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Towards a Biolinguistic Understanding of Grammar

Essays on interfaces

Edited by

Anna Maria Di Sciullo

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Interfaces in a biolinguistic perspective

Anna Maria Di Sciullo
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The purpose of this book is to contribute to the understanding of the points of contact between the Faculty of Language and the external systems, semantic and sensorimotor. The Chapters bring to the fore biolinguistic questions pertaining to the properties of the language design, in the sense of Chomsky (2005), namely the genetic endowment, experience, and factors reducing complexity.

The book is organized in five sections, covering syntax-semantic phenomena, the role of features for interface legibility, the properties of the phonological system, language development and experimental studies.

The Chapters in the first section discuss the properties of the units of computation at the syntax-semantic interface. The second section includes papers on the role of features in syntactic computation and the effect of feature-based derivations on interface legibility. In the third section, the chapters address basic questions on the elemental properties of the phonological system, and their incidence on the emergence of the Faculty of Language in the narrow sense (FLN) (Hauser, Chomsky & Fitch 2002). In the fourth section, two papers on language development and language variation discuss the role of external factors in language development. Results from brain imaging and parsing are reported in the chapters of the last section on experimental studies. These chapters also address questions related to the properties of the interfaces, as well as they discuss the role of the principles reducing complexity.

The theoretical proposals and the discussion of results from experimental studies present genuine contributions to the Biolinguistic program. They contribute to our understanding of the properties of the interfaces derived by the computations of FLN, viewed as an organ of human biology. The chapters add to the usual notion of interfaces, which is generally understood as the connection between the semantic system on the one hand and the sensorimotor system on the other. They raise novel interface questions on how these connections are possible at all. They anchor the formal properties of grammar at the interfaces between language and biology, language and experience, as well as factors reducing complexity.

The following paragraphs present each chapter, point out how they are related to one another, and how taken as a whole they contribute to our understanding of FLN and its interfaces with the external systems.

1. Syntax, semantics

The first section includes contributions from Howard Lasnik, Tim Hunter and Paul Pietroski. The three chapters address issues related to principles regulating the derivations of FLN, as well as more general issues pertaining to the mapping of syntactic expressions onto logical forms. By doing so they raise fundamental questions on the nature of FLN and its interfaces with the semantic system, addressing the central biolinguistic questions on the properties of the genetic endowment of human language. The discussions on the properties of the form of the operations and the derivations on FLN contribute to theoretical biolinguistics. They are briefly presented below.

In 'A surprising consequence of single cycle syntax', Howard Lasnik discusses phenomena that have been dealt with in terms of quantifier lowering, which falls into the class of improper movements. While different accounts are available for the phenomena, Lasnik argues that the single syntax of Lasnik (1972), a precursor of the multiple spell-out syntax (Uriagereka 1999), prevents quantifier lowering rather than allows it. Under this view, quantifier scope is determined cyclically, but as part of the syntactic cycle, not as part of a later LF cycle. The apparent lowered readings of indefinites are argued to follow from the fact that indefinites can be assigned their scopes without QR, via existential closure, as in Reinhart (1997).

In 'Syntactic effects of conjunctivist interpretation' Tim Hunter discusses a possible Universal Grammar constraint on remnant movement: the Just Outside Constraint (JOC). This constraint is a consequence of previous work (Hunter 2010) aiming at the unification of adjunct island effects and freezing effects, as well as the ruling out of all extraction from adjuncts and from moved constituents. The proposal is based on the hypothesis that the language design provides the simplest syntactic structures that can be interpreted in a restrictive theory of semantic composition by the mapping of syntactic structures into neo-Davidsonian logical forms.

In 'Language and conceptual reanalysis', Paul Pietroski argues that natural languages are also used to introduce formally new concepts, and that this is where the real cognitive utility of the human faculty of language (HFL) lies. While Frege introduced logically interesting concepts, such as saturation (functional composition) that let him explore the foundations of arithmetic, and many current theories assume that natural languages are similar in this respect, Pietroski posits that HFL introduces logically boring but psychologically useful concepts that can be combined by means of simple (neo-Davidsonian) operations: restricted forms of conjunction, existential closure, and appeals to a few thematic concepts. The author discusses a range of facts suggesting that lexicalization is a formally creative process in which available concepts of various sorts are used to introduce concepts that are monadic and number-neutral.

The notion of simplicity of syntactic derivations in their mapping onto semantic representations ensures the connection between these papers. This notion plays a central notion in the Minimalist Program as well as in Biolinguistics. While the reduction of the technical apparatus of the grammar is a means of achieving greater explanatory adequacy in Minimalism, the reduction of the formal apparatus defining the operations and the derivation of the FLN may lead to a better understanding of the emergence and the development of language. Interestingly, the papers in this section also lead to posit the question on the properties of the mapping of the syntactic units of the derivation onto their semantic interpretation. Viewed in a biolinguistic perspective, it might be the case that simple mapping could be preferred for reasons of efficiency.

2. Features and interfaces

The second section includes three papers on the role of functional features at the syntax-semantic interface. The first chapter, by Dana Isac, derives Force from the interaction of independently needed functional features. The second chapter, by Christina Christodoulou and Marina Wiltschko, offers an account of the semantics of the subjective marker *na* in Greek by allowing flexible feature valuation. The third chapter, by Atsushi Fujimori, exploits the featural representation of lexical aspect in the analysis of vowel alternations in Japanese verbs.

In 'An exercise in syntactic (de)composition', Dana Isac proposes that Imperative Force is not encoded in the syