] That is, as the length of the input n increases, the time spent by the machine to halt only grows as a polynomial function of n with a relatively low exponent like, for example, n^3.

[3] In other words, problems in **NP** are those whose solution (independently arrived at by a non-deterministic computation) is efficiently *verifiable*, whereas problems in **P** are those that are efficiently *solvable*. That is, the problem of verifying the solution to an **NP** problem is efficiently solvable and therefore is in **P**.

[4] This is not to say that all cognitive activity is computational; it cannot be. For example, games like checkers, chess, and go are in **EXPTIME**, a class of highly intractable problems. However, humans are capable of solving these problems, some even quite efficiently, meaning that the strategies we use also include some heuristic shortcuts.

space and time resources of machines in order to verify whether something can be computed within these bounds or not. We need both perspectives to work out realistic models for natural computational systems. The more so because, as it should be expected, there exist correlations between degrees of structural complexity and degrees of computational complexity. In other words, one can safely transit from one perspective to the other. Some equivalences of concern are the following: (1) The problem of context-free recognition is in **P**; (2) the problem of context-sensitive recognition is in **PSPACE**(-complete); and better still, (3) the class of mildly context-sensitive languages is in **P** (Joshi 1985). We'll come back to these in a moment, since it is here where some connection with knotting can be established. But, first, let us turn to knots.

Recall that our main goal was to try to fill with some formal contents the intuition behind Uriagereka's Generalization. It is not a trivial question, however, whether the tools of FLT may be applied in order to get a reliable measure of the structural complexity underlying knotting abilities. The fact that the end products of knotting activities are continuous shapes, to which descriptions as sequences of discrete symbols seem to be alien, may be seen as a potential objection to applying the theory of formal languages to this particular domain. But for the same reason, one could also feel tempted to exclude natural languages from the scope of the theory, since the perceptible outputs of the Faculty of Language are continuous physical events too, devoid of true linguistic properties – one of the enduring lessons of Saussure's *Cours de Linguistique Générale*. So this is not a real objection, even if it certainly singles out a real challenge for the project: namely, that of establishing a level of analysis at which, as in the case of linguistic signals, the relevant descriptions legitimately apply when dealing with knots.

Tying and untying knots ultimately translates into motor sequences, in a way similar to that in which producing and perceiving sentences relate to sensory-motor operations. But one can also imagine the tying or untying of a knot without performing the relevant actions, as one can compose and interpret sentences without pronouncing them actually; and one can even conceive new kinds of knots, never previously done, even without actually executing them, as we routinely compose sentences never previously heard. Indeed, tying, untying, learning, and inventing real knots, or assessing their adequacy through visual inspection, all presuppose, as a set of distinct but familiar practices, a common level of analysis at which certain basic properties of knots need to be represented as prior to and perhaps independent of the motor programs capable (more or less efficaciously) of accomplishing them.[5] It is our contention that

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[5] Studies on knotting abilities from a cognitive perspective are scarce and mostly focused on motor aspects (Michel and Harkins 1985; Tracy *et al*. 2003). In one of these studies (Michel and Harkins 1985), the conclusion reached is that, although performance improves when there is coincidence in handedness between the instructor and the instructed, humans are not particularly

this is a level of analysis equivalent to that at which sentences are composed as expressions devoid of any phonetic content. It is also our claim that this is a level at which (minimally) the number and direction of crossings that each particular knot consists of are abstractly represented (Turing 1954; Balari *et al.* 2012: 102–103), the format of which is probably not very different from that of other tasks implied in object recognition in the visual modality. This is a welcome conclusion, because in the case of vision it is a common assumption that object parsing involves the identification of geometric primitives, which compose abstract representations based on part–whole (mereological) relations, supplemented with (topological) connections among them (Marr 1982; Biederman 1987; Casati and Varzi 1999). An extension of a similarly abstract mereotopological field as the locus of the mental operations underlying knot recognition paves the way for the application of the different perspectives of FLT to this domain.

After decades of practicing generative linguistics – i.e., of compressing linguistic productions into different formats of rule systems – there exists an ample evidential base to derive conclusions regarding the formal complexity of natural languages. Nothing remotely similar exists in the case of knotting abilities. Thus, in our earlier attempts to provide some formal content to Uriagereka's Generalization, we focused our attention on the mathematical theory of knots, under the assumption that the entities studied by the theory could be seen as abstract models of real knots. Knot theory (Adams 2004) is a branch of topology dedicated to study of abstract figures (Knots) defined as the embedding of circles (S^1) into spheres (S^3) – or, alternatively, in Euclidean space (R^3). Knots (capitalized) are not the (lowercase) knots one uses when sailing, fishing, mountain climbing, building a hut, and so on: Knots are closed structures (knots are open, but one can approximate them to Knots by somehow connecting the two ends of a string after tying a knot), with no thickness (contrary to knots), so its cross-section is a single point. In Adams's words: "The [K]not is then a closed curve in space that does not intersect itself anywhere" (Adams 2004: 1–2). Knots are thus abstract objects, of no use whatsoever for the many practical purposes that knots routinely serve. But Knots are models of knots, and thus useful tools to think about knots in the abstract – see Figure 14.1. They provide, therefore, a helpful format for representing the mereotopological properties of knots in the internal level of representation that we hypothetically endorse.

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gifted in learning and executing new knots by just observing the necessary motor sequences to tie them. In our opinion, studies like this basically point to the necessity of observing in the case of knotting a distinction between "competence" and "performance" parallel to that introduced by Chomsky (1965) in the case of language; see Casati (2013) for a congenial view, a work to which we will return presently.
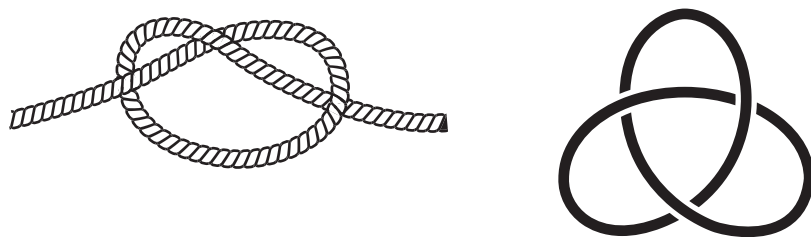
Figure 14.1. An overhand knot (left) and a trefoil Knot (right). By joining together the two loose ends of the former, a figure obtains equivalent to the latter. The overhand knot can be used to prevent the end of a rope from disentangling; the trefoil Knot can be used to think about overhand knots. The trefoil image has been generated with the KnotPlot© software developed by Rob Scharein.

Now, some of the problems that Knot theory confronts have been analyzed from the perspective of the theory of computational complexity, and some interesting conclusions have been reached. These problems – the unknotting problem and the genus problem – are, essentially, Knot recognition problems that try to establish the complexity of the task of telling apart certain types of Knots from others. Without going now into the details of what questions exactly each of these problems are supposed to answer (but see Hass *et al*. 1999; Agol *et al*. 2002, 2005; Kuperberg 2011), the encouraging result is that Knot recognition problems show a level of complexity around the **NP** class – maybe slightly higher. Ristad (1993) independently concluded that natural language computations are **NP**-complete, which is also the same complexity level shown by Knot recognition problems, as we have just pointed out above.[6] So

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[6] The possibility exists, however, that this conclusion should be revised as to the level of complexity of knots and language, which may turn out to be lower for both. In the text, we have appealed to complexity results for Knot recognition problems, whose task is to identify some specific Knot (e.g., the unknot) when presented with a Knot *in any of its many possible deformations*. This may in the end be an unrealistic model for human knot recognition, where the added complexity of the identification of topologically equivalent deformations may not actually play a critical role. If, however, we assumed that something akin to the method described in Turing (1954: 585-586) is used to represent knots in 3D space, with an indication of the steps taken in each of the three dimensions, *but not taking into account possible deformations*, things may turn out to be much simpler. Turing's 3D representations may easily be transformed into strings of characters, that, as we speculated in Balari *et al*. (2012), may conform a "knot language," which in the cited paper we wrongly characterized as indexed, on the tacit assumption that the number of columns might not be fixed. It happens to be the case, however, that this will always be a six-column language (two for each dimension) and, consequently, belong to the class of Linear Context-Free Rewriting (LCFR) languages. Now, LCFR systems are currently taken to be formal representatives of the mild context-sensitivity that characterizes natural languages, and they happen to be recognizable (and perhaps also parsable) in polynomial time – Ristad's (1993) results may be too pessimistic after all; see Castaño (2004) and Kallmeyer (2013) for details.

we concluded that natural language and Knot recognition problems have similar or perhaps equivalent degrees of complexity and therefore can be computed by machines requiring a similar amount of resources.

We can only recognize today that the conclusion above is a weak one, even though encouraging. Its main weakness is that it fails to establish a strong connection between the structural complexity of natural language and knotting, especially as far as the knot competence is concerned: Nothing in what we have said so far provides evidence for the existence of a grammar of knots. Fortunately, the issue has been taken up recently by Casati (2013), who has set up the basic building blocks for establishing the desired connection between knots and language.

Casati's main point is that topology can give us only a partial account of what is involved in knot-tying abilities (Casati 2013: 6), so he provides a detailed analysis of performance with the aim of eventually establishing some basic elements of the underlying competence. His analysis is interesting because it shows that by extending our observations to general fastening abilities – i.e., those involving not just knots but also structures like hitches that are not topological knots – one can eventually identify a set of primitives or, in Casati's words, "the mental lexicon for the basic operations one performs on ropes when tying" (Casati 2013: 12). He relies on the theory of Atomic Graphic Schemes developed by Pignocchi (2010) to explain drawing abilities to suggest that humans develop a lexicon of Atomic Knotting Schemes (AKS) that are compositionally combined to construct Molecular Knotting Schemes (MKS). Such MKS can eventually be "lexicalized" to function in turn as AKS that may become part of new knotting schemes. Thus, Casati (2013: 13) concludes, "the peculiarities of learning, innovation, generalization and transmission would be explained by using the resources of the AKS-MKS framework." To be sure, one cannot claim that knotting is exactly like language in emulating its compositionality and systematicity. After all, as it is also the case with drawing, even experts appear to have difficulties in results of the composition of some basic knotting schemes – something we could hardly say of language. One thing is nonetheless clear; in our opinion, both knotting and language can be said to be based on the arrangement of basic atomic elements following specific structural patterns.

Indeed, this result is in principle compatible with the following alternatives:

(1) Human minds carry out language computations and knot computations with specialized modules that just happen to have the same computational power.
(2) Both kinds of computations are performed by the same device.

In the following pages we will try to motivate the latter alternative on diverse grounds. Before coping with this question in section 3, let us first devote some space to the natural history of human knots.

2   The Fossils of Knotting: What Are They? Who Had Them?

Evidence of knotting abilities is specifically used in Piattelli-Palmarini and Uriagereka (2005) and Camps and Uriagereka (2006) as a pointer of the existence of full-blown language at certain stages of human evolution, not to signal the moment of its emergence. It is important to clarify this point. As a matter of fact, Piattelli-Palmarini and Uriagereka (2005) claim that the evolutionary onset of complex language coincides with the mutations leading to the human specific variant of *FOXP2*, which may have occurred around some 120 ka B.P. (Enard *et al*. 2002). But it is the age of known remains of knotting behavior – maybe going back 110 ka, according to Camps and Uriagereka (2006) – that for them signals when language was fully operative. Where alternative dates of said mutations are more accurate than that, say 200 ka B.P., as alternatively suggested in Enard *et al*. (2002), or even 400 ka B.P., as argued in Krause *et al*. (2007), this technical detail will only affect the model of evolution preferable to the case of language, attending to the different speed that language would take to evolve according to each scenario. This is precisely so because both Piattelli-Palmarini and Uriagereka (2005) and Camps and Uriagereka (2006) presuppose that *FOXP2* is not a reliable marker of the existence of full-blown language (see also Benítez-Burraco *et al*. 2008): The real signposts for language, according to these papers, are the remains of knotting abilities themselves, thus the centrality of Uriagereka's Generalization in the evolutionary musings of these authors. What we want to underscore now is that, attending to such a chief role, connections between prehistoric material remains and knotting abilities, which are not always direct, must be very rigorously settled in order to serve the purpose of the generalization. In this section we offer some examples in which we think that this is actually the case, and some others where the connection is too speculative to serve such a purpose – dates of the corresponding illustrations are not particularly important to our concern here.

Knots are not directly attested until 27 ka B.P., by means of weaving both in clothing and in clothing representation (Soffer *et al*. 2000). However, they can be inferred long before that from different perforated ornaments and small projectile technology, the oldest evidence of which is about 90–75 ka, maybe even earlier (Henshilwood *et al*. 2002; d'Errico *et al*. 2005; Vanhaeren *et al*. 2006). As for projectiles, mounting of points as bone harpoons and stone arrowheads, as well as their flinging by means of arches or other propeller aids, all presuppose strong knotting. As for ornaments, most of these pieces contain signals of having been carefully and intentionally perforated in egg or snail shells and teeth, which makes unavoidable the conclusion that they were either sewn to clothes or hung to the body, also presupposing firmly tied knots. We think that in cases like these the inference of knotting abilities from the fossil record is unproblematic. However, connections are not always so straightforward.

Take, for example, the case of the collection of perforated shells found in the cave of Aviones (Murcia, Spain), dated at approximately 50 ka. These are extremely interesting items, particularly for their purported association with Neanderthals (Zilhão *et al*. 2010). That they served some symbolic purpose has been inferred from two facts: (1) some of them belong to non-edible species – so they were collected for reasons other than nutrition; and (2) they show remnants of pigments of different colors – indicative of an ornamental use. A further intriguing fact in relation to these pieces is that some of them show perforations, thus paving the way to speculating about their putative use as beads and inferring knotting abilities also in the case of Neanderthals. But the inference is weak, because a crucial premise is lacking in this case: Perforations are not intentional, but due without exception to easily identifiable natural causes, as shown by Zilhão and coworkers themselves. So this is a situation in which a finding of great interest for independent reasons cannot be reliably alleged in the context of Uriagereka's Generalization in the absence of further support (Balari *et al*. 2011; Lorenzo 2012; Balari and Lorenzo 2013: ch. 7). In more extreme cases, knotting abilities are inferred from so feeble a material base that conclusions cannot even be taken into consideration in this context. For example, Bednarik (2008: 306) suggests that *Homo erectus* was already endowed with knotting abilities, a conclusion that he bases on the fact they were "great colonizers," which necessitated the construction of "rafts" and thus the use of "cordage of some type," which "can only be employed usefully by means of knotting." But aside from the fact that Erectus were actually "great colonizers," no single piece of this inferential chain is minimally granted.

Let us now bring to the fore another example in which we claim that the inference of knotting abilities can be firmly derived from the archeological record – hopefully avoiding the kinds of shortcomings sometimes raised regarding these kinds of projects (Botha 2010). Remember that dates are not what are at stake here, but the strength of the inferential chains leading to the existence of knotting abilities as a conclusion.

A remarkable feature of the Upper Paleolithic in Europe (50–10 ka B.P.), as well as rock art at different times all around the world, is the number of representations that were made at heights above the floor level not accessible for a human being without some aid, probably ladders or scaffoldings of some kind. Smith (1983), writing about some paintings in Baja California, points out the alternative method of attaching a series of sticks together in order to reach the painting areas. But while this technique also presupposes some type of strong knotting, we think that it is unlikely to be generalized to all the cases that we will review below, in that it seems incompatible with the accuracy that most of these paintings show. Besides, the use of scaffoldings in at least some of them has been independently deduced on the basis of the existence of holes in the walls that purportedly served to fix such constructive structures, as originally

Table 14.1. *Some paintings from the European Upper Paleolithic that required the use of scaffoldings*

Location and description	Relevant bibliography
Labastide (Hautes-Pyrénées, France). Polychrome horse at 14 feet.	Johnson (2003)
Bernifal (Dordogne, France). Painted mammoths at 20 feet.	Johnson (2003), Desdemaines-Hugon (2010)
Font de Gaume (Dordogne, France). Painted woolly rhinoceros – not specified, but very high.	Johnson (2003), Desdemaines-Hugon (2010)
Lascaux (Dordogne, France). Painted bulls at 20 feet.	Mauriac (2011); see also main text
Rouffignac (Dordogne, France). 66 animal designs (painted and engraved) at 13 feet.	Barrière (1980), Desdemaines-Hugon (2010)
Candamo (Asturias, Spain). A painted head of a bison at 9 feet, a dark red horse (plus other figures around) at 13 feet, and a complete mural at 6 feet.	González Sáinz *et al.* (2003), Saura and Múzquiz (2007)
Tito Bustillo (Asturias, Spain). A mural with horses and reindeers (22 feet wide; two horses are 6 feet wide each) at 13 feet, and 22 vulvar figures at 6–8 feet.	Balbín Behrmann and Moure Romanillo (1981), Moure Romanillo and González Morales (1988), Saura and Múzquiz (2007), Polledo González (2011)
El Pendo (Cantabria, Spain). A mural with deer (82 feet wide) at 8 feet (average).	Montes Barquín *et al.* (1998), Montes Barquín (2003)

suggested in Barrière and Sahly (1964) regarding some paintings in Lascaux (Dordogne, France), and subsequently defended in Delluc and Delluc (1979), Tyldesley and Bahn (1983), Jones (1994), Lister and Bahn (1994), Johnson (2003), and Bahn (2007). Specifically at Lascaux, twenty such holes have been identified located at 5–6 feet above the floor level.[7] A representative inventory of paintings from this and other European Upper Paleolithic sites that probably required the use of scaffoldings is listed in Table 14.1.

As an illustrative example, the main mural of El Pendo (Cantabria, Spain), known as the Frieze of the Paintings or the Frieze of Deer, is 82 feet wide, with most of the paintings located within the last 29 of the left part – see Figure 14.2. The frieze is at an average of 8 feet from the floor level, but some parts are at even 19 feet.[8] In spite of such a distance from the ground, the paintings are far

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[7] It has been argued that a 30 cm long fragment of fossilized rope (7 mm of diameter) found in the Alleyway of the Felines (Delluc and Delluc 1979; Leroi-Gourham 1982) may also have been used in the constructive structures of Lascaux.

[8] We want to express our gratitude to Roberto Ontañón, Director of the Prehistoric Caves of Cantabria, for having provided these technical details for us.

Figure 14.2. A fragment of the Frieze of the Paintings in El Pendo (Cantabria, Spain).
Source: Braña. Revista de la Red Cántabra de Desarrollo Rural 6, March 2006. Reproduced with permission.

from being simple or sketchy drawings, which makes the conclusion inescapable that some kind of stable structure – scaffolds or ladders – was used by the painters.

To this we can add that the access to certain decorated spaces in some of the caves referred to in Table 14.1 might have required climbing, allegedly with the help of ropes. For example, a small chamber containing paintings in Candamo (Asturias, Spain) is located above a calcitic pouring at 39 feet from ground level; similarly, the Gallery of the Anthropomorphs in Tito Bustillo (Asturias, Spain) is within a hole 12 feet below the ground. In any event, access to these spaces is nonetheless possible with some care and using the natural protrusions of the walls that the original painters should have known well, so the inference is not completely granted in this case.[9]

We need to make it clear that most papers referred to in Table 14.1 are only incidentally concerned with the use of scaffolds and ladders as an aid of rock art from its earliest stages and remain indifferent to the techniques that were actually used in the construction of such supportive elements. Actually, while the inference from painting at locations higher than the stature of men to the

[9] We thank Miguel Polledo González for his comments on this.

use of said artifacts is a clear and direct one, the inference from painting to knotting as associated to the manufacturing of such devices is at best indirect. Some kind of intermediate step seems in order to fulfill the inferential gap. It is our opinion that an ethnographic perspective may provide the basis for confirming that the whole inferential chain leading from the forms of rock art of concern to knotting activity is perfectly warranted, as ladders and scaffolds made by knotting together pieces of wood or bamboo continue to be common – some examples are offered in Figure 14.3. Curiously enough, Bednarik (1986) has pointed out that a chain of continuity has existed in the use of wooden scaffolds for ochre mining from prehistoric to ethnographic times, which, in the case of Australian aborigines, has been broken only very recently. In the same vein, we also suggest that a continuity of sorts exists between knotting as associated to wooden ladders and scaffolds from prehistoric to ethnographic times, as may be easily attested even today in different human communities. We think that it is an outstanding fact in itself that the emergence of complex forms of rock art was accompanied by the use of devices that presuppose strong knotting from rather early stages of such practices. We also believe that the connection between the corresponding practices is a strong pointer to the existence of contemporary forms of complex language, a conclusion that is readily explained under the hypothesis that we put forward in the next section.

3   Computational Phenotypes ... and Neophenotypes

According to our argument, natural language and Knot recognition problems are of a similar complexity level, and consequently they can be dealt with by means of the same type of automata – a slightly enhanced pushdown machine or PDA+ (Uriagereka 2008). When confronting the question of the physical realization of such virtual machines in natural brains, the most elegant alternative is to posit the existence of just one such internal device as capable of simultaneously dealing with both kinds of problems. We thus consider that splitting the corresponding tasks into two different computational systems is an alternative to be discarded unless strong evidence accumulates against a simpler competing alternative. So forced to explore the idea that just one system of computation is at work underlying behaviors apparently as diverse as speaking and making knots, an obvious question immediately arises: Is this system the Faculty of Language – in the "narrow" (FLN) sense of Hauser *et al*. (2002)? We feel inclined to give the following answer to this question: If it is, it is not FLN as we used to think that it was. So we suggest a terminological switch here and, in order to avoid confusion, we will use the term Natural Computational System (NCS) – as in Balari and Lorenzo (2013), instead of Hauser *et al*.'s (2002) FLN concept.

Figure 14.3. a. A bamboo ladder (upper left) from Delhi (India); b. and c. bamboo scaffolds (upper right and bottom, from Ambert Fort, Jaipur, Rajasthan, India), made by knotting together the rails and the rungs or boards.
Source: Marta Camps' personal collection.

The difference between FLN and NCS is obvious: While the former is hypothesized as a human and language-specific system of computation, NCS is a species- and domain-unspecific computational device. For us, NCS is a core component of the animal mind/brain, subserving many (but not necessarily all) of its main cognitive functions, ranging from low-level activities like motor planning and execution to highly sophisticated ones like mathematical, social, or linguistic abilities, to name just a few. This NCS may be conceptualized as a serial, digital, von Neumann machine implemented on an analog, parallel, and continuous substrate, which may be modeled by an abstract machine or automaton (Sarpershkar 1998, 2009; Alle and Geiger 2006; Shu *et al*. 2006; Zylberberg *et al*. 2011). We think of the activity of this system as a phenotypic trait associated to certain neuroanatomical configurations, to the models of which we refer as "computational phenotypes" (Balari and Lorenzo 2013). Computational phenotypes are thus abstract characterizations of the basic models of computation implemented by the said brain configurations. Consequently, we think that automata theory is the obvious place to look at in order to provide such abstract characterizations. Besides, the idea gives rise to the interesting possibility that the hierarchy of automata put forward by that theory corresponds to one of the dimensions of variation of our computational phenotypes. Under this interpretation, the human version of NCS (NCS_{Human}) is just a particular "homologue" of many other versions of the same organ (Balari and Lorenzo 2015). This is a further important point of departure from Hauser *et al*.'s (2002) framework, since their only reason to deem FLN human specific is that there seem to be no other systems in nature with computational capacities equivalent or superior to context-freeness – which, by the way, is not completely granted, as we will see below. We, however, see no obstacle against the idea that systems of computation corresponding to different types result from the evolutionary radiation of a single organ.

In agreement with the model provided by the hierarchy of automata, it is the memory resources available to each type of system to carry out its computational tasks (or "working memory") that define this particular dimension of variation. But it is important to note that our use of the term "working memory" here does not entail any particular psychological model – say, Baddeley's (2007) Working Memory or other competing models, corresponding to the requirements of full-fledged performance models. This is not a problem, since our computational phenotypes are not performance models: They are abstract characterizations of models of computation, which establish some limiting conditions that performance models must respect when exploring the psychological nature of our abstract memory component.[10] Thus, if the analysis of

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[10] It is thus unsubstantial to our project that it can recognize only "weak" equivalences between grammars underlying different languages, without identifying them in a "strong" sense. Insofar

behavior reveals that the complexity of computations necessary to perform a certain task is equivalent to a Finite State Automaton (FSA), we conjecture that no such component is actually active; similarly, when behavior reveals computations of complexity equivalent to a PDA or a PDA+, we conjecture that natural counterparts of these automata are evolved phenotypic traits of the corresponding organisms, active in the execution of the task of concern. A second consequence is that diversity corresponding to this dimension of variation may be continuous or "quantitative," corresponding to different phenotypes within the same space of the hierarchy of automata, or discontinuous or "qualitative," corresponding to phenotypes within different spaces of the hierarchy.

A second dimension of inter-specific variation that we hypothesize regarding NCS relates to the interfaces that it establishes with other cognitive systems in different organic contexts. Thus, for example, it subserves (among others) tasks underlying linguistic production and knotting activities in the case of humans, thanks to the sensory-motor, conceptual, spatial systems of representation that it has access to, while in other species it may subserve a subset or a different set of such tasks. It is these representational systems that provide both the alphabet and the grammar that NCS makes use of in each case – with the type of rules severely constrained by the memory component of NCS itself. Following terminology introduced in Balari and Lorenzo (2013), we refer to the resulting cognitive architecture as the Central Computational Complex (CCC) of a species – for example, the CCC_{Human}, a system that comprises an NCS plus the representational domains that it interfaces with.

Considering the dimensions of variation above, certain cognitive phenotypes become readily conceivable, associated to different potentials and limitations of behavioral patterns, including uncommon phenotypes – or even unrealized in nature. Slightly reinterpreting a term introduced in Kuo (1967), we will refer to these exceptional architectures/behaviors as "neophenotypes." For example, it is a neophenotype in the sense, one in which NCS interfaces with the spatial systems underlying knotting behaviors, instead of the sensory-motor and conceptual systems underlying linguistic behaviors. This seems to be an uncommon cognitive phenotype, but not a non-existent one, as brought to attention in Balari and Lorenzo (2009, 2013: ch. 7) based on studies on the constructive behaviors of some avian species (Hansell 2000, 2005): namely, two families within the order of Passeriformes, the Ploceidae (or Old World weavers) and the Fringillidae, although in this case only in the Icterini, within the subfamily of the Emberizinae (or New World weavers: oropendolas, caciques, and

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as the corresponding languages can be deemed weakly equivalent, it becomes sufficiently granted that the same device can eventually deal with them all, a "strong enough" conclusion to our concerns. See Balari *et al*. (2012) for further details.

orioles). According to Balari and Lorenzo's analysis, the complexity of knots routinely made by birds of these subspecies is comparable to that of human knots – some of them are actually variants of common human knots, and the fact that individuals adapt the details of each particular knot to contingencies like the space or materials available (Collias and Collias 1962) seems to corroborate the idea that more sophisticated procedures than those of an FSA working in a strictly standardized step-by-step fashion are really at work in this practice. Thus, Balari and Lorenzo conclude that these birds are endowed with an NCS (NCS_{Weaver}) equivalent to NCS_{Human}, but connected to different external or peripheral systems and composing a type of CCC (CCC_{Weaver}) different from the human version of the equivalent system.

Complementarily, a neophenotype exists – unattested in nature but anyway conceivable – in which linguistic behavior does not correlate with knotting activities. We must be open to such a possibility, which, for example, might have been the case of some extinct human species – say, Neanderthals. This is not, by the way, a rebuttal of Uriagereka's Generalization but, rather, serves to clarify that the connection that the generalization establishes is not one of conceptual necessity, and thus that it is defeasible. However, we consider such a possibility quite unlikely, for reasons that have to do with the profound conservatism of systems of development (Shubin *et al.* 2009), including that of brains, and their propensity to fall into canalization patterns (Waddington 1957) or to follow certain developmental inertias (see Striedter 2005 and Minelli 2011 for comparative data on vertebrate brains). So in the case under consideration, a more probable alternative seems to be that an overall pattern of brain organization existed (CCC) as a function of the evolutionary closeness of different human species, with the modern behavioral neophenotype, markedly innovative according to the fossil record, arising in connection with some minor parameter of variation: the working memory resources of the NCS. In our opinion, this is a preferable alternative on conceptual grounds, but obviously one that can be empirically defeated – for example, the archeological record might turn out to be not as asymmetric as it seems to be in the current state of knowledge.

In any event, the substantive part of Uriagereka's Generalization boils down to the observation that, jointly, composing/interpreting sentences and tying/untying knots make up a human-specific behavioral neophenotype, a fact that we can put into a heuristic use as a strategy to compensate for the evanescence of linguistic productions and the relatively recent advent of writing systems testifying them directly. The model of the architecture of mind defended here – the NCS/CCC model – offers an elegant explanation of this and other phenotypes, about which the FLN/FLB model of Hauser *et al.* (2002) has nothing to say. Moreover, there exists ample biological evidence that appears to favor the NCS/CCC model over the FLN/FLB model on empirical grounds, for as Table 14.2 shows, a number of recently described patterns of comorbidity

Table 14.2. *Some patterns of comorbidity between linguistic and non-linguistic deficits*

Clinical evidence	Relevant bibliography
Linguistic and visuo-spatial deficits in Williams–Beuren syndrome	Karmiloff-Smith (2006), Hudson and Farran (2010)
Drawing deficits among dyslexics	Eden *et al.* (2003), Lipowska *et al.* (2011)
Linguistic and motor developmental deficits (including mutations of *FOXP2*)	Vargha-Khadem *et al.* (2005), Webster *et al.* (2005), Shriberg *et al.* (2006), Cheng *et al.* (2009), Rechetnikov and Maitra (2009), Iverson and Braddock (2011)
Linguistic and motor degenerative deficits (for example, Huntington's and Parkinson's diseases)	Murray (2000), Gusella and MacDonald (2006), Grossman *et al.* (1991), Duffy (2005)
Other acquired damages associated to verbal, motor, and visual deficits	Fung *et al.* (1997), Troyer *et al.* (2004)

between linguistic and non-linguistic deficits support the idea that different representational domains are accessed by a multipurpose system of computation, so when the corresponding neural architecture is damaged, admixtures of symptoms (linguistic, motor, visual, and so on) are frequently observed in affected populations – double dissociation situations being probably limiting cases of these general patterns.

4   Conclusions

Knotting is much easier to infer from the archeological record than speaking. Uriagereka's Generalization is thus a welcome observation, since it allows one to read fossils of knotting as putative fossils of language. But two conditions are required for such identification to be acceptable: (1) the inferential chains from remains of the archeological record to knotting behaviors must be sufficiently strong; and (2) an independently plausible model of mind organization must legitimate the conclusion that knotting and linguistic activity is actually the same at some level of mental analysis. Regarding this latter point, we are aware that the image of the computational mind that we have elaborated in section 3 is one about which Uriagereka himself has declared some skepticism (Piattelli-Palmarini and Uriagereka 2005). Uriagereka's original opinion is that behaviors other than language showing hints of context-sensitivity – for example, knotting behaviors – are to be conceptualized as "parasitic" (p. 56) on the Faculty of Language, explicitly adhering to the Chomskyan thesis of the "domain-specificity" (p. 53, fn. 31) of the mental machinery in charge of language. Uriagereka honestly declares that this thesis is no more than a "bet" (p. 56), in that it does not rely on clear empirical grounds. According to him,

for the alternative position to be endorsed, the following condition should be borne out: "One would have to show that, for instance, a procedural-memory process as complex as the one presupposed in the analysis of the previous paragraphs [devoted to context-sensitivity in FL] is present in non-human species. That would win the argument" (Piattelli-Palmarini and Uriagereka 2005: 56).

Despite Uriagereka's skepticism, we have mentioned here one such species (actually, two families within the same species) in which this seems very reasonably to be the case. We don't know whether Uriagereka will find this piece of evidence sufficiently persuasive. In any event, we believe that a picture of the organization of mind along the lines suggested in section 3 seems to be biologically well grounded, and that it offers very strong support to the methodology for the analysis of archeological remains on which Uriagereka's Generalization is based.

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15   (Neural) Syntax

Cedric Boeckx and Constantina Theofanopoulou

1   Introduction

The present chapter[1] seeks to articulate what we regard as some necessary steps towards a linking hypothesis between two levels of analysis that are central for any integrative attempt of the sort that animates the biolinguistic enterprise: the 'cognome' (Poeppel 2012) and the 'dynome' (Kopell *et al*. 2014), or more generally, the mind and the brain.[2] Unlike previous work seeking to bridge the gap between mind and brain, we intend to develop an approach that is not merely locationist. Rather, the goal, as advocated in Friederici and Singer (2015), is to ground aspects of linguistic knowledge and processing onto basic neurophysiological principles. That is to say, the goal is not to discover where cognition arises, but how it arises. More specifically, our ultimate aim is to see to what extent some aspects of the syntactic principles of our language faculty could be grounded in the basic workings of the brain – what Buzsaki (2010) has aptly called neural syntax, whence the title of this chapter.

We feel that the time is ripe to attempt this kind of unification given recent advances in both linguistic theory (refinement of the characterization of the cognome) and neuroscience (especially at the level of brain activity, the 'dynome'). The key notion, on which our entire linking hypothesis will rest, is that of *rhythm*. At the level of the cognome, rhythm is intrinsically related to the better-known notion of cyclicity. At the level of the dynome, rhythm is investigated under the notion of brain oscillation. In both cases, the basic idea we will exploit is that rhythmic processes act as structuring principles.

In the context of linguistic theory, the idea of the cycle is a very old one, going back to Chomsky, Halle, and Lukoff (1956), but it has recently been more central under the notion of 'phase' (Uriagereka 1999, 2012; Chomsky 2000, 2001, 2008), to the point that virtually all fundamental properties of grammatical processing has been claimed to reduce to the cyclic spell-out of grammatical constructs (Samuels 2011; Boeckx 2014).

Likewise, in neuroscience, brain rhythms were discovered long ago (Hans Berger's seminal discoveries go back almost a century), but it is only recently that they have been systematically examined (Buzsaki 2006). Over the past ten years or so, oscillatory activity has been associated with the encoding, communication, and storage of information in nervous systems. Distinct oscillatory frequencies are correlated with distinct behavioral states, and the coupling of oscillations is now routinely hypothesized to organize the processing of information across distributed brain circuits in a most efficient fashion (see Wilson *et al.* 2015 for a good, succinct overview; see also Riecke *et al.* 2015 and Romei *et al.* 2016 for evidence in favor of a causal cognitive role of brain oscillations, as opposed to a merely correlational effect).

Here we wish to bring together these two lines of research to outline an approach that is meant to make testable predictions, indeed one that aims to offer a guiding theory to interpret experimental results (in the spirit of Marcus 2014). Building on our previous work, we will begin by spending some time describing some elementary properties of natural language syntax that we want to capture, and then turn to the interactions of brain oscillations that we think could underlie them. We will conclude with a few remarks concerning which brain structures may be responsible for generating these rhythms (what is known as the 'connectome' level of description) and highlight a few recent results from the neurolinguistics literature that lend support to our claims.

2   Cognome

At the heart of syntax lies the concept of 'phrase'. At bottom, all syntax does is build phrases. But contrary to what introductory textbooks still describe,

'Phrase Structure Building' is not a unitary, indivisible process.[3] In line with what we have argued in previous work (Boeckx 2009, 2013, 2014, and references therein), we claim that it is necessary to recognize at least four interacting sub-processes that partake in phrase structure building. These sub-processes may have received different names in different theoretical traditions, but we feel that by and large the necessity of these sub-processes is well established and, terminology aside, theory-neutral. We also wish to state right away that we view this decomposition as critical in order to map mind onto brain, given the mounting evidence that the neural circuits deals with generic and elemental processes (Poeppel 2005; Boeckx *et al.* 2013). A lack of appropriate decomposition would make it impossible to begin to relate structural descriptions offered by linguists to the range of processes the brain deploys.

The first sub-process we describe could be called *monadicization*. Arguably, this is one of the most important factors in shaping modern cognition. In principle, the syntactic engine of our language faculty allows for the combination of any 'conceptual' units into a phrase. Sure enough, in practice, languages filter out many of these combinations. Also, it is not always immediately clear what some of these combinations mean (think of *colorless green ideas sleep furiously*). But in a very real sense, in principle, conceptual units can be combined freely in language. We have argued elsewhere (see, e.g., Boeckx 2011) that this combinatorial freedom sets us apart from the conceptual capacities observable in other species. It is ultimately what underlies the sort of creativity that characterizes our species.

The second sub-process we describe boils down to something akin to *set-formation*. It is the basic 'combine' operation. Many linguists take this combination process to be restricted to the combination of two elements, a position that we will adopt here for convenience.

The next sub-process we want to discuss is the one corresponding to *categorization*, or, as it is more often referred to, labeling. It is the process by which a phrase is identified (as a verb, noun, etc.). Labeling is the notion that captures the fact that one, and only one, lexical unit taking part in the set-formation process eventually gives the entire phrase its identity. Traditionally, this generalization has been implemented 'endocentrically' or 'from within': one of the two units combined gives the phrase its name. In recent years, however, it's become more widespread to think of labeling 'exo-skeletally'. That is, a phrase gets its name/label based on its structural environment (Borer 2005; Marantz 2008;

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[3] In this chapter we keep to basic phrase structural constructs and do not attempt to examine more complex notions like specifiers or adjuncts, which were the focus of Ramirez (2014), who relied on Boeckx (2009, 2013, 2014) to try to derive these but in a way that our model as presented here prevents us from adopting.

Boeckx 2014). That is to say, a phrase acquires a nominal identity once it is surrounded by a determiner (**the** *run*), not because it contains a noun. A phrase is designated as a verb phrase not because it contains a verb, but because a tense marker immediately dominates it (**to** *run*). *Run*, on its own, is neither verb nor noun (it is a 'root'). It's now common to mention that this exo-skeletal conception of labeling appears to be transparently at play in Lewis Carroll's poem *Jabberwocky* (incidentally, a paradigm which has been increasingly used in neurolinguistics).

The last sub-process we will discuss, and which we could call *consolidation*, is very much related to the third one. Categorization is monotonic: once labeled, a phrase retains its identity throughout the syntactic structure building process. In other words, once categorized, a phrase is stored in working memory as a chunk (consolidated). This monotonicity could be seen as a reflex of what linguists call 'strict cyclicity'.

It is clear even from this all too brief description that all these sub-processes are related to one another: without the set-formation operation taking place in the linguistic domain, there is no monadicization; and vice versa: properties of the monads guide the structure building process. Likewise, labeling and consolidation (cyclic 'spell-out') are two sides of the same coin. But we think it is important to keep these inter-related operations distinct, because they highlight necessary procedural ingredients. To form a phrase, one needs units to combine, one needs, of course, an act of combination, and a way to designate these units (a 'labeler' and a 'labelee').

In the linguistics literature, these four operations are often described as taking place in a bottom-up fashion. Accordingly, psycholinguists take these to be descriptions of competence, rather than performance, which, at least in the act of sentence comprehension, happens most clearly 'from left to right'. As such, these descriptions, it is claimed, should not be taken as the basis for a temporal organization to be mapped onto the brain. But we don't think this is necessarily so.[4] After all, what these sub-operations describe are merely different kinds of information, and they are perfectly symmetric (reversible). In fact, the labeling step, once understood exo-skeletally, is clearly 'top-down', not bottom-up. Moreover, even if comprehension parses the sentence left to right, the representational construct called phrase is clearly part of the top-down predictions present at every step of language comprehension. There is now considerable evidence that human sentence processing is expectation-based. As people encounter sentences, they use their linguistic knowledge to generate predictions (i.e., impose structures) about what they will encounter next.

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[4] This is one of the main differences between this chapter and previous work of ours. For example, in Ramirez *et al.* (2015) we were arguing for a model that took the derivational steps assumed in linguistic theorizing too literally. This led to a specific articulation of brain frequency interactions that we no longer endorse.

Phrase structure, in this sense, is an aspect of predictive coding, the anticipatory function of the brain. As such, the building of phrases, in some real sense, 'precedes' the act of language processing, and so properly speaking, phrases (*qua* predictions) are adjusted left-to-right, not built left-to-right. They are like 'constructions' or computational subroutines called upon in the act of language processing.

3 Dynome

Recent years have seen the publication of a growing number of studies suggesting that rhythmic patterns of electrical activity produced by the brain may play a significant role in a wide range of basic and higher cognitive processes (Buzsaki 2006). Specifically, brain oscillations operating at different frequencies may offer a temporal organizer of neural activity, one that allows the processing and transferring of information within and between brain circuits (neural ensembles). Such descriptions, we think, are helping us construct what could be called 'endocognotypes'. In the context of language we have been impressed by the detailed model put forth in Giraud and Poeppel (2012), who provided evidence in favor of both fast (gamma) and slow (theta/delta) tracking of the dynamics of human speech. According to that model, brain rhythms sample incoming information into chunks that provide the basis for cognitive representations like syllables. Outside the realm of language, it is increasingly easy to find studies claiming that the interactions of various oscillatory frequencies may support cognitive processes like 'working memory' (Lisman 2005; Dipoppa and Gutkin 2013; Roux and Uhlhaas 2014). All these proposals have heavily influenced our thinking and provide (tentative as they are) fruitful ground for the reflections that follow.

The literature on brain rhythms remains controversial because it goes beyond the neuron doctrine – the idea that individual neurons are the functional unit of the nervous system – which has been the conceptual framework for modern neuroscience for over a century. However, as reviewed in Yuste (2015), that doctrine has been dissolving under new evidence from multi-electrode recording. Rather, it seems that it is ensembles of neurons, and not just individual neurons, that count as functional units (see also Lisman 2015). The explanatory force of brain rhythms has also been questioned because many studies tended to establish a correlation between brain rhythms and external stimuli but, as Snyder (2015) stresses, recent work like Riecke *et al.* (2015) has brought to the fore the causal role of rhythmic fluctuations in neural activity. Finally, the literature on brain rhythms has also been criticized because of its dependence on notions that are at odds with the computational lessons coming from cognitive science (notions revolving around synaptic transmissions, questioned by Gallistel and King 2009, who stress that all relevant computations take place

inside single neural cells). There is, however, work like Deisseroth *et al*. (2003) showing that signaling from synapse to nucleus (the locus of 'hard' computation for researchers like Gallistel) is vital for activity-dependent control of neuronal gene expression and represents a sophisticated form of neural computation. As Deisseroth *et al*. show, the nucleus is able to make sense of a surprising amount of fast synaptic information through intricate biochemical mechanisms, so that the conflict between work heavily depending on neuronal ensembles, like the work on brain rhythms, and Gallistel's sophisticated critique of the computational properties of the synapse is perhaps more apparent than real. It strikes us as likely that both 'neuronal ensemble' and 'cell internal' perspectives will be needed to truly understand neuronal computation in the same way that genetic and epigenetic perspectives are needed to capture how the organism is 'computed'.

To characterize aspects of phrase structure building in neural terms, we see the need to implicate several rhythms (frequencies): alpha, beta, gamma, and theta. But crucially we think it is necessary to exploit their interactions, for this is where key aspects of structural representations can be captured. We will claim that these rhythms interact in such a way as to yield the four fundamental operations making up phrases that we listed in the previous section. In other words, rhythmic activity at different scales will be said to convey different categories or types of information and coordinate the activity of multiple functional assemblies (Canolty *et al*. 2010). To guide us, we have relied on an emerging consensus in the neuroscience literature that takes fast oscillatory activity to be more local than slow oscillatory activity, responsible for long-range communication. That is to say, there seems to be a relationship between rhythm frequency and the spatial extent of engaged brain networks, with low frequencies binding large-scale networks and high frequencies coordinating smaller networks.

Having said this, there is a very real sense in which the nature of our goal, and therefore our proposal, differs from previous studies. Most of the studies on brain rhythms, especially in the language domain, have examined situations where internal representations match external stimuli, as in the case of the phonological representations of speech. This is even the case for studies focusing on sentence structure, as in the paradigm of Ding *et al*. (2015), as Lau (2015) observes.

The nature of our question is not limited to sentence comprehension (tracking of an external stimulus). We are facing a situation where action selection is dependent on thought rather than conditioning, as Lisman (2015) puts it. The point here is not to decompose and integrate information from external stimuli but to compose thoughts – a process driven by free-floating associations, mental imagery, planning, etc. Still, we think that linguistic cognition, internally guided as it is, follows the same biological principles as 'externally guided'

cognition: it emerges from rhythmic coordination, from the coordinated activity of spatially distributed neural ensembles.

Here is our proposal in a nutshell: monadicization characterizes itself by the nesting of local, fast gamma activity inside a slow, long-distance alpha rhythm. This take on the gamma rhythm is related to the idea that this frequency underlies the formation of 'words' in 'neural syntax' (Buzsaki 2010); or the binding of features into coherent objects (Bosman *et al.* 2010). It is what linguists call 'bundling' to refer to lexical feature assemblies. As for the role of the alpha-frequency, our proposal is in line with work by Palva and Palva (2011) in the context of their 'active processing hypothesis', and more specifically its role in modulating the gamma frequency (Saalmann *et al.* 2012; Roux *et al.* 2013; Honkanen *et al.* 2014). In agreement with Palva and Palva (2011), Klimesch (2012), and Theofanopoulou and Boeckx (2016), we take the function of the alpha band to go beyond the traditional inhibitory role it has been associated with in lower-level, perceptual tasks. In fact, the role of the alpha frequency we envisage here is consistent with its functioning as 'a selective amplification of information' (forming binary sets) and 'a selective filter' (temporarily removing selectional restrictions). In this context it is also worth taking into account results like the ones presented in Martínez *et al.* (2015), where the impaired ability to bring appropriate brain regions 'on line' through alpha desynchronization is said to contribute substantially to impaired cognitive dysfunction in mental diseases like schizophrenia (see also Rivolta *et al.* 2015; Theofanopoulou and Boeckx 2016; and Theofanopoulou 2015).

The labeling or categorization process is, we suggest, associated with interactions led by the beta rhythm. The beta frequency has been related to the notion of top-down control (Chan *et al.* 2014), the sustainment of status quo (Engel and Fries 2010), and the holding of information in working memory (Tallon-Baudry *et al.* 2004; Deiber *et al.* 2007; Engel and Fries 2010; Salazar *et al.* 2012; Parnaudeau *et al.* 2013; Martin and Ravel 2014; Chen and Huang 2016), all of which are clearly related to the essence of labeling/categorization.

The consolidation step we take to be the result of a nesting of gamma activity in a theta rhythm. Theta-nested gamma activity is well attested in numerous cognitive tasks, especially the storing of items in working memory (Roux and Uhlhaas 2014). As should be obvious from our description of the cognome, the role of the theta-frequency will interact with the role of the alpha-frequency. Interaction between these two frequencies has been discussed in studies on attention (Song *et al.* 2014), with alternating periods of theta/alpha-rhythm dominance.

As already pointed out, of all the instances of cross-frequency couplings examined in the literature, the theta-gamma nesting relation is by far the best studied one. It has been suggested that theta-nested gamma modulations may serve as a means to organize and integrate covertly (internally) generated information to

ensure the flexible control of attention during goal-directed behaviors (Voloh *et al*. 2015; see also Womelsdorf *et al*. 2010; Landau *et al*. 2015; Micheli *et al*. 2015). In Voloh *et al.*'s (2015) study, there was an increase in theta synchrony between anterior and posterior frontal cortex as humans performed tasks that required greater abstraction. This may allow more anterior frontal cortex to communicate the higher-level goals to motor cortex. This is consistent with the long-held hypothesis that theta-gamma cross-frequency interactions are an essential means of interareal integration of distributed activities in a multi-node cortical network. It is also consistent with the idea that oscillatory coherence allows one brain region to 'read' the contents encoded in another region. Coherent gamma activity across a widely distributed network would be achieved through theta-nesting, and would allow for feature bundles to form, and ultimately for syntactic, semantic, and phonological information to be unified.

It would then be the role of the theta-nesting step to cause an impact on local cortical computation. Together with the alpha-frequency, the theta-frequency would allow the local gamma-synchronized processes to be integrated, thus forming a unified mental construction such as a 'thought'.

It may be worth noting that, in the context of phonology, it has been claimed that theta-nesting enhances gamma processing (Hyafil *et al*. 2015). Specifically, the control of gamma by theta oscillations could both modulate the excitability of gamma neurons to devote more processing power to the informative parts of syllabic sound patterns and constitute a reference time frame aligned on syllabic contours for interpreting gamma-based phonemic processing. Likewise, the phrase in which gamma activity is nested may allow for the more contentful parts of the lexicon (the roots) to be the focus of grammatical processing.

4   Some Remarks on the Connectome

Our proposal begs the question of where in the brain these rhythms are generated. We have come to realize that this is a more essential question than we originally thought. Although brain oscillation studies tend to stress their potential mechanistic virtues, as opposed to 'neo-phrenologist', locationalist proposals ('how' versus 'where' questions; or as Poeppel 2012 would put it, 'mapping' versus 'maps'), it is clear that in order to capture the specificity of the representations we are interested in, it is crucial to try to identify over which brain areas neural activity is being synchronized. The rhythmic frequencies we invoke, as well as their interactions, are so generic that they are not unique to the language domain. Consider, for example, the following passage from Fries (2015: 232):

Local cortical neuronal groups synchronize by default in the alpha band. During alpha-band synchronization, network excitation fluctuates at 100 ms cycles, but is tracked by

network inhibition within 3 ms. This curtails effective communication and renders the respective activity invisible to other neurons. It allows holding 'on-stock' local neuronal representation, which can be accessed flexibly. It might be an important contribution to making optimal use of the brain's massively parallel processing architecture. Attention samples from this internal store at a theta rhythm. Attentional top-down influences are mediated by alpha-beta-band synchronization.

Fries's (2015) reflections are intended to be very general, but we are sure that readers can see the relation between this passage and our steps towards a linking hypothesis. Accordingly, if we want to capture the specificity of natural language syntax, the 'distinctiveness' of phrase structures, as it were, or why we humans have the syntactic abilities we do, we must seriously consider the possibility that it lies not so much in the 'how', but 'where' this 'how' takes place. In other words, 'cartographic' ('maps') considerations will also have to figure prominently in any 'mapping' hypothesis.

We think, and have argued in the past, that at least some of them have remote (i.e., subcortical) generators. Direct evidence for this is still hard to come by, due to technical limits, but we think that some plausible hypotheses can already be put forward in this context. At the very least, we think that the cross-frequency couplings implicated in the previous section can be seen as the results of the coordinated function of many anatomical structures: prefrontal, parietal, temporal, cerebellar, thalamic, hippocampal, and basal ganglia. The coordinated function of these networks, coordinated over both hemispheres by the corpus callosum, has already been involved in decision-making, reward-seeking behavior, and cognitive flexibility, but it is less frequently considered in the realm of language. In part this is because neurolinguistics continues to be cortico-centric. But it is also because most neuroscientists think of language in very concrete terms: words, sounds, etc. Our focus here is on an aspect of language that is much more closely related to the formation of thoughts, and, as such, is to some extent (though not completely) separate from the morpho-phonological substance used in languages. Not surprisingly, then, the network we have in mind overlaps with large-scale cognitive networks involved in passive or internally driven tasks, as opposed to active or externally driven tasks, such as the default mode network (Raichle *et al*. 2001; Buckner *et al*. 2008), or the Multiple Demand network (Duncan 2010, 2013) put forward to capture cognitive notions like 'fluid intelligence' and 'complex cognition', 'mind wandering', or 'divergent (unconventional) thinking'. There are also obvious points of convergence with the global workspace model in Dehaene *et al*. (1998) or the 'connective core' in Shanahan (2012), or the neural conception of creativity advocated in Beaty *et al*. (2015).

It is also worth noting that several of the anatomical structures we suspect are crucially implicated in giving rise to syntactic representations have been

modified in our lineage. For example, we have claimed that the globularity of our species' brain, explicitly associated with parietal expansion, is likely to have also led to an expansion of the pulvinar and a concomitant reduction of the portion allocated to it that connects with the occipital lobe (see Pearce *et al*. 2013 and Boeckx and Benítez-Burraco 2014 for discussion). It seems to us plausible that this expansion of dorsal thalamic nuclei had an effect on how effective thalamic synchronization of widely spaced cortical regions could be, thereby allowing for the robust establishment and maintenance of cross-modular combinations. (For relevant considerations in the context of the coupling of rhythms over widely distributed networks, see Salami *et al*. 2003; Vicente *et al*. 2008; and Bastos *et al*. 2015.) Other constitutive elements of the globular brain, such as an expanded fronto-parietal network (Buckner and Krienen 2013; Genovesio *et al*. 2013; Woolgar *et al*. 2015), an expanded cerebellum (Ito 2008; Balsters *et al*. 2010; Barton and Venditti 2014), and a selectively asymmetric corpus callosum (Theofanopoulou 2015), were also necessary to make this a language-ready brain.

We contend that the widely distributed network envisaged here is in line with claims that the language network is more extended than the classical language regions (Petersson *et al*. 2012; Poeppel 2014; Blank *et al*. 2016) and includes, next to Broca's area, adjacent cortex in the left inferior and middle frontal region, substantial parts of superior and middle temporal cortex, inferior parietal cortex, as well as subcortical structures such as the thalamus, the basal ganglia, the hippocampus, and the cerebellum, but also the corpus callosum mediating between the two hemispheres. In short, linguistic cognition is a 'whole-brain' affair.

This is not to say that classical brain regions like Broca's area or Wernicke's area have no role to play in the landscape we envisage. We readily acknowledge the evidence in favor of Broca's area playing a role in the processing of hierarchical representations (Pallier *et al*. 2011; Ohta *et al*. 2013; Fitch and Martins 2014; Goucha and Friederici 2015). We have in fact argued in independent work that Broca's area is well suited to provide a memory stack that is independently needed to linearize complex syntactic structures (Boeckx *et al*. 2013) and to integrate or unify several linguistic representations (Hagoort 2005; Flinker *et al*. 2015), including sound and meaning (Bornkessel-Schlesewsky and Schlesewsky 2013).

In a similar vein, although we do not subscribe to the view that takes the anterior temporal lobe to be the locus of syntactic structure building (Brennan *et al*. 2012), we find congenial the more nuanced claim that this region is critical for the compositional interpretation of syntactic structures (Del Prato and Pylkkänen 2014; Westerlund and Pylkkänen 2014). As a matter of fact, we find it promising to think of our hypothesis concerning the neurobiological implementation of phrase structure building as embedded in an 'output system' that

would correspond to the canonical fronto-temporal language network. Such an output system, grounded in the primate auditory network (Bornkessel-Schlesewsky *et al*. 2015; Wilson *et al*. 2015), could have been recruited (in the sense of neuronal recycling advocated by Dehaene 2005 and Parkinson and Wheatley 2013) to pair sound and meaning in the context of the emergence of a sophisticated combinatorial memory device made up of the sub-operations which are the focus of this chapter.

Certainly, the theta-gamma nesting is a ubiquitous phenomenon evident across multiple circuits including hippocampal-cortical circuits, hippocampal-striatal networks, cortico-striatal networks, and cortico-cortical networks, and so should be easiest to detect.

The involvement of the hippocampus in our model is consistent with its widely connected nature (de Pasquale *et al*. 2012) and claims that it is in service of other systems (Rubin *et al*. 2014). Though traditionally seen as the locus of long-term memory, we think that memory plays a much more active role during online processing (in line with Hasson *et al*. 2015), and so we anticipate some involvement of the hippocampal complex in language processing (see Alamri 2017 and references therein for further discussion).

As is standard, we take gamma activity to dominate in supragranular layers of the cortex, but we also expect to find it in subcortical structures. We take the alpha-frequency to be generated in the dorsal thalamus, whose "burst" firing mode acts as a wake-up call for transient cortical networks (Womelsdorf *et al*. 2014), and whose tonic firing mode strengthens the dialog among cortical network nodes.

Quite plausibly, the beta rhythm implicates the basal ganglia-thalamo-cortical loop, with the dorsolateral striatum playing a fundamental role, as well as the cerebello-thalamo-cortical loop. (Striatal structures, as well as the medio-dorsal thalamic nucleus, have been shown to operate at the beta range; see Leventhal *et al*. 2012 and Parnaudeau *et al*. 2013; on the beta-frequency in the cerebellum, see Peiker *et al*. 2015.)

We suspect that when the time comes to detect properties of our proposal at a fine-grained neural level, it will be necessary to exploit layer-specific properties of the neo-cortex, as distinct layers have distinct rhythmic preferences, and thus ultimately play distinct cognitive roles. Thus, Bastos *et al*. (2012) associate high gamma-frequency oscillations mostly with the supra granular layers, and lower frequencies (specifically, beta and alpha) with infra granular layers. Infra granular layers connect to higher-order thalamic nuclei such as the medio-dorsal nucleus and the pulvinar, which generate a robust alpha rhythm (Bollimunta *et al*. 2011) and are crucially involved in cortico-cortical information management (Theyel *et al*. 2010; Saalmann *et al*. 2012). Infra granular layers also connect to the basal ganglia, in particular the striatum, which is implicated in sequencing and chunking procedures, as well as a process of

characterization in tandem with the cortex and higher-order thalamic nuclei like the medio-dorsal nucleus (Antzoulatos and Miller 2014).

It stands to reason that the expanded network we envisage for syntax is underspecified. The information provided above rests on results in other cognitive domains, but hopefully, our reflections will lead experimentalists to seek ways to bring the model to the level of anatomical and physiological details that is ultimately necessary, and which has been achieved in other domains of language (see, e.g., Hickok 2012 on speech production).

5   Closing Observations

Needless to say, the entire model offered here remains to be tested experimentally. But already some evidence in its favor can be found, which we would like to list here. To begin with, at the level of the connectome, Bonhage *et al.* (2015) tested the neural substrate of word category prediction and found active a distributed network of cortical and subcortical brain regions, including the classical left-hemispheric language systems involving Brodman's area 44/45 in the left inferior frontal gyrus, and the left superior temporal areas, but also the basal ganglia, thalamus, cerebellum, and hippocampus. At the level of the dynome, Bastiaanse and Hagoort (2015) endeavored to test the hypothesis that semantic and syntactic unification are segregated by means of neuronal synchronization of the functionally relevant networks in different frequency ranges. They found that semantic unification takes place in the gamma range, but that syntactic unification requires slower frequencies (for them, the low beta range; for more on the beta-frequency in language comprehension, see Weiss and Mueller 2012). It is also interesting to note the involvement of slow oscillations in the context of supra-segmental prosody (Friederici and Singer 2015), given the close correspondence between supra-segmental prosodic representations and syntactic constructs (Samuels 2011). Complementary attempts to fractionate language comprehension into various frequencies (Roehm *et al.* 2004) revealed that the theta range is also involved, as we would predict. In addition to the theta-frequency, Roehm *et al.* (2001) and Strauss *et al.* (2014) also found the alpha-frequency implicated.

As technology advances, we think that neurolinguistic studies will be able to probe better below the cortex and detect the various frequencies predicted by our model in various subcortical nuclei, along the lines of Schwab *et al.* (2015). Experimental paradigms like the story building entrainment task in Himberg *et al.* (2015) may reveal alignment of 'semantic' and 'syntactic' processes, thereby allowing us to go beyond speech alignment tasks that proved so useful in the context of rhythms involved in auditory processing (Giraud and Poeppel 2012).

Recent studies such as Ding *et al.* (2015) showing how cortical activity at different frequencies tracks hierarchical linguistic structures reinforce our

belief that brain oscillations are critically involved in phrase structure building. As a matter of fact, the linguistic model we build on in the section on the cognome (Boeckx 2014) leads us to expect that, independently of word use, phrase rate is constant (sentences boiling down to a recurring alternation of cyclic and non-cyclic nodes). Such a model may therefore avoid some of the potential shortcomings pointed out by Lau (2015) in the context of Ding *et al*.'s study.

We think that a major avenue of further research opened by our approach lies in the role of subcortical structures in language beyond the domain of speech (Kotz and Schwartze 2010). We anticipate that properties once thought to be the exclusivity of the cortex will turn out to be mirrored subcortically, as recent research indicates (Friederici 2006; Wahl *et al*. 2008; Jeon *et al*. 2014). Specifically, we expect more studies of the ilk of Teichmann *et al*. (2015) and Mirman *et al*. (2015), which show how fundamental subcortical structures are for syntactic processing.

Our model may also provide a useful point of departure to understand cognitive deficits across a wide range of mental disorders, for which we have an increasing amount of information couched in oscillatory terms (Buzsaki and Watson 2012; Benítez-Burraco and Boeckx 2014). Complete journal issues such as volume 77 of *Biological Psychiatry* (Watson and Buzsaki 2015), updating seminal reviews like Basar and Guntekin (2013), provide strong evidence for the idea that impaired cognition results from rhythm dysfunctions, which entails impaired connectivity (rhythm pathologies leading to pathologies of coordination among neuronal ensembles).

Finally, we think that taking the frequencies of neural oscillations seriously may help us understand the biophysical determinants of the sizes of the units that can be manipulated for linguistic purposes, and may help us shed light on some of the grammatical constraints identified in the theoretical linguistic literature. As pointed out in Boeckx (2013), some of the locality constraints found there may receive a natural interpretation in terms of the model presented here. Indeed, the literature on brain frequency coupling routinely mentions bottleneck effects that arise from the narrow windows of opportunities that wave-cycles offer, or the limited patterns of oscillations that local structures can sustain. Thinking of 'local' patterns of exclusion known as 'anti-locality' or 'identity avoidance' (Richards 2010; Boeckx 2014) strikes us as worth examining in this light.

For all these reasons we think that the attempt to bring the study of syntax into the fold of studies focusing on the rhythmic dynamics of cognitive processing may ultimately show that even cognitive functions seemingly realized only in human brains rely on canonical, generic neuronal mechanisms – thus bringing to an end the biological exceptionality that theoretical linguistics often seems to require.

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16   Syntax and Uncertainty

Douglas Saddy

1   Introduction: Topology and Cognitive Dynamics

We propose that the ground state of cognitive systems is (a very rich) uncertainty and that an essential part of the dynamics of such uncertain systems necessarily leads to transient simplifications.[1] These simplifications are the stuff of syntax, and without them we could not exploit the information embedded in cognitive systems. The approach we pursue here assumes that physical principles apply not only to the physiological systems that support cognition but also to the content of cognitive space these systems determine. Here we will not focus on the physiology, but we would like to note that the principles we appeal to apply to the physiology as well as the computation (the latter, our main focus in the present chapter). Our story depends upon the core notion of dynamic frustration and a further tension between ultrametric and metric topological spaces. We show that dynamically frustrated systems, as in the case of spin glass,[2] instantiate ultrametric spaces (Stein and Newman, 2011; Ramal *et al*., 1986). As such, they allow for very rich associative fields or manifolds but lack mechanisms that can categorize. However, a general property of dynamical systems is that manifolds can/will interact given an external perturbation to the ground dynamics of the field. The consequences of such interactions are captured in the centre manifold theorem (CMT henceforth) which tells us that the intersection of manifolds leads to dynamic extensions that manifest as a new manifold that is of lower-dimensionality and which combines the core dynamics of the intersecting higher-dimensional manifolds (Carr, 2006). This is the first core observation: a dynamically frustrated system under conditions

[2] A spin glass is a magnetically disordered lattice in which the components are not magnetically aligned. A stronger condition requires points in the lattice to be locally anti-aligned: two neighbouring points cannot have the same spin. In local configurations (think, for instance, of a triangular lattice; see (2) below), this condition cannot be satisfied, and gives rise to a *frustrated system*.

found in biologically instantiated systems will necessarily manifest oscilla-
tions between higher and lower dimensionalities and hence between higher
and lower entropies. The second core observation is that, while a dynamically
frustrated system expresses an ultrametric space, the consequence of the inter-
section of manifolds in that space, following from the CMT, is to impose met-
rical structure onto the lower dimensional, lower entropy offspring. Thus, in
a dynamically frustrated system, we have an engine that necessarily delivers
oscillatory behaviour, a very good thing from the neurophysiological point of
view,[3] and that also moves between ultrametric and metric spaces, quite useful
from the information processing point of view (because the oscillations pro-
vide a built-in mechanism that can update the associative manifolds).

   In what follows we will flesh out and provide support for these ideas. For
ease of exposition, we will highlight two main assertions that we will put forth
in the remainder of the chapter.

   Our first assertion is that the mental landscape, at least in its early stages,
is a largely unstructured weakly associative space;[4] a sort of mental frothy
sabayon. This is not purely conjecture. We know some things about the dynam-
ics of the neural assemblies that support our cogitations. The fact that living
creatures can learn to navigate their environment, find food, and ultimately
write papers, etc., tells us that these dynamic neural systems can encode and
structure information (learn) about the external world in terms of the proper-
ties (shape, overall topology) of the phase space.[5] Thus we will base most of
our argument on the not surprising hypothesis that we are looking at a com-
plex system with interesting internal dynamics, which *varies over space and
time*. Moreover, those variations are not random but derive from the interaction
between the system and external factors, as well as from the interplay among
the system's own internal tendencies.

   This kind of non-static geometrical-physical configuration is a *dynamical
system*, with the property of being *nonlinear* since the outputs are not directly
proportional to the inputs. We are dealing with a system (or a collection of
systems) in which a function describes the time dependence of a point (or set
thereof) in a geometrical space, whose properties are also variable, as we will
see below. Some basic properties of dynamical systems are listed below (based

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[3] See Ding *et al.* (2016) for recent evidence regarding the role of oscillatory regimes in coding for
higher-order cognitive properties.

[4] For the purposes of brevity, we will leave the nature of 'association' and what is 'associated'
unexplored here.

[5] Turbulence is a good example of the kind of dynamics we have in mind. We will see that the con-
siderations about ultrametricity and metricity we will make below are also related to this point,
insofar as, in the range of Kolmogorov distances, the energy input from nonlinear interactions
and the energy drain from viscous dissipation are in exact balance. The small scales have high
frequency, causing turbulence to be locally isotropic and homogeneous. Syntax, in our perspec-
tive, can be characterized in terms of the behaviour of this dynamical system.

on Boccara, 2002; Hasselblat and Katok, 2003; Baranger, 2004; Ladyman *et al*., 2012):

(1) a. Open to external influence
     b. Complex (i.e., contain subsystems)
     c. Dynamic (i.e., change over time)
     d. Emergence (i.e., the collective behaviour of the system is not a linear function of the behaviour of its individual components)
     e. Nesting / hierarchical organization
     f. Existence of feedback loops

We assume that the cognitive systems exhibit the same phenomena as physical properties in (1). More specifically, natural languages seem to fulfil all the requirements specified in (1) for being systems of the kind studied by nonlinear dynamics:

a. They are *open* because whatever cognitive system is appropriate to characterize them must interact with other cognitive systems (in the case of language, those in charge of sound and meaning representations) as well as with the phenomenological world.
b. They are *complex* because there is a structure-building computational process that interfaces with other cognitive systems that each impose different requirements, thus giving rise to a tension insofar as these requirements are orthogonal to each other.
c. They are *dynamic*, on the scale at which we are working, because computations proceed in real time and incrementally. This 'derivational diachrony' is an essential feature of an account of a pair of integral characteristics of linguistic derivations and representations, which are *locality* – in representational terms – and *cyclicity* – in derivational terms.
d. They present *emergent* properties. *Emergence* is a key point to take into account when considering the interpretation of linguistic structures: at each cycle, the interpretation of the derived representation (particularly at the semantic component) is not a linear function of the computations performed at that cycle alone but is influenced by (i) previous cycles, (ii) expectations and anticipation processes, as well as (iii) interactions between elements within and across cycles, in ways we will attempt to derive from the physical properties of the system as well as the topology of the objects and the workspace in which they are derived.
e. Considerations of *hierarchy* and *nesting* appear in the theory of phrase structure and syntax, more generally, when analysing the relations between objects that are established by means of a set of formal rules.

We will now turn our attention to a particular kind of *nonlinear* dynamics: *dynamical frustration.* Dynamical frustration emerges from an irreconcilable tension between opposing tendencies (Moesner and Ramírez, 2006; Binder, 2008; Uriagereka, 2012). The concept was first developed to analyse lattice

arrangements of electrons and spin glass, but its domain of applicability has been generalized to dynamical systems. The relation between complex dynamical systems and dynamical frustrations is made explicit by Binder (2008: 322):

The essence of complexity may lie here: A system without dynamical frustration will either settle to equilibrium or grow without bounds.

Uriagereka (2014: 363) defines a dynamical frustration in a system-neutral way, as 'the irreconcilable tension between certain opposing tendencies that, in some conditions at least, give rise to a form of dynamical stability'. In physics, these frustrations arise, for example, in a triangle crystal lattice under the condition that all three vertices be antialigned (that is, aligned in an opposite direction) with respect to one another: three neighbouring spins cannot be pairwise anti-aligned, and thus a frustration arises (Moessner and Ramírez, 2006: 25–26; Binder, 2008: 322). Let us schematize the situation with a diagram:

(2)
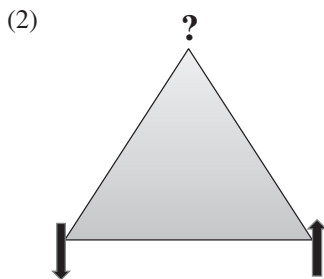
It should be clear that the antialignment condition cannot be satisfied by the system as a whole (that is, for all three electron pairings) for any given time, and this tension forces the system to display ever-changing dynamics which can nonlinearly generate emergent properties, which are not proportional to the system's input or componentially predictable. Binder (2008) proposes that one of the defining properties of complex systems is precisely *the presence of a dynamical frustration at its core*. He goes even further, positing that a complex system where no frustration arises will 'either settle to equilibrium or grow without bounds' (p. 322).

Crucially for our purposes, all dynamical frustrations are *time-sensitive*, that is, they evolve over time;[6] this property makes them suitable candidates for modelling complex systems (and, as Binder suggests, for understanding emergent behaviour as a whole). Moreover, time sensitivity is at the core of a dynamical system, without it being a major factor in the specific topology of said system.[7]

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[6] This is, apart from other factors that might enter the game, like electromagnetic interactions in the case of antialigned lattices.

[7] In the case of spin glass, we are dealing with atomic distances; if we have two neural networks competing for nutrients and connections, we are dealing with a different level of organization of matter and of course the distance between the relevant actants in the system will be greater. This point about distance may seem far-fetched now but will be essential in a few paragraphs' time.

We can now motivate our first assertion – that the mental landscape, at least in its early stages, is a largely unstructured weakly associative space; a sort of mental frothy sabayon.

Before going further into the properties of the oscillatory system we propose, let us remind ourselves of some basic characteristics of ultrametric spaces and what makes them suitable to model the initial topological space.

A *metric* space is a specific kind of topological space in which the following properties hold (d is a metric function over a set of points, or simply put, distance):

(3) a. $d(x, y) > 0$ if $x \neq y$
     b. $d(x, y) = 0$ iff $x = y$
     c. $d(x, y) = d(y, x)$
     d. $d(x, z) \leq d(x, y) + d(y, z)$ (triangle inequality) (for all $x, y, z, \ldots \in \mathbb{R}$)

Metric spaces define Euclidean topologies, including the perceptually familiar 3-D Euclidean space. Distances, except in special cases, are not only real (with zero imaginary part) but also positive (i.e., $\mathbb{N}$), and they are not constant: two distinct points x and y can be arbitrarily near or far apart, but never have 0 distance (given 3a, b).

An *ultrametric* space is a set of points with an associated distance function d mapped onto the set of real numbers $\mathbb{R}$ such that:

(4) a. $d(x, y) \geq 0$
     b. $d(x, y) = 0$ iff $x = y$
     c. $d(x, y) = d(y, x)$
     d. $d(x, z) \leq max\{d(x, y), d(y, z)\}$ (ultrametric inequality)

Ultrametric spaces have interesting topological properties. For instance, only a subset of isosceles triangles is allowed (acute isosceles), given the replacement of the triangle inequality that holds for metric spaces (in formal terms, $d(x, z) \leq d(x, y) + d(y, z)$, for x, y, and z vertices of a triangle) by the ultrametric inequality in (4). Another interesting property is that, for every point within a sphere, that point is the centre of the sphere (given a constant distance function between distinct points), something that defies our conscious geometrical imagination. An interesting property for a theory of associative manifolds in ultrametric spaces is that, due to the strong triangle inequality, distances in ultrametric spaces do not sum. Ultrametric spaces are metrizable, that is, they can be converted to metric spaces.

Now let's return to dynamical systems and their dynamics. The dynamics of both real neural assemblies and artificial neural networks is known to be governed by dynamic frustration (Hansel *et al.*, 1995; Papo *et al.*, 2014). Furthermore, there is dynamical frustration between this physical substrate, which provides a dynamic architecture, and the sensory information which is

accommodated by this substrate.[8] In terms of scale, the interactive and temporal properties of neural oscillations tell us that the computational activity of the brain is taking place at the mesoscopic level. The properties of such complex dynamically frustrated systems have been described in the mathematical theory of spin glasses which captures the behaviour of systems with many energy minima: these systems are, by definition, *frustrated*. As Manrubia *et al*. (2004: 204) point out, these energy minima are organized in such a way that *the space of attractors is an ultrametric space*. These systems, the physical substrate and the information, are frustrated internally, which generates a 'layered' complex dynamical system. The physical substrate is subject to a tension between output maximization and energy minimization, as is conceivably shared among physical systems at a certain scale in general. The sensoria, in turn, is also frustrated, the relevant opposing tendencies following Zipf's (1949) forces of Unification and Diversification:

> *Force of Unification*: minimize the number of words – information units – (to 1), maximizing their frequency (to 100%) and associated meanings.
>
> *Force of Diversification*: maximize the number of possible words, minimizing their frequency and associated meanings (tending towards a bi-univocal relation between words and meanings).

The multi-layered frustrated system we have described necessarily instantiates an *unrestricted multidimensional ultrametric space*; this will be unpacked in some detail below. This initial space, uncountable in nature (i.e., *qua* set of points, its cardinality is greater than ℵ), gives us a very rich representation in terms of the organization of the sensoria, but since this space is *unrestricted* we cannot do anything with it: there is nothing that is not in there. In slightly more technical terms, there is no point in this unrestricted space that does not have a probability amplitude associated with it. This space has no *hard conditions* imposed upon it, which allows for very rich and high-dimensional representations – *multidimensional* complex manifolds – but also leaves us with no way to limit the phase space: there is no grammar that can generate such a space.[9] This, we contend, is in fact the cognitive ground state.

In order for the information held by this space to be put to use, we need to translate critical properties of the complex manifolds into a lower-dimensional and metric instantiation of this space. That is, we need a dynamic process that will project or translate information from the ultrametric space into a metric space that is mediated by strict topological and computational conditions.

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[8] Thus this system instantiates both geometrical (tendencies in different directions within a level of granularity) and scale frustrations (opposing global and local tendencies).

[9] All grammars have hard conditions; thus, no formalism can capture the space's properties or operate directly over its elements.

Our second assertion is that a mechanism that delivers the necessary dynamic translations is not only available but also follows from the dynamics inherent to the system described above. Given an unrestricted high-dimensional ultrametric space of the kind we mentioned above, there will be an infinite number of *n-dimensional* manifolds which represent dimensional surfaces and, provided the topology of the space is disrupted – as from external input[10] – they may intersect. In other words, for while in an ultrametric space the distance function *d* between a point $x \in X$ and a point $y \in Y$ (for X and Y manifolds) is fixed and > 0, the intersection of X and Y at *x, y* means that $d(x, y) = 0$. If such intersection happens, we actually have a well-established mathematical/topological property that determines a class of possible consequences. This property is the *centre manifold theorem*:

When an attractor of a high-dimensional dynamical system … becomes unstable there is typically one direction in the high-dimensional space along which the restoring forces begin to fade; while in other directions, the stabilization mechanism remains strong. The one direction along which forces fade spans the center manifold.

(Schöner, 2009: 9)

Schöner introduces the CMT in the context of Neural Field Theory (see also Spencer *et al*., 2009; Sandamirskaya *et al*., 2014) which models neural activity in terms of varying electromagnetic activation in real time. Haragus and Iooss (2011: 34), within a more rigorous mathematical framework, also show that CMT reduces the dimensionality of a problem, as centre manifolds arise near critical points in a dynamical system:[11]

Starting with an infinite dimensional problem … the center manifold theorem reduces the study of small solutions, staying sufficiently close to 0, to that of a small system with finite solutions.

(Haragus and Iooss, 2011: 34)

The CMT applies in the case we are analysing here, for a dynamical system with the properties summarized in (1), when external perturbation drives manifolds to intersect. The intersection spans the centre manifold, and the new construct condenses through the faded dimensional attractor, maintaining their

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[10] See Schöner (2009: 33) for some discussion about internal and external perturbations on dynamical systems.

[11] Zeeman (1977) narrows the scope of the theory to the interplay between neural structure and cognitive processes, focusing on discontinuities ('catastrophes'), which he claims are a major characteristic of the systems of differential equations that model neurocognitive dynamics. Moreover, while some properties of n-dimensional complex systems might be difficult to solve with ordinary differential equations, solutions in a centre manifold can always be described by a finite-dimensional system of such equations, which is indeed an advantage from both theoretical and empirical perspectives.

combined core properties but clearly losing information corresponding to the faded dimension. This process not only involves the transition from a non-metric to a metric space but also restricts the phase space, since there is a transition from the infinite, unrestricted, ultrametric initial state to an also infinite, but restricted, low-dimensional state. Restrictions over this space follow from the fact that there are hard conditions over possible structures, defined by the physical and topological properties of the metric space and the kind of manifolds manipulated there.

This transition between non-metric and metric spaces delivers objects into a space in which computational operations yield a non-trivial output. This is in contrast to the undifferentiated consequences of computation in ultrametric space where no cumulative process is possible since no interpretable, differentiated output emerges: here, the property of ultrametric spaces that distances do not sum becomes relevant. If we are dealing with vector manifolds in ultrametric spaces, there is no way to guarantee that the interaction between those manifolds in terms of their vector product will yield a cumulative output.

Let us consider the situation in a bit more detail. We have argued that the dynamical frustration inherent in the establishment of cognitive states necessarily delivers an ultrametric space with its manifolds that intersect. The dynamics of the intersection of manifolds leads to the existence of lower-dimensional, less-entropic and necessarily metric states that are extensions of the ongoing dynamics of the intersecting manifolds. The extension of the manifolds into metric space comes about because the distance function between any point x in manifold X and any point y in manifold Y varies as the manifolds get closer and finally intersect. This is a state of affairs that is impossible in ultrametric space, as we said above, for $x \in X$, $y \in Y$, $d(x, y) = k$ (some constant) in the ultrametric space (see (4)); but $k \rightarrow 0$ as the space in which the manifolds exist is deformed. This is a process of *metrization*. Crucially, the metrization of the initial space is a consequence of the intersection of manifolds.

We have thus two operations: (a) the transition from a non-metric space to a metric space, and (b) the transition from high-dimensionality to low-dimensionality. Each is underpinned by different, and potentially independent, mathematical and physical principles, and could, in principle, be analysed in isolation: the CMT is in charge of dimensionality reduction, but it remains agnostic with respect to the metric properties of the space in which the manifolds exist; in contrast, the deformation of the manifolds in ultrametric space brings them closer together and modifies the distance function between them (i.e., between any two points belonging to each of them). Both processes are intimately related and, moreover, they are both necessary to account for cognitive computation and their neurobiological underpinnings.

It is important to note that the process of metrization and dimensionality reduction is only part of an ongoing dynamical process; manifold X has its

own internal dynamics, which carries on after its encounter with manifold Y and vice versa. The intersection between the two (or more) manifolds yields a shared extension of the manifolds into a lower-dimensional metric space. The internal dynamics driving the overall manifolds (X and Y) carries on – time does not stop. Recall we said that the intersection between manifolds is triggered by a perturbation of the ground state of the system, in the form of an external input: this energy input disrupts the ultrametricity of the ground state and causes manifolds to intersect, triggering the CMT. This intersection yields the lower-dimensional extension we are working with here. Over time, once the external perturbation has been removed or has ended *sponte sua*, the lower-dimensional extension is drawn back into the ground state dynamics: any physical system tends towards energy minima and the metric extension of the collided manifolds is an excited state. This process materially changes the nature of the two initiating high-dimensional manifolds X and Y. Their shared extension manifests the combined core properties of the two manifolds at the point of intersection – say, at time t_1 – and is a transient departure from the ground state dynamics of the manifolds. As the lower-dimensional components are drawn back into the ongoing ultrametric manifolds' dynamics – at some future time t_2 – information about the *previous* state of both manifolds – at time t_1 – is brought into the ground state dynamics of each. Note that the extension combines, as we said, the core properties (vector components) of X and Y at the point of collision: crucially, this means the system has a built-in 'memory', as it is capable of accessing aspects of its own past dynamics.[12] It is important to note that we have been handling only two manifolds, X and Y, for the sake of concreteness: the ultrametric sabayon is densely populated, and the number of intersecting manifolds need *not* be always *two*. Moreover, *many collisions can take place at any given time, generating many extensions which reach the lower-dimensional metric space in which they can be subject to further operations*: the overall system dynamics presents an ongoing engine with manifolds intersecting and generating lower-dimensional extensions via CMT simultaneously and continuously (i.e., the overall dynamics of the system is most emphatically not discrete, even though it can be *modelled 'as if'*). That is, not only the high-dimensional manifolds collide and relate: the extensions themselves also combine within the metric space by means of perturbations of that space,[13] thus generating a more complex object that will be further operated on. Therefore, while the metric extension is drawn back into the ongoing dynamics of the ultrametric manifolds, the products of operations over

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[12] This delivers both a damping effect on the higher-dimension manifold – as a simplified version of its early state is brought into the current dynamics – and an excitatory effect – as a simplified version of the intersecting manifold's early state comes along too.

[13] The distance function *d* between any two extensions is variable because we are not dealing with an ultrametric space in low-dimensionality.

extensions in the metric space remain in this space and are, for the purposes of further operations, *cycles* (impenetrable units of syntactic computation). Thus, the oscillation between ultrametric and metric spaces provides a mechanism for *both* memory of previous states and integration between states: an oscillatory and cumulative system.

At this point, we have the stuff of syntax. Operations over the extensions in metric space will conform to general principles of normal-grammatical computation (see fn. 9 above). However, the options for modifying conceptual space is limited to the oscillatory mechanism we have just described. This delimits the phase space (which gives us locality conditions) and restricts possible syntactic mechanisms (which pertains to aspects of computation and the architecture of grammars).

Recapitulating, the dynamics we have been characterizing here, defined by *a double-layered dynamical frustration*, display two fundamental properties:

- They are oscillatory.
- They are – globally – cumulative.

The interplay between these two properties, as time goes by, gives us a system that oscillates between a high-dimensional non-metric space and a lower-dimensional metric space, thus optimally satisfying both requirements dynamically; at the same time, the operations that apply over the condensed residues of the high-dimensional representation progressively establish dependencies among these residues as long as they remain active in the syntactic/cognitive workspace, thus building structure step by step. Both properties are essential, because a purely oscillatory system with no cumulative structure building would never produce a usable output. Similarly, if we only had the initial ultrametric high-dimensional space to work with, given its unrestricted nature, there is nothing we can actually do in terms of reducing uncertainty because every point in the phase space has an immutable probability amplitude associated to it.

2 Syntactic Consequences

We can now consider the syntactic consequences of our proposal. The whole manifold intersection process we have been describing is not very different in spirit from what a generalized transformation is supposed to be, following Chomsky (1995: 189):

Generalized Transformation:

  i Target a category α
 ii Add an external $\emptyset$ to α, thus yielding $\{\emptyset, \alpha\}$
iii Select category β
iv Substitute $\emptyset$ by β, creating $\{\gamma, \{\alpha, \beta\}\}$

The internal complexity of α and β is arbitrary, such that either can be a phrase marker itself. Phrase markers can be considered to be notations for manifolds (Krivochen, 2015); thus a generalized transformation can be understood as reducing a manifold to a lower-dimensional term which becomes a *terminal* for all subsequent structural intents and purposes. This lower-dimensionality extension can subsequently be inserted into a (wider) phrasal context linking it with other low-dimensional manifold extensions; call this context β following Chomsky's definition. Thus, there are two possible fates for an extension in the metric space:

(5) a. It gets Spelled-Out – thus abandoning the syntactic workspace altogether.
   b. It gets realized as an atomized *token* within a wider phrasal context – thus remaining within the syntactic workspace and, moreover, being subject to further syntactic operations.

Both options are freely available and correspond to a monotonic computation and an oscillatory computation, respectively, if there is nothing left in the workspace after the cycle has been Spelled-Out: since we have claimed computation need not be uniform, it would be foolish of us to restrict the possibilities for a 3-manifold to either (5a) or (5b) exclusively and uniformly. In fact, (5b) can be more generally phrased as '*a lower-dimensionality version of α serves as* (part of) *the input for a set of processes P at a parallel or subsequent system*' (our italics).[14] Importantly, these further processes may need to identify or tag the objects involved in the operations, or provide means for such identification to take place: these identification tags are nothing other than *labels* and characterize *normal grammars*.[15] While normality is a property associated with structure building within a metric space (the syntactic operations in charge of relating elements being in fact operations that modify the distance function among them, as suggested by Juan Uriagereka, p.c.), it is not feasible to use

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[14] This wider formulation seems to be relevant for the study of syntactic manifolds in relation to neural networks as irreducible graphs, which connect with other such graphs via paths of a lower-dimensionality than those that make up the network itself.

[15] 'Normal grammars' are, in this context, grammars in Chomsky/Greibach Normal Form, where:

> *Chomsky-normal grammar*: every context-free language is generated by a grammar for which all productions are of the form A → BC or A → b (A, B, C, nonterminals, b a terminal, including ε).
> *Greibach-normal grammar*: every context-free language is generated by a grammar for which all productions are of the form A → bα, where b is a terminal and α is a string of nonterminal variables.

Unless explicitly indicated, we will use 'normal' to refer to either kind of formal grammar, for they are equivalent in most relevant cases.

Hi-dimension   X →← Y   X' →← Y'   Non-metric

Lo-dimension   Extension 1: core aspects   Extension 2 + Extension 1   Metric
                    of X ∩ Y
                t_1 t_2
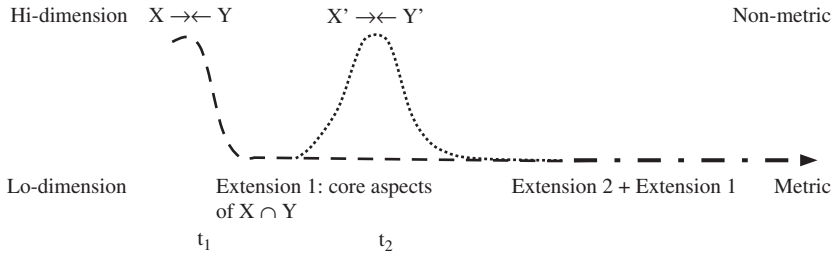
Figure 16.1. Cumulative oscillatory dynamics

normal grammars to model the interface between high-dimensional/non-metric and low-dimensional/metric spaces. We therefore require a formalism that captures oscillatory dynamics of the specific kind shown in Figure 16.1. Luckily, such a formalism already exists: Lindenmayer grammars (L-grammars henceforth). L-grammars, in this architecture, describe the *interface* between the two topological spaces we have been characterizing.[16] The L-formalism captures an oscillatory dynamics of the kind we need. Furthermore, they are non-normal *but* capable of being *normalized* at the cost of introducing nonterminals if so required. The expression of the L-grammar generates an output that contains the seed for further derivation plus a residue, in terms we will return to below in explicit detail. There is a further aspect to highlight here: *the interface between the two topological spaces is in essence a syntactic procedure*, which projects A to B in the way specified above. In fact, we will argue, this is the *simplest possible syntactic engine* given L-grammatical assumptions.

The claim here, then, is that the most fundamental aspect of *syntax* is this: it delivers the building blocks which are metric and can be operated over; and (*per* L-grammars) it reduces the uncertainty inherent to the unrestricted ultrametric space. The dynamics captured by the L-formalism describes the interface between the ultrametric and the metric spaces and provides us with something to work with (the extension). The dynamics also drives the derivation via the copy of the original term within the projection of this term, which gets pushed back to the high-dimensional space, thus allowing the process to start again.

Note that the overall system describes three spaces: an ultrametric space, a metric space, and a space determining the interface between those two. This

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[16] At this point, a new question arises: can the L-formalism *be* the interface itself? If something along the lines of Tegmark's (2007) Mathematical Universe Hypothesis is on the right track, then the L-formalism can be studied not as a *description* of the interface between ultrametric and metric spaces, but *as the interface* itself.

should come as no surprise given the close connections the present proposal has with Quantum Field Theory (see Schwarts, 2014, for an introduction): a field can excite another directly or via a third field; the Higgs field (whose local excitations correspond to the recently discovered Higgs boson) interacts with all the other fields corresponding to massive particles within the Standard Model, and these interact among themselves as well. The L-formalism defines a phase space, in which all possible developments of L-grammars are represented and have a probability amplitude associated with them:[17] this space that exists between the ultrametric and the metric provides us with a way to go from one to another, back and forth. The ultrametric space is infinite and unbounded; the L-space is bounded as any grammatical space is but does not support labels (non-normal); the metric space is both bounded and normal: the importance of boundedness in the formalization of the ultrametric–metric interface cannot be overstated. Crucially, boundedness implies the existence of hard conditions. The infinitude of the L-space is not unlike the infinitude of the cardinality of the set of prime numbers: while the set is countably infinite, there are clearly elements which do not belong in the set (for instance, any even number). This is not the case with the ultrametric space. There are *hard conditions* (i.e., inviolable conditions) that must hold for a string to be 'L-grammatical', and violations to these conditions cannot be repaired by means of mapping operations: as such, these conditions delimit the phase space, restricting our object of inquiry. There are grammars which *do not* belong to the L-space (and cannot be reduced to an L-grammatical form), notably sequential Chomsky-normal and Greibach-normal grammars. The metric space is also infinite and bounded by hard conditions, but those are different from the ones holding for the L-space. Whereas the L-formalism relies on the extension containing an exact copy of a previous generation's main term as a sort of 'built-in' memory, the metric space requires a different kind of memory to keep track of the objects that are being computationally manipulated, and also to tag them so that they are identified for the purposes of further computations: with the normal-formalism comes a memory stack.

Let us now consider the simplest example of L-grammar for $\Sigma = \{1, 0\}$:

Axiom: 0
Rules: 0 → 1
        1 → 0 1

Let us call it the 'Fib grammar', because the number of 1s and 0s *per generation* follow the Fibonacci sequence $\{1, 1, 2, 3, 5, 8...\}$. Furthermore, let us illustrate the first eight generations of the development of said grammar in Figure 16.2.

---

[17] This is consistent with the form of a *ket* vector; see Dirac (1958).

Fib-grammar
```
                     0
                     1
                    01
                   101
                  01101
                 10101101
               0110110101101
             101011010110110101101
         0110110101101101011010110110101101
```
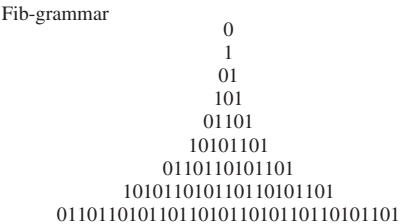
Figure 16.2. First eight generations of the Fib grammar

The notation used in Figure 16.2, which omits branches for graphical conveni-
ence, hides an important fact: the Fib grammar growth pattern, which in this case
is left-adjoining, can be exhaustively characterized in terms of a 'main term' and
an 'extension', where the 'main term' for any generation g_n is a copy of g_{n-1} and
the 'extension' for g_n is a copy of g_{n-2}. This means, crucially, that, in infinite time,
the extension will 'catch up' with the main term, because *the residue contains the
'seed' of the main term*. This is essential for the story we are telling here. The core
property of these simultaneous expansion systems is that there is a *perfect* mapping
between some value A and some value B but an *imperfect* mapping from B back
to A and, importantly, B leaves something behind. In this case, the right branches
constitute the copy of A; and the left branches, the residue. Importantly, the map-
ping is continuous, so this remnant of B must map to A, eventually. A striking
result is that we have a system with a built-in local memory without the need to
invoke a stack (because there's nothing in A that will not eventually pop up in the
extension of B): this extension eventually returns to A, with all emergent properties
untouched. Derivationally, the growth process is perfectly self-similar, and we can
say that, in infinite time, A and B are topologically identical: there is an isomor-
phism between A's and B's residue. Let us illustrate this process, which we have
described generally above, within the context of the L-formalism (see Figure 16.3).
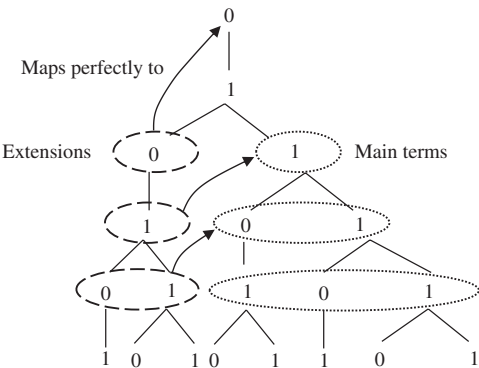
Figure 16.3. Self-similarity in the Fib tree

Let us now summarize the story. From successive cyclicity in syntactic derivations (exemplified by hard conditions on extraction – see Ross, 1967; Postal, 1997, among others) through electro-neurodynamics (Villegas *et al.*, 2014) to the oscillatory nature of polarization and depolarization membrane cycles (see, e.g., Koester, 1991), 'back-and-forth' processes are ubiquitous at the levels of both physical substrate and informational dynamics, which make up the quintessential dynamical frustration in neurocognition. In this chapter we have embraced this central insight, explored the mechanisms that underpin this global dynamic and applied it to understanding the nature of syntactic operations from the physical and topological perspective.

We argued that our internal map of the world is a very rich and unrestricted space. Manifolds in this high-dimensional ultrametric unrestricted sabayon condense into lower-dimensional metric extensions via intersections and the application of the CMT. The dynamics of this system returns these metric extensions to their higher-dimensional parents, taking along an encoding of the core properties of the intersecting manifolds at an earlier time. *The dynamics of the system is oscillatory.* The essential properties of this dynamic interface between ultrametric and metric spaces are captured by the L-grammar formalism which characterizes the flow between the two in terms of main terms and residues (see Figure 16.3). The low-dimensional residues can be the input to further (normalized) computational operations. Assuming that linguistic workspaces are instances of such a low-dimensional space, narrowly linguistic operations are then expressible in terms of normalized manipulations of the residues: this is the domain of grammatical operations and corresponds to the usual understanding of the term 'syntax'.

The continuous dynamics of the overall system guarantees that the output of such operations will inform the subsequent dynamics in the ultrametric space. Thus, we cyclically resolve the tension between the inherent uncertainty of the ultrametric model and the need for a simplified vocabulary such that syntactic operations can yield usable outputs.

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17 The Golden Phrase: Steps to the Physics of Language

David P. Medeiros and Massimo Piattelli-Palmarini

1 Introduction

This chapter is about some previously unnoticed (and, we suspect, significant) properties of the celebrated X-bar schema (Chomsky 1970; Jackendoff 1977).[1] We observe that the X-bar schema is a uniquely special recursive format; this Golden Phrase is "just right" with respect to certain fundamental mathematical properties, of the kind that crop up repeatedly in the study of physical systems.[2,3] We focus on three properties that seem likely to be of significance, noting that the X-bar form is the only kind of structure with all three properties.

In familiar terms, the X-bar schema describes a recipe for constructing phrases (XPs) by combining their heads (X^0) with first one other phrase (YP, called the complement), then combining the resulting object (X') with a second phrase (ZP, called the specifier).

(1)

```
          XP
         /  \
       ZP    X'
            /  \
          X⁰    YP
```
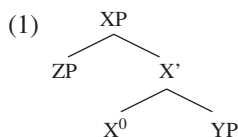
Arguably, this configurational schema, known as X-bar theory, is the only kind of structure that syntactic representations exploit. Other structural options, such as adjuncts to phrases, multiple specifiers of a single head, etc., have been experimented with in various ways but Cartographic research has, for the most part, eschewed these options,

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[1] The work reported here has been directly inspired by previous publications by Juan Uriagereka on Fibonacci patterns (see, e.g., Idsardi and Uriagereka 2009; Piattelli-Palmarini and Uriagereka 2008; Uriagereka 1996, 1998) and by many of his bold ideas exchanged, over the years, in conversation. We are grateful to Noam Chomsky and Juan Uriagereka for comments and suggestions on a previous draft.

[2] It is suggestive that the Golden Phrase – the X-bar schema – is intimately associated with the Fibonacci numbers and the Golden Mean, which appear in many other places in nature. Juan Uriagereka has been discussing Fibonacci patterns in linguistic structure for many years (see footnote 1).

[3] For a close parallelism between the historical development and the conceptual foundations of linguistic theory and modern physics, see Freidin and Vergnaud (2001), a paper that we find quite congenial.

retaining only the core structures afforded by the X-bar schema … The core structural relations defined by X-bar theory seem to be not only necessary, but sufficient to characterize syntactic structure.

(Shlonsky 2010: 2)

However, recent developments within syntactic theory have undermined the theoretical foundation of X-bar theory, especially the notions of "bar-level" and projection on which it is based. This makes the empirical phenomenon all the more mysterious: within the vast morphospace of conceivable structural patterns, why should human grammars keep to this tiny corner?[4] In the context of the Minimalist Program (Chomsky 1995), we suspect that this structural pattern is not elaborately and specifically encoded as such but rather emerges from the interaction of deeper principles.[5,6]

In this chapter, we show that the structural format of the X-bar schema, when compared against all other patterns that could provide a self-similar basis for binary-branching discrete infinity, stands out as special in a number of ways. The properties that set it apart are best brought to light by describing syntactic patterns with matrices; the matrix properties we discuss are familiar in other sciences, though to our knowledge their consideration in theoretical linguistics is novel (some might say, premature). Matrices seem, anyway, a natural choice for describing grammars, as they encode transformations and self-similar growth, two themes that loom large in recent work.[7]

In quantum physics it is standard to treat the initial state of a system as a vector and the application of forces, fields, and perturbations as matrices. The result of this operation (a vector-matrix multiplication) is a new vector (the final state). Well-behaved (so to speak) vector transformations correspond to diagonalizable matrices (see below). The special vectors that preserve their orientation under the transformation expressed by matrix multiplication are called

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[4] Obviously, phrasing the question this way presupposes that the X-bar schema is, in fact, an accurate description of syntactic structure. This is a fraught topic, depending in part on theory-internal concerns, and touching on controversial topics such as the nature of endocentricity (see e.g. Chomsky 2013, 2015). Such matters are beyond the scope of this chapter.

[5] Of course, the enterprise of explaining X-bar-like syntactic formatting through deeper principles has a rich history. Notable here is Kayne's (1994) theory of Antisymmetry, in which a version of X-bar theory was made to fall out from the requirements of linearizing an unordered branching tree. For a different approach to antisymmetry in language, see Moro (2000, 2013).

[6] Chomsky has suggested to us, in recent conversations, that the remarkable properties of the X-bar structure which we detail here, rather than being part of Narrow Syntax, are part of the NS interface with the Conceptual-Intentional system, something about which very little is known. In fact, he now conceives the X-bar structure as emergent from recursive Merge. He was kind enough to say that the properties revealed in our present work are "more interesting than you think," precisely because of this.

[7] For the derivation of the X-bar schema and the Fibonacci series by repeated application of the binary Pauli matrices, see Piattelli-Palmarini and Vitiello (2015, 2017).

eigenvectors, and the factors by which these stable vectors grow (or shrink) in each step are called eigenvalues. These are computed by finding the roots of the characteristic polynomial of the matrix.

The special classifications that converge uniquely in the X-bar schema involve the spectrum of eigenvalues associated with the matrix representation A of a phrasal recurrence pattern. Let us call the degree of a phrasal pattern the degree of its characteristic polynomial. Let G (mnemonic for "growth factor") represent the dominant eigenvalue (i.e., the largest-magnitude, necessarily real, root of the characteristic polynomial), and G' stand for an arbitrary Galois conjugate (a distinct eigenvalue; equivalently, a distinct root of the characteristic polynomial). Among "Prime" systems (those whose matrix forms have irreducible characteristic polynomials), the three classes of interest are as follows:

i. *The Endocentric class*. These forms can be described as generalized X-bar schemata; intuitively, each combines a terminal at the deepest level with a complement phrase, and then combines the result with some number of specifier phrases one at a time, to make a full phrase. These forms have the largest G for systems of their degree; there is one such system of each degree (up to permutation of which non-terminal is chosen as the root). Relative to other patterns of their degree, these structural formats support the minimum number of c-command relations (Medeiros 2008).

ii. *The Pisot class*. These patterns have a G that is a so-called Pisot-Vijayaraghavan (PV) number, an algebraic integer (i.e., solution to a polynomial with integer coefficients) greater than 1, with Galois conjugates (here, G') all of magnitude less than 1. Although discovered only in the twentieth century, these numbers have been the focus of considerable interest in number theory, harmonic analysis, and crystallography (see, e.g., Moody 1997). These patterns have a kind of structural purity; all eigenvectors (interpreted as a stable structural "theme") save the dominant one vanish as the pattern is grown. All non-Pisot systems, in turn, have infinite growing "warts" of structure distinct from the dominant theme.

iii. *The Polygonal class*. Finally, there is a class of patterns whose G is of the form $2\cos(\pi/n)$. These forms are polygonal: their G is the ratio of the shortest internal diagonal to a side in a regular polygon. They, and only they, have all real-valued G', and diagonalizable matrices. The odd polygonal systems (whose G relates to the geometry of a polygon with an odd number of sides) furthermore have symmetric matrices ($a_{ij} = a_{ji}$). In polygonal systems the growth of the pattern reflects real scaling of each of its components, thus an inhomogeneous dilation. On the other hand, all non-polygonal systems have eigenvectors (stable configurations) associated with some complex-valued G', and their growth involves a kind of rotation.
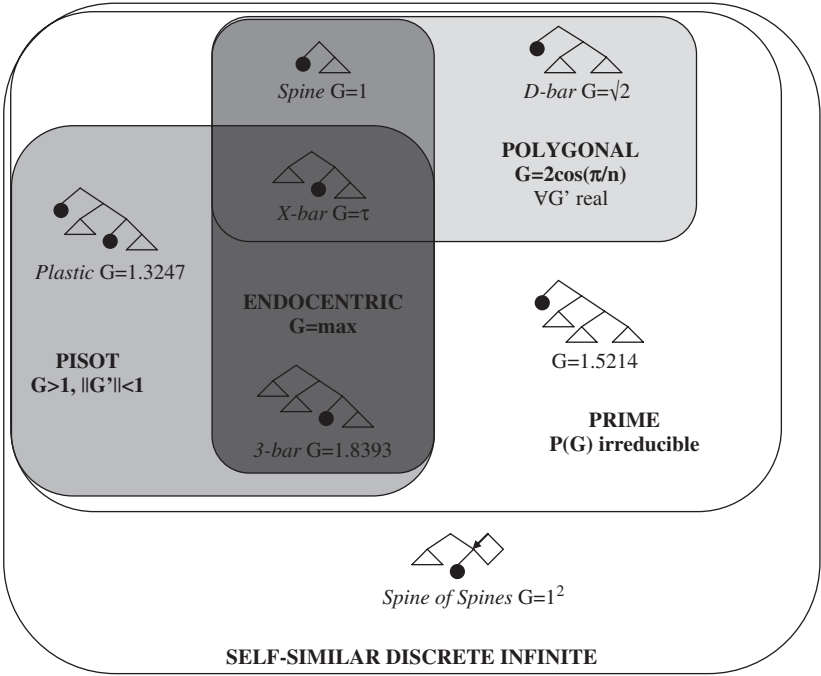
Figure 17.1. Intersection of spectral classes of phrasal recurrence patterns

Figure 17.1 is a Venn diagram of these classes. The intersection of all three classes is exhausted by a unique form, corresponding to the X-bar schema. We speculate that the unique convergence of these properties in this structural format might partly explain why language is that way. If so, X-bar-like phrase structure might follow from the "third factor" in language design (Chomsky 2005), the result of very general principles (namely, those related to the mathematics of matrices, a natural way of capturing syntactic patterning, and arising in too many physical applications to mention).[8]

The X-bar schema, whose dominant eigenvalue *G* is the so-called Golden Number τ, is the only pattern in all three of the classes described here (Endocentric, with maximal *G* for its degree; Pisot, with unique structural purity; and Polygonal, with real growth).

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[8] For a similar, germane, though distinct, mathematical and physical approach to "third factors," see Piattelli-Palmarini and Vitiello (2015, 2017).

2   Expressing Syntactic Patterns as Matrices

The X-bar schema is just one of (infinitely) many patterns that could form a structural basis for language-like structures, combining terminals and non-terminals into indefinitely large structures. We consider the X-bar schema against the background of other binary-branching deterministic context-free patterns of syntactic recurrence. As a way of coming to grips with the consequences of different ways of building structure, we will isolate the patterns and consider what happens as they are expanded rigidly, deterministically, and unboundedly.

Formally, we take a pattern of syntactic recurrence to be a tuple consisting of an alphabet containing a single terminal and some finite number n of non-terminals (without loss of generality, we may label the terminal with 0, and non-terminals with distinct natural numbers i, $n \geq i \geq 1$), a designated root non-terminal (again without loss of generality, we can designate the root with the largest-value non-terminal symbol n), and a set of binary production rules i → j k (a one-to-one function associating to each non-terminal a distinct unordered pair of elements drawn from the alphabet). We will further impose the conditions that each element of the alphabet is dominated by the root, and each non-terminal dominates the terminal type.

Thus the class of objects under consideration here form a restricted class of D0L-grammars (deterministic context-free Lindenmayer systems), used in many fields, including algorithmic botany, dynamical systems, and the study of quasi-crystals.[9] In this case we will consider them as idealizations of possible patterns of syntactic recurrence, each a potential scaffolding for the expressions of natural language.

Each phrasal pattern can be expressed as a matrix A recording immediate domination relations among non-terminals, a_{ij} the number of objects of type j immediately dominated by the object of type i. Thus, the 1st, 2nd, 3rd row/column is associated with the first/second/third non-terminal type; the rows are in effect the inputs to rewrite rules, and the columns the outputs. Thus, the X-bar form corresponds to the following matrix:

(2) $\begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix}$

[9] There is a large literature on L(indemayer)-systems; see, e.g., Prusinkiewicz et al. (1990) for an introduction. Much of that work is concerned with word sequences and formal language properties, and is thus irrelevant to the concerns here: we ignore linear order, and with only a single terminal type, all systems concerned here produce the dull (terminal) formal language a^n. Although matrix formulations of L-systems are well-established (see, e.g., Rozenberg and Salomaa 1980), we are not aware of prior work that has investigated the properties considered here.
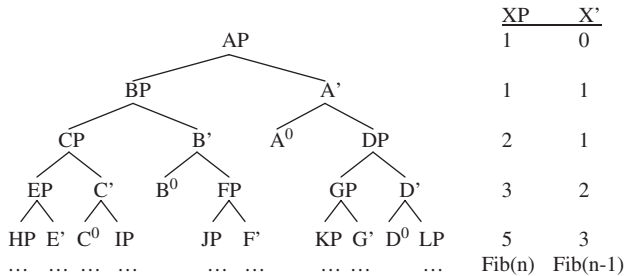
Figure 17.2. Maximal expansion of X-bar schema

	XP	X'
AP	1	0
BP ... A'	1	1
CP ... B' ... A^0 ... DP	2	1
EP C' B^0 FP GP D'	3	2
HP E' C^0 IP JP F' KP G' D^0 LP	5	3
	Fib(n)	Fib(n-1)

Just to make the correspondence between the matrix form and the phrase structure rules absolutely clear, we can think of the matrix as a rewrite table, as follows:

(3)

	XP	X'
XP →	1	1
X' →	1	0

As mentioned above, we designate with G the dominant eigenvalue of this matrix; it is the limiting ratio of the number of nodes on successive lines of the tree, as the pattern is maximally expanded. In turn, G' are non-dominant eigenvalues (Galois conjugates, other roots of the characteristic polynomial of the matrix). In syntactic terms, the other eigenvectors are other stable configurations among non-terminals.

We can distinguish "prime" phrasal patterns from "composite" ones. Prime patterns with n non-terminals have irreducible characteristic polynomials of degree n (and so, their G, the largest magnitude root of the polynomial, is an algebraic integer of degree n). Composite patterns have polynomials that can be factored into polynomials of lesser degree; these systems can be described as geometrically substituting one pattern within another. It follows that the G of a composite pattern over n non-terminal types is an algebraic integer of degree $< n$.[10]

To illustrate the utility of matrix mathematics for describing the properties of syntactic patterns, consider the maximal expansion of the X-bar pattern, as in Figure 17.2.

Each stage of line-by-line growth can be represented as a vector in the plane, associating the non-terminal types to the coordinate axes (the distance along

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[10] The simplest example of a composite pattern is the "Spine of Spines," defined over two non-terminals. It can be expressed as a traditional rewrite system (XP → XP X', X' → X^0 X'); its polynomial is $x^2 - 2x - 1$, which factors as $(x-1)^2$, reflecting its geometric description as Spines substituted in at the head positions of a Spine (the Spine has polynomial $x-1$).
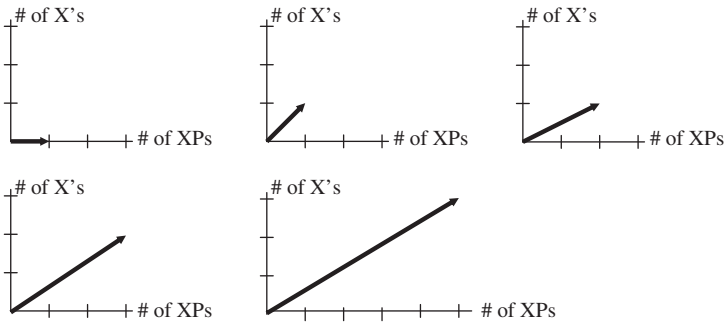
Figure 17.3. Vector representation of X-bar growth
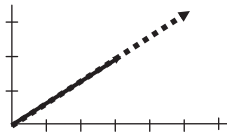
Figure 17.4. Eigenvector of the X-bar schema (solid line), and one step of growth (dashed line), corresponding to multiplication of the eigenvector by the X-bar matrix

each axis simply counts the number of that type of non-terminal on a line of the tree). To get the sequence of vectors $(x_0, x_1, ...)$ representing maximal expansion of the pattern, we simply iterate multiplication of the vectors by the phrasal matrix A:

(4) $Ax_i = x_{i+1}$

Figure 17.3 illustrates the first few steps of growth of the X-bar pattern.

Figure 17.4 shows the eigenvector for the X-bar scheme (the diagonal of a golden rectangle, as it turns out), with dominant eigenvalue $G = 1.618 ...$, the golden mean. Notice that the vectors representing subsequent levels in the tree converge in this direction.

An eigenvector is a column vector x, such that multiplication by the matrix A simply scales the eigenvector by the associated eigenvalue λ. We illustrate this for the X-bar pattern and its dominant eigenvector x and associated eigenvalue λ in (5):

(5) $Ax = \lambda x$ $\begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} 1.618... \\ 1 \end{bmatrix} = \begin{bmatrix} 2.618... \\ 1.618... \end{bmatrix} = 1.618... \begin{bmatrix} 1.618... \\ 1 \end{bmatrix}$

With this much in hand, we turn to the properties of each of the three special spectral classes; the first such is the Endocentric class.

3-bar

$$\begin{bmatrix} 1\ 1\ 0 \\ 1\ 0\ 1 \\ 1\ 0\ 0 \end{bmatrix} \quad \begin{array}{l} XP \rightarrow XP\ X'' \\ X'' \rightarrow XP\ X' \\ X' \rightarrow X^0 XP \end{array}$$

Figure 17.5. Matrix, rewrite rules, and tree schema for 3-bar, the Tribonacci grammar.

3   The Endocentric Class

The Endocentric class contains generalized X-bar forms, with one head and one complement at the deepest level of the phrase, and some fixed number of specifiers merged one-at-a-time above that, with complements and specifiers identical to the root object (in intuitive terms, all non-head daughters are phrasal). Such forms have the highest growth factor G for their degree (see Medeiros 2008 for an informal proof). For example, the X-bar schema grows faster than any other form with two non-terminals; 3-bar, the generalized X-bar form with two specifiers per phrase, has the largest G among all systems with three kinds of non-terminals. We give (in Figure 17.5) one orientation of the 3-bar system, its matrix form, a description in terms of PSRs,[11] and an abstract tree diagram encoding the recurrence pattern. It has $G = 1.839$ ..., the so-called Tribonacci constant.[12]

The Spine, though it is in fact the "worst" system – it has the lowest possible growth factor (1) for a binary-branching discrete infinite pattern – is also best in its class, by virtue of being the only kind of discrete infinite structure with one non-terminal. The alternatives to the Spine ($1 \rightarrow 1\ 0$), namely $1 \rightarrow 0\ 0$ and $1 \rightarrow 1\ 1$ (where 1 is the non-terminal object and 0 the terminal), don't work: The first case (the Pair) is discrete but not infinite; the second is infinite but not discrete (the Bush, with no terminals).

The characteristic polynomial of an Endocentric system is one of the generalized Fibonacci polynomials, with this general form:

(6) $x^n - x^{n-1} - \ldots - x - 1$

The X-bar system is, interestingly, the last Endocentric system whose growth value can be physically constructed with straightedge and compass (Cipu and Luca 2001: 28). See also Medeiros (2012) for the observation that, while Endocentric systems support the minimum number of c-command relations globally (over the whole tree), for Endocentric systems of degree 3 and beyond there are other patterns that accumulate fewer new c-command relations locally

---

[11] Note that this format corresponds to Jackendoff's (1977) "Uniform Three-Level Hypothesis," where all X-bar phrases were taken to project three layers of structure.

[12] The Tribonacci constant is the limiting ratio among successive terms of the Tribonacci sequence, where each term is the sum of the three preceding terms. Compare this to the case of the golden number τ, which is the limiting ratio of terms in the Fibonacci sequence, where each term is the sum of the previous two terms.

(within the horizon of a single phrase). In other words, the X-bar schema is the "last" Endocentric system that minimizes c-command relations both locally and globally.

4   The Pisot Class

Next we turn to the Pisot class, containing patterns that have growth factors G that are Pisot-Vijayaraghavan numbers. These are numbers that are algebraic integers – solutions of polynomials with integer coefficients – where all but one of the roots lie within the unit circle on the complex plane, and the Perron-Frobenius eigenvalue is > 1.[13]

These systems are likely to be significant, for the following reason. Recall that we have identified the eigenvectors of these systems with stable ratios among non-terminal nodes. In Pisot systems, those eigenvectors with eigenvalues of magnitude less than one (i.e., all but the dominant one) are vanishing: their associated eigenvalue is less than one, so they shrink as the tree grows. Put another way, non-Pisot systems have growing "warts" of stable non-terminal configurations other than the dominant one, while in Pisot sytems all but the dominant ratio are configurations that extinguish themselves during growth.

The generalized X-bar form of degree ≥ 2 (i.e., all members of the Endocentric class save the Spine) is always of Pisot type. As mentioned above, its polynomial is the generalized Fibonacci polynomial, the largest root of which is always a Pisot number (Cipu and Luca 2001: 27).

5   The Polygonal Class

Finally, we turn to the last of the three spectral classes to be described, the Polygonal class. In these systems, the growth factor G expresses the ratio of the shortest diagonal to a side in a regular n-gon. The ratio of shortest diagonal to side for a regular n-gon is this value:

(7) $2*\cos(\pi/n)$

To see why, note that the exterior angle θ_1 is $2\pi/n$, because the exterior angles for the whole n-gon sum to a complete circle. The angle θ_2 in the diagram in Figure 17.6 is then π/n, half of the exterior angle.
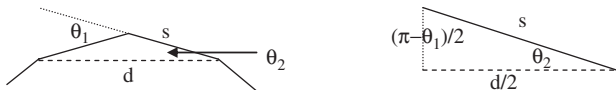
Figure 17.6. Geometry of diagonal-to-side ratio in a regular polygon

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[13] All integers greater than 1 are therefore Pisot numbers, trivially: integer n is the lone root of the degree 1 polynomial $x – n$. In what follows, we will be interested in non-integer Pisot numbers < 2. The golden mean τ is the lowest-degree non-integer Pisot number (it is the larger root 1.618 ... of $x^2 – x – 1$).

The cosine of angle $\theta_2 = \cos(\pi/n)$ then expresses the ratio of half a diagonal ($d/2$) to a side (s; see the triangle at right in Figure 17.6); we double this to get the diagonal-to-side ratio stated above, $2*\cos(\pi/n)$.

The first, trivial case is an equilateral triangle; we may take the diagonals to coincide with the sides, so that the ratio of diagonal to side is simply 1. This growth factor is associated with the Spine. The Spine makes use of a single non-terminal type. With two non-terminal types, we get the D-bar and X-bar systems, with growth factors $\sqrt{2}$ and τ, respectively. These values, as it turns out, are the diagonal-to-side ratios for the next polygons, the square and pentagon.

In fact, we find the shortest-diagonal-to-side ratio for each regular n-gon as the growth factor of some phrase structure system. For example, the hexagon has diagonal-to-side ratio of $\sqrt{3}$; this is the growth factor for one family of systems with three non-terminal types. We also find the heptagon diagonal-to-side ratio among the class with three non-terminals; this is the value 1.8019 ... This pattern continues, with two polygonal systems of each degree (for degree n, these are the (2n)-gon and (2n+1)-gon).

Only these "polygonal" systems have diagonalizable matrices. Matrix A is diagonalizable if it is similar to a diagonal matrix D; this is so if there is an invertible matrix P such that the following relation holds:

(8) $A = PDP^{-1}$

In contrast, all non-polygonal systems have non-diagonalizable matrix expressions; such matrices are called defective. This fact has a syntactic interpretation: in polygonal systems, the eigenvectors, corresponding to the stable configurations (ratios among the various kinds of non-terminals), all have real growth. The system as a whole thus represents an inhomogeneous dilation. Non-polygonal systems have some "complex" growth, and thus have an element of rotation in the growth of certain eigenvectors (stable syntactic configurations).

The systems corresponding to odd polygons appear to be even more special, in that their matrices (in all orientations, i.e., for any choice of which non-terminal to place at the root of the tree) are symmetric. A symmetric matrix with real entries is a special case of the more general property of Hermitian matrices, which are their own conjugate transpose (where for arbitrary matrix element $a_{ij} = a + bi$, $a_{ji} = a - bi$ where i is the imaginary unit). In the search for a possible "physics of language," this sounds interesting, in light of the fact that the matrix operators representing observables in quantum theory (e.g., momentum, position, energy, etc.) are always Hermitian.

Diagonalizability and symmetry are important properties in a number of physical applications. Curiously, "polygonal" ratios in the sense described here have been found in the quasiperiodic oscillations of multiperiod variable stars. For example, Escudero (2003: 235–236) gives three examples of multivariable
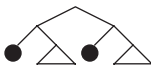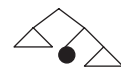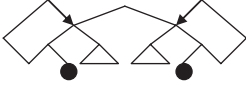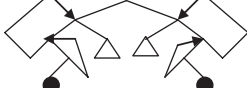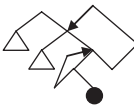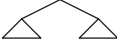
Number	Diagonal/side ratio in n-gon	Phrasal matrix	Syntactic pattern with this growth factor:
$2\cos(\pi/3)$ $= 1$	Triangle	[1]	Spine
$2\cos(\pi/4)$ $= \sqrt{2}$ 1.4142…	Square	$\begin{bmatrix} 0 & 2 \\ 1 & 0 \end{bmatrix}$	D-bar
$2\cos(\pi/5)$ $\Phi = (1+\sqrt{5}/2)$ 1.6180…	Pentagon	$\begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix}$	X-bar
$2\cos(\pi/6)$ $= \sqrt{3}$ 1.7320…	Hexagon	$\begin{bmatrix} 0 & 2 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}$	
$2\cos(\pi/7)$ 1.8019…	Heptagon	$\begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}$	
$2\cos(\pi/8)$ 1.8478…	Octagon	$\begin{bmatrix} 0 & 2 & 0 & 0 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix}$	
$2\cos(\pi/9)$ 1.8794…	Nonagon	$\begin{bmatrix} 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix}$	
$2\cos(\pi/n)$ $\varepsilon\ [1, 2)$	n-gon	$\begin{bmatrix} \text{Matrix} & 0 \\ \text{for } n\text{-2-} & … \\ \text{gon} & 0 \\ & 1 \\ 0\ …\ 0\ 1 & 0 \end{bmatrix}$	
$2\cos(\pi/\infty)$ $= 2$	∞-gon (circle)	[2]	Bush

Figure 17.7. Summary of Polygonal properties

stars, giving values for the ratio of their two periods and polynomials that are, exactly, those of the pentagon, octagon, and nonagon (for stars UW Her(culis), ST Cam, and V Boo, respectively).

Figure 17.7 summarizes the properties of polygonal phrasal patterns. Each row contains four related objects. In the leftmost column is a *G* value; the tree diagram in the rightmost column represents the syntactic pattern with this

growth factor. The second column shows the regular *n*-gon where the indicated number is the ratio of shortest internal diagonal to a side. The third column is a matrix encoding the recurrence relations among non-terminals in the relevant syntactic pattern.

6   Conclusion

In this chapter, we have described three special classes of syntactic patterns, defined in terms of the spectrum of eigenvalues of the matrix expressing each pattern. These are the Endocentric class, with largest growth factor (dominant eigenvalue) G of its degree; the Pisot class, where all non-dominant eigenvalues G' are of absolute value less than 1; and the Polygonal class, with all real eigenvalues and diagonalizable matrix forms (the odd polygonals furthermore have symmetric matrices). Each of these classes manifests properties that may be of significance for syntactic patterning.

Endocentric systems, as argued in Medeiros (2008), are desirable in that they support the minimum number of c-command relations. This means that such structures minimize the search space for the establishment of long-distance dependencies, a plausible desideratum for computational optimization (see Medeiros 2012 for details). Systems in the Pisot class are special in that they have only a single growing structural theme, with all non-dominant stable configurations vanishing under growth. Non-Pisot systems have infinite growing "warts" of stable configurations other than the dominant one. Finally, Polygonal systems have all real growth, encoding inhomogeneous dilations, by contrast with the complex rotations found in the growth of all other systems.

As we have stressed, these special spectral classes have a single pattern in common, the X-bar schema that seems to characterize the syntax of human language. This "Golden Phrase", which grows according to the golden mean, is thus a uniquely special structural format. We suggest that its unique cluster of spectral properties might be part of why it is found in syntactic structures, whether they are part of syntax as such or, as Chomsky suggests, part of the interface between syntax and the Conceptual-Intentional interface. If this is on the right track, this peculiar fact about language may turn out to be of a kind with many familiar physical phenomena, no more than "business as usual" in nature. If so, that would represent an advance in the understanding of language and a vindication of Chomsky's (2005) suspicion that "third factor" considerations play a significant role in determining the character of linguistic cognition.

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Appendix: Partial Catalog of Phrasal Patterns

In this appendix, we provide a partial list of possible phrasal patterns. This list is necessarily incomplete, as there is no a priori limit on the number of non-terminals that could be used to define the local "molecule" of structure; moreover, the number of systems of each degree increases dramatically as the degree increases. We provide tree diagrams and matrices for all orientations of all viable systems (prime and composite) of degrees 1 and 2. For degree 3 systems, we provide only matrices, polynomials, and dominant eigenvalues, and only for the prime systems. For reasons of space, for the large class of degree 4 systems we omit both trees and matrices, providing only the characteristic polynomials and dominant eigenvalues of the prime systems.

Let us recall that the systems of interest are binary-branching, discrete infinite recursive patterns. They each contain a single kind of terminal, and n distinct non-terminals, with a designated "root" non-terminal. The root must dominate (not necessarily immediately) each of the distinct types of nodes (terminal and non-terminals). In the prime systems, each non-terminal must also dominate (again, not necessarily immediately dominate) the root; composite systems are precisely those in which at least one non-terminal does not meet this condition.

These systems were found with the aid of a computer-assisted search. The characteristic polynomials and eigenvalues given here were calculated using the following site: www.arndt-bruenner.de/mathe/scripts/engl_eigenwert.htm

Degree 1

There is only a single discrete infinite system in this class, what we call the Spine. Recall that in our tree diagrams, a triangle indicates another root-type non-terminal (recursion of other non-terminals is indicated with arrows), and black circles are terminals. As throughout, linear order is unimportant.

Matrix:	Tree:	Polynomial:	Dominant eigenvalue:
[1]		x − 1	1

Figure 17.8. Degree 1 system

Intuitively, we can think of this system as corresponding to the following phrase structure rule: $XP \rightarrow X^0 \ XP$. Note that the other naïve possibilities ($XP \rightarrow XP \ XP$, $XP \rightarrow X^0 \ X^0$), what we call the Bush and the Pair, respectively, are either not discrete (the Bush has no terminals) or not infinite (the Pair doesn't grow).

Degree 2

We give the prime systems first. There are two distinct systems, with two "orientations" each (the different orientations result from distinct choices of which non-terminal is designated as the root). The different orientations have distinct matrices and tree forms, but identical polynomials and eigenvalues.

Matrix: Tree: Polynomial: Dominant eigenvalue:

$\begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix}$ $x^2 - x - 1$ 1.6180...

$\begin{bmatrix} 0 & 1 \\ 1 & 1 \end{bmatrix}$

$\begin{bmatrix} 0 & 2 \\ 1 & 0 \end{bmatrix}$ $x^2 - 2$ 1.4142...

$\begin{bmatrix} 0 & 1 \\ 2 & 0 \end{bmatrix}$

Figure 17.9. Prime systems of degree 2

There are two composite systems in this class as well, what we call the Spine of Spines and the Spine of Pairs.
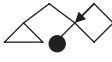
Matrix: Tree: Polynomial: Dominant eigenvalue:

$\begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$ $x^2 - 2x + 1$ 1

$\begin{bmatrix} 1 & 1 \\ 0 & 0 \end{bmatrix}$ $x^2 - x$ 1

Figure 17.10. Composite systems of degree 2

Degree 3

We omit trees for all systems, and all information about composite systems, in this class. The prime systems of degree 3 admit three rootward orientations, so the list below gives the three matrices corresponding to each orientation in a single row, together with their shared polynomial and dominant eigenvalue.

Matrices:			Polynomial:	Dominant eigenvalue:
$\begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 1 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 1 & 1 \\ 0 & 0 & 1 \\ 1 & 0 & 1 \end{bmatrix}$	$x^3 - x^2 - x - 1$	1.8383...
$\begin{bmatrix} 0 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 1 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 0 \\ 1 & 0 & 1 \end{bmatrix}$	$\begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}$	$x^3 - x^2 - 2x + 1$	1.8019...
$\begin{bmatrix} 0 & 1 & 1 \\ 0 & 0 & 1 \\ 2 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 2 \\ 1 & 1 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 2 & 0 \\ 1 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}$	$x^3 - 2x - 2$	1.7693...
$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \end{bmatrix}$	$\begin{bmatrix} 1 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 1 \end{bmatrix}$	$\begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \end{bmatrix}$	$x^3 - 2x^2 + x - 1$	1.7548...
$\begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 0 \\ 2 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 2 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 2 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}$	$x^3 - 3x$	1.7321...
$\begin{bmatrix} 1 & 1 & 0 \\ 0 & 0 & 1 \\ 2 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 2 \\ 1 & 0 & 1 \end{bmatrix}$	$\begin{bmatrix} 0 & 2 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \end{bmatrix}$	$x^3 - x^2 - 2$	1.6956…
$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & 1 \\ 2 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 2 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 1 \end{bmatrix}$	$\begin{bmatrix} 1 & 1 & 0 \\ 0 & 0 & 2 \\ 1 & 0 & 0 \end{bmatrix}$	$x^3 - x^2 - 2$	1.6956…[14]
$\begin{bmatrix} 0 & 2 & 0 \\ 0 & 0 & 1 \\ 2 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 2 & 0 \\ 0 & 0 & 2 \\ 1 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 0 & 1 \\ 2 & 0 & 0 \\ 0 & 2 & 0 \end{bmatrix}$	$x^3 - 4$	1.5874…
$\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 2 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 1 & 1 \\ 0 & 0 & 2 \\ 1 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 0 & 2 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}$	$x^3 - x - 2$	1.5214...
$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 1 \end{bmatrix}$	$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 1 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}$	$x^3 - x^2 - 1$	1.4656...
$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 1 & 1 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}$	$x^3 - x - 1$	1.3247...
$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 2 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 2 \\ 1 & 0 & 0 \end{bmatrix}$	$\begin{bmatrix} 0 & 2 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}$	$x^3 - 2$	1.2599...

[14] This is not an error; this system and the one immediately above it are genuinely distinct phrasal patterns, but happen to have identical polynomials and dominant eigenvalues.

Degree 4

Finally, we list the prime systems of degree 4. They are numerous enough that, to save space, we present them in a table, indicating only their polynomials and dominant eigenvalues, omitting the matrices and tree diagrams.

All the prime systems in this class have four orientations, reflecting distinct choices of non-terminal as root, with all four sharing the same polynomial and dominant eigenvalue. However, as we saw with the value 1.6956 … in the degree 3 systems, some genuinely distinct patterns happen to share the same polynomial and eigenvalue. We also find one dominant eigenvalue (the one associated with the nonagon) for distinct systems with distinct polynomials.

Eigenvalue (growth factor)	Polynomial(s)	Notes
1.92756	$x^4-x^3-x^2-x-1$	Endocentric, Pisot
1.92129	$x^4-x^3-x^2-2x+1$	
1.91439	$x^4-x^3-2x^2+x-1$	
1.90517	$x^4-x^3-2x^2+1$	Pisot
1.89932	x^4-2x^2-2x-2	
1.89718	$x^4-2x^3+x^2-x-1$	
1.89329	x^4-2x^2-3x	
1.88721	x^4-3x^2-2	
1.88320	$x^4-2x^3+x^2-2x+1$	
1.87939	$x^4-x^3-3x^2+2x+1$ & x^4-3x^2-x	Nonagon, 2 polynomials
1.87371	x^4-x^3-2x-2	
1.87018	x^4-3x^2-2x+2	
1.86676	x^4-2x^3+x-1	Pisot
1.86371	x^4-x^3-3x	
1.85356	$x^4-x^3-x^2-2$	
1.85163	x^4-x^3-4x+2	
1.84776	x^4-4x^2+2	Octagon
1.83509	x^4-4x-4	
1.82462	$x^4-x^3-2x^2+2x-2$	
1.82105	$x^4-x^3-x^2-2x+2$	
1.81917	$x^4-3x^3+3x^2-x-1$	
1.81712	x^4-6x	
1.80843	x^4-x^2-3x-2	

(*Contd.*)

Eigenvalue (growth factor)	Polynomial(s)	Notes
1.79891	x^4-2x^2-4	
1.79632	x^4-x^2-4x	
1.79431	x^4-x^3-2x-1	
1.79004	$x^4-2x^3+x^2-2$	
1.78537	x^4-2x^2-x-2	
1.74840	x^4-x^3-4	
1.74553	x^4-x^2-3x-1	
1.72775	x^4-4x-2	
1.72534	x^4-x^3-x-2	
1.72208	$x^4-x^3-x^2-x+1$	
1.71667	x^4-2x^3+2x-2	
1.71064	x^4-2x^2-x-1	
1.70211	x^4-3x^2-x+2	
1.69028	$x^4-x^3-2x^2+2x-1$	
1.68377	x^4-2x^2-2x+1	
1.68179	x^4-8	
1.67170	x^4-x^2-3x	
1.66980	$x^4-x^3-x^2+x-2$	
1.65440	x^4-x^3-3x+2	
1.65289	x^4-2x^2-2	
1.64293	x^4-2x-4	
1.60049	x^4-x^2-4	
1.56638	x^4-x^2-x-2	
1.55898	x^4-x^3-2x+1	
1.55377	x^4-2x^2-1	
1.54369	x^4-x^3-2	
1.51288	$x^4-x^3-x^2+x-1$	
1.49453	x^4-2x-2	
1.49022	x^4-2x^2-x+1	
1.44225	x^4-3x	
1.39534	x^4-2x-1	
1.38028	x^4-x^3-1	Pisot
1.35321	x^4-x-2	
1.27202	x^4-x^2-1	
1.22074	x^4-x-1	
1.18921	x^4-2	

18   Science, Mind, and Limits of Understanding

Noam Chomsky

It is a pleasure to be able to take part in this celebration of Juan Uriagereka's outstanding contributions, not only to linguistic theory and practice but also to exploring the deeper and more far-reaching concerns within which these inquiries acquire the much broader significance that has been recognized through the ages in reflections on our fundamental nature.

One of the most profound insights into language and mind, I think, was Descartes's recognition of what we may call "the creative aspect of language use": the ordinary use of language is typically innovative without bounds, appropriate to circumstances but not caused by them – a crucial distinction – and can engender thoughts in others that they recognize they could have expressed themselves. Given the intimate relation of language and thought, these are properties of human thought as well. This insight is the primary basis for Descartes's scientific theory of mind and body. There is no sound reason to question its validity, as far as I am aware. Its implications, if valid, are far-reaching, among them what it suggests about the limits of human understanding, as becomes more clear when we consider the place of these reflections in the development of modern science from the earliest days.

It is important to bear in mind that insofar as it was grounded in these terms, Cartesian dualism was a respectable scientific theory, proven wrong (in ways that are often misunderstood), but that is the common fate of respectable theories.

The background is the so-called "mechanical philosophy" – mechanical science in modern terminology. This doctrine, originating with Galileo and his contemporaries, held that the world is a machine, operating by mechanical principles, much like the remarkable devices that were being constructed by skilled artisans of the day and that stimulated the scientific imagination much as computers do today; devices with gears, levers, and other mechanical components, interacting through direct contact with no mysterious forces relating them. The doctrine held that the entire world is similar: it could in principle be constructed by a skilled artisan, and was in fact created by a super-skilled artisan. The doctrine was intended to replace the resort to "occult properties"

on the part of the neoscholastics: their appeal to mysterious sympathies and antipathies, to forms flitting through the air as the means of perception, the idea that rocks fall and steam rises because they are moving to their natural place, and similar notions that were mocked by the new science.[1]

The mechanical philosophy provided the very criterion for intelligibility in the sciences. Galileo insisted that theories are intelligible, in his words, only if we can "duplicate [their posits] by means of appropriate artificial devices" (Machamer 1998:69). The same conception, which became the reigning orthodoxy, was maintained and developed by the other leading figures of the scientific revolution: Descartes, Leibniz, Huygens, Newton, and others.

Today Descartes is remembered mainly for his philosophical reflections, but he was primarily a working scientist and presumably thought of himself that way, as his contemporaries did. His great achievement, he believed, was to have firmly established the mechanical philosophy, to have shown that the world is indeed a machine, that the phenomena of nature could be accounted for in mechanical terms in the sense of the science of the day. But he discovered phenomena that appeared to escape the reach of mechanical science. Primary among them, for Descartes, was the creative aspect of language use, a capacity unique to humans that cannot be duplicated by machines and does not exist among animals, which in fact were a variety of machines, in his conception.

As a serious and honest scientist, Descartes therefore invoked a new principle to accommodate these non-mechanical phenomena, a kind of creative principle. In the substance philosophy of the day, this was a new substance, *res cogitans*, which stood alongside *res extensa*. This dichotomy constitutes the mind–body theory in its scientific version. Then followed further tasks: to explain how the two substances interact and to devise experimental tests to determine whether some other creature has a mind like ours. These tasks were undertaken by Descartes and his followers, notably Géraud de Cordemoy; and in the domain of language, by the logician-grammarians of Port Royal and the tradition of rational and philosophical grammar that succeeded them, not strictly Cartesian but influenced by Cartesian ideas.

All of this is normal science, and like much normal science, it was soon shown to be incorrect. Newton demonstrated that one of the two substances does not exist: *res extensa*. The properties of matter, Newton showed, escape the bounds of the mechanical philosophy. To account for them, it is necessary to resort to interaction without contact. Not surprisingly, Newton was condemned by the great physicists of the day for invoking the despised occult properties of the neo-scholastics. Newton largely agreed. He regarded action at a distance, in his words, as "so great an absurdity that I believe no Man who has in philosophical matters a competent faculty of thinking can ever fall into it."

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[1] For further discussion and sources, here and below, see Chomsky (2016).

Newton, however, argued that these ideas, though absurd, were not "occult" in the traditional despised sense. Nevertheless, by invoking this absurdity, we concede that we do not understand the phenomena of the material world. To quote one standard scholarly source, "By 'understand' Newton still meant what his critics meant: 'understand in mechanical terms of contact action.'"[2]

It is commonly believed that Newton showed that the world is a machine, following mechanical principles, and that we can therefore dismiss "the ghost in the machine," the mind, with appropriate ridicule. The facts are the opposite: Newton exorcised the machine, leaving the ghost intact. The mind–body problem in its scientific form did indeed vanish as unformulable, because one of its terms, body, does not exist in any intelligible form. Newton knew this very well, and so did his great contemporaries.

John Locke wrote that we remain in "incurable ignorance of what we desire to know" about matter and its effects, and no "science of bodies [that provides true explanations is] within our reach." Nevertheless, he continued, he was "convinced by the judicious Mr. Newton's incomparable book, that it is too bold a presumption to limit God's power, in this point, by my narrow conceptions." Though gravitation of matter to matter is "inconceivable to me," nevertheless, as Newton demonstrated, we must recognize that it is within God's power "to put into bodies, powers and ways of operations, above what can be derived from our idea of body, or can be explained by what we know of matter." And thanks to Newton's work, we know that God "has done so." The properties of the material world are "inconceivable to us," but real nevertheless.[3]

Newton understood the quandary. For the rest of his life, he sought some way to overcome the absurdity, suggesting various possibilities, but not committing himself to any of them because he could not show how they might work and, as he always insisted, he would not "feign hypotheses" beyond what can be experimentally established (Janiak 2008).

Replacing the theological with a cognitive framework, David Hume agreed with these conclusions. In his history of England, Hume describes Newton as "the greatest and rarest genius that ever arose for the ornament and instruction of the species." His most spectacular achievement was that while he "seemed to draw the veil from some of the mysteries of nature, he shewed at the same time the imperfections of the mechanical philosophy; and thereby restored [Nature's] ultimate secrets to that obscurity, in which they ever did and ever will remain" (Hume 1754–1761, VI, LXX).

Modern commentators observe that Einstein's relativity theory provides a local interpretation of gravitational attraction, overcoming the non-locality that

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[2] Letter from Isaac Newton to Richard Bentley, available at www.newtonproject.sussex.ac.uk/view/texts/normalized/THEM00258. See McMullin (1978).

[3] Locke, second reply to Stillingfleet, *Works III*, discussed in Janiak (2008).

was an absurdity to Newton and others. But while the observation is correct, it does not bear on the recognition that the world is unintelligible to us. Such concepts as curved space-time are no less remote than action-at-a-distance from the mechanical philosophy that provided the very criterion of intelligibility and understanding for the great founders of modern science – and that also seems to be basically our commonsense conception of physical reality and the material world.

As the import of Newton's discoveries was gradually assimilated in the sciences, the "absurdity" recognized by Newton and his great contemporaries became scientific common sense. The properties of the natural world are inconceivable to us, but that does not matter. The goals of scientific inquiry were implicitly restricted: from the kind of conceivability that was a criterion for true understanding in early modern science from Galileo through Newton and beyond, to something much more limited: intelligibility of theories about the world. This seems to me a step of considerable significance in the history of human thought and inquiry, more so than is generally recognized, though it has been understood by historians of science.

Friedrich Lange, in his classic nineteenth-century history of materialism, observed that we have

so accustomed ourselves to the abstract notion of forces, or rather to a notion hovering in a mystic obscurity between abstraction and concrete comprehension, that we no longer find any difficulty in making one particle of matter act upon another without immediate contact … through void space without any material link. From such ideas the great mathematicians and physicists of the seventeenth century were far removed. They were all in so far genuine Materialists in the sense of ancient Materialism that they made immediate contact a condition of influence.

This transition over time is "one of the most important turning-points in the whole history of Materialism," he continued, depriving the doctrine of much significance, if any at all. "What Newton held to be so great an absurdity that no philosophic thinker could light upon it, is prized by posterity as Newton's great discovery of the harmony of the universe!" (Lange 1865).

Similar conclusions are commonplace in the history of science. In the mid twentieth century, Alexander Koyré observed that Newton demonstrated that "a purely materialistic pattern of nature is utterly impossible (and a purely materialistic or mechanistic physics, such as that of Lucretius or of Descartes, is utterly impossible, too)"; his mathematical physics required the "admission into the body of science of incomprehensible and inexplicable 'facts' imposed upon us by empiricism," by what is observed and our conclusions from these observations (Koyré 1985:210).

With the disappearance of the scientific concept of body (material, physical, etc.), what happens to the "second substance," *res cogitans*/mind, which

was left untouched by Newton's startling discoveries? A plausible answer was suggested by John Locke, also within the reigning theological framework. He wrote that just as God added to matter such inconceivable properties as gravitational attraction, he might also have "superadded" to matter the capacity of thought (on "Locke's suggestion" and its development through the next century, see Yolton 1984). In the years that followed, Locke's "God" was reinterpreted as "nature," a move that opened the topic to inquiry. That path was pursued extensively in the years that followed, leading to the conclusion that mental processes are properties of certain kinds of organized matter. Restating the fairly common understanding of the time, Charles Darwin, in his early notebooks, wrote that there is no need to regard thought, "a secretion of the brain," as "more wonderful than gravity, a property of matter" – all inconceivable to us, but that is not a fact about the external world; rather, about our cognitive limitations (Darwin 1838, Notebook C 166).

It is of some interest that all of this has been forgotten and is now being rediscovered. Nobel laureate Francis Crick, famous for the discovery of DNA, formulated what he called the "astonishing hypothesis" that our mental and emotional states are "in fact no more than the behavior of a vast assembly of nerve cells and their associated molecules" (Crick 1994). In the philosophical literature, this rediscovery has sometimes been regarded as a radical new idea in the study of mind. To cite one prominent source, the radical new idea is "the bold assertion that mental phenomena are entirely natural and caused by the neurophysiological activities of the brain" (Churchland 1994). In fact, the many proposals of this sort reiterate, in virtually the same words, formulations of centuries ago, after the traditional mind–body problem became unformulable with Newton's demolition of the only coherent notion of body (or physical, material, etc.): for example, eighteenth-century chemist/philosopher Joseph Priestley's conclusion that properties "termed mental" reduce to "the organical structure of the brain" (Passmore 1965), stated in different words by Locke, Hume, Darwin, and many others, and almost inescapable, it would seem, after the collapse of the mechanical philosophy that provided the foundations for early modern science, and its criteria of intelligibility.

The last decade of the twentieth century was designated "the Decade of the Brain." In introducing a collection of essays reviewing its results, neuroscientist Vernon Mountcastle formulated the guiding theme of the volume as the thesis of the new biology that "Things mental, indeed minds, are emergent properties of brains, [though] these emergences are … produced by principles that … we do not yet understand" – again reiterating eighteenth-century insights in virtually the same words (Mountcastle 1998).

The phrase "we do not yet understand," however, should strike a note of caution. We might recall Bertrand Russell's observation in 1927 that chemical laws "cannot at present be reduced to physical laws" (Russell 1927). That was

true, and led eminent scientists, including Nobel laureates, to regard chemistry as no more than a mode of computation that could predict experimental results, but not real science. Soon after Russell wrote, it was discovered that his observation, though correct, was understated. Chemical laws never would be reducible to physical laws, as physics was then understood. After physics underwent radical changes, with the quantum-theoretic revolution, the new physics was unified with a virtually unchanged chemistry, but there was never reduction in the anticipated sense.

There may be some lessons here for neuroscience and philosophy of mind. Contemporary neuroscience is hardly as well established as physics was a century ago. There are what seem to me to be cogent critiques of its foundational assumptions, notably recent work by cognitive neuroscientists C. R. Gallistel and Adam Philip King (Gallistel & King 2009).

The common slogan that study of mind is neuroscience at an abstract level might turn out to be just as misleading as comparable statements about chemistry and physics ninety years ago. Unification may take place, but that might require radical rethinking of the neurosciences, perhaps guided by computational theories of cognitive processes, as Gallistel and King suggest.

The development of chemistry after Newton also has lessons for neuroscience and cognitive science. The eighteenth-century chemist Joseph Black recommended that "chemical affinity be received as a first principle, which we cannot explain any more than Newton could explain gravitation, and let us defer accounting for the laws of affinity, till we have established such a body of doctrine as he has established concerning the laws of gravitation." The course Black outlined is the one that was actually followed as chemistry proceeded to establish a rich body of doctrine. Historian of chemistry Arnold Thackray observes that the "triumphs" of chemistry were "built on no reductionist foundation but rather achieved in isolation from the newly emerging science of physics." Interestingly, Thackray continues, Newton and his followers did attempt to "pursue the thoroughly Newtonian and reductionist task of uncovering the general mathematical laws which govern all chemical behavior" and to develop a principled science of chemical mechanisms based on physics and its concepts of interactions among "the ultimate permanent particles of matter." But the Newtonian program was undercut by Dalton's "astonishingly successful weight-quantification of chemical units," Thackray continues, shifting "the whole area of philosophical debate among chemists from that of chemical *mechanisms* (the *why*? of reaction) to that of chemical *units* (the *what*? and *how much*?)," a theory that "was profoundly antiphysicalist and anti-Newtonian in its rejection of the unity of matter, and its dismissal of short-range forces." Continuing, Thackray writes that "Dalton's ideas were chemically successful. Hence they have enjoyed the homage of history, unlike the philosophically more coherent, if less successful, reductionist schemes of the Newtonians" (Thackray 1970).

Adopting contemporary terminology, we might say that Dalton disregarded the "explanatory gap" between chemistry and physics by ignoring the underlying physics, much as post-Newtonian physicists disregarded the explanatory gap between Newtonian dynamics and the mechanical philosophy by rejecting the latter, and thereby tacitly lowering the goals of science in a highly significant way, as I mentioned.

Contemporary studies of mind are deeply troubled by the "explanatory gap" between the science of mind and neuroscience – in particular, between computational theories of cognition, including language, and neuroscience. I think they would be well-advised to take seriously the history of chemistry. Today's task is to develop a "body of doctrine" to explain what appear to be the critically significant phenomena of language and mind, much as chemists did. It is of course wise to keep the explanatory gap in mind, to seek ultimate unification, and to pursue what seem to be promising steps toward unification, while nevertheless recognizing that, as often in the past, unification may not be reduction, but rather revision of what is regarded as the "fundamental discipline," the reduction basis, the brain sciences in this case.

Locke and Hume, and many less-remembered figures of the day, understood that much of the nature of the world is "inconceivable" to us. There were actually two different kinds of reasons for this. For Locke and Hume, the reasons were primarily epistemological. Hume in particular developed the idea that we can only be confident of immediate impressions, of "appearances." Everything else is a mental construction. In particular, and of crucial significance, that is true of identity through time, problems that trace back to the pre-Socratics: the identity of a river or a tree or most importantly a person as they change through time. These are mental constructions; we cannot know whether they are properties of the world, a metaphysical reality. As Hume put the matter, we must maintain "a modest skepticism to a certain degree, and a fair confession of ignorance in subjects, that exceed all human capacity" – which for Hume includes virtually everything beyond appearances. We must "refrain from disquisitions concerning their real nature and operations." It is the imagination that leads us to believe that we experience external continuing objects, including a mind or self. The imagination, furthermore, is "a kind of magical faculty in the soul, which … is inexplicable by the utmost efforts of human understanding," so Hume argued (for sources and discussion, see Thiel 2011).

A different kind of reason why the nature of the world is inconceivable to us was provided by "the judicious Mr. Newton," who apparently was not interested in the epistemological problems that vexed Locke and Hume. Newton scholar Andrew Janiak concludes that Newton regarded such global skepticism as "irrelevant – he takes the possibility of our knowledge of nature for granted." For Newton, "the primary epistemic questions confronting us are raised by physical theory itself" (Janiak 2008). Locke and Hume, as I mentioned, took

quite seriously the new science-based skepticism that resulted from Newton's demolition of the mechanical philosophy, which had provided the very criterion of intelligibility for the scientific revolution. That is why Hume lauded Newton for having "restored [Nature's] ultimate secrets to that obscurity, in which they ever did and ever will remain."

For these quite different kinds of reasons, the great figures of the scientific revolution and the Enlightenment believed that there are phenomena that fall beyond human understanding. Their reasoning seems to me substantial, and not easily dismissed. But contemporary doctrine is quite different. The conclusions are regarded as a dangerous heresy. They are derided as "the new mysterianism," a term coined by philosopher Owen Flanagan, who defined it as "a postmodern position designed to drive a railroad spike through the heart of scientism." Flanagan is referring specifically to explanation of consciousness, but the same concerns hold of mental processes in general (Flanagan 1992).

The "new mysterianism" is compared today with the "old mysterianism," Cartesian dualism, its fate typically misunderstood. To repeat, Cartesian dualism was a perfectly respectable scientific doctrine, disproven by Newton, who exorcised the machine, leaving the ghost intact, contrary to what is commonly believed.

The "new mysterianism," I believe, is misnamed. It should be called "truism" – at least, for anyone who accepts the major findings of modern biology, which regards humans as part of the organic world. If so, then they will be like all other organisms in having a genetic endowment that enables them to grow and develop to their mature form. By simple logic, the endowment that makes this possible also excludes other paths of development. The endowment that yields scope also establishes limits. What enables us to grow legs and arms, and a mammalian visual system, prevents us from growing wings and having an insect visual system.

All of this is indeed truism, and for non-mystics, the same should be expected to hold for cognitive capacities. We understand this well for other organisms. Thus we are not surprised to discover that rats are unable to run prime number mazes no matter how much training they receive; they simply lack the relevant concept in their cognitive repertoire. By the same token, we are not surprised that humans are incapable of the remarkable navigational feats of ants and bees; we simply lack the cognitive capacities, though we can sometimes duplicate their feats with sophisticated instruments. The truisms extend to higher mental faculties. For such reasons, we should, I think, be prepared to join the distinguished company of Newton, Locke, Hume, and other dedicated mysterians.

For accuracy, we should qualify the concept of "mysteries" by relativizing it to organisms. Thus what is a mystery for rats might not be a mystery for humans, and what is a mystery for humans is instinctive for ants and bees.

Dismissal of mysterianism seems to me one illustration of a widespread form of dualism, a kind of epistemological and methodological dualism, which tacitly adopts the principle that study of mental aspects of the world should proceed in some fundamentally different way from study of what are considered physical aspects of the world, rejecting what are regarded as truisms outside the domain of mental processes. This new dualism seems to me truly pernicious, unlike Cartesian dualism, which was respectable science. The new methodological dualism, in contrast, seems to me to have nothing to recommend it.

Far from bewailing the existence of mysteries-for-humans, we should be extremely grateful for it. With no limits to growth and development, our cognitive capacities would also have no scope. Similarly, if the genetic endowment imposed no constraints on growth and development of an organism it could become only a shapeless amoeboid creature, reflecting accidents of an unanalyzed environment, each quite unlike the next. Classical aesthetic theory recognized the same relation between scope and limits. Without rules, there can be no genuinely creative activity, even when creative work challenges and revises prevailing rules.

Contemporary rejection of mysterianism – that is, truism – is quite widespread. One recent example that has received considerable attention is an interesting and informative book by physicist David Deutsch. He writes that potential progress is "unbounded" as a result of the achievements of the Enlightenment and early modern science, which directed science to the search for best explanations. As philosopher/physicist David Albert expounds his thesis, "with the introduction of that particular habit of concocting and evaluating new hypotheses, there was a sense in which we could do anything. The capacities of a community that has mastered that method to survive, and to learn, and to remake the world according to its inclinations, are (in the long run) literally, mathematically, infinite" (Albert 2011, a review of Deutsch 2011).

The quest for better explanations may well indeed be infinite, but infinite is of course not the same as limitless. English is infinite, but doesn't include Greek. The integers are an infinite set, but do not include the reals. I cannot discern any argument here that addresses the concerns and conclusions of the great mysterians of the scientific revolution and the Enlightenment.

We are left with a serious and challenging scientific inquiry: to determine the innate components of our cognitive nature in language, perception, concept formation, reflection, inference, theory construction, artistic creation, and all other domains of life, including the most ordinary ones. By pursuing this task we may hope to determine the scope and limits of human understanding, while recognizing that some differently structured intelligence might regard human mysteries as simple problems and wonder that we cannot find the answers, much as we can observe the inability of rats to run prime number mazes because of the very design of their cognitive nature.

There is no contradiction in supposing that we might be able to probe the limits of human understanding and try to sharpen the boundary between problems that fall within our cognitive range and mysteries that do not. There are possible experimental inquiries. Another approach would be to take seriously the concerns of the great figures of the early scientific revolution and the Enlightenment: to pay attention to what they found "inconceivable," and particularly their reasons. The "mechanical philosophy" itself has a claim to be an approximation to commonsense understanding of the world, a suggestion that might be clarified by experimental inquiry. Despite much sophisticated commentary, it is also hard to escape the force of Descartes's conviction that free will is "the noblest thing" we have, that "there is nothing we comprehend more evidently and more perfectly" and that "it would be absurd" to doubt something that "we comprehend intimately, and experience within ourselves" merely because it is "by its nature incomprehensible to us," if indeed we do not "have intelligence enough" to understand the workings of mind, as he speculated (letter to Queen Christina of Sweden, 1647; *Principles of Philosophy*. For discussion, see Schmaltz 1996).

Concepts of determinacy and randomness fall within our intellectual grasp. But it might turn out that "free actions of men" cannot be accommodated in these terms, including the creative aspect of language and thought. If so, that might be a matter of cognitive limitations – which would not preclude an intelligible theory of such actions, far as this is from today's scientific understanding.

Honesty should lead us to concede, I think, that we understand little more today about these matters than the Spanish physician-philosopher Juan Huarte did 500 years ago when he distinguished the kind of intelligence humans shared with animals from the higher grade that humans alone possess and is illustrated in the creative use of language, and proceeding beyond that, from the still higher grade illustrated in true artistic and scientific creativity (Huarte 1575).[4] Nor do we even know whether these are questions that lie within the scope of human understanding, or whether they fall among what Hume took to be Nature's ultimate secrets, consigned to "that obscurity in which they ever did and ever will remain."

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[4] For discussion, see Chomsky (1966) and Virués Ortega (2005).

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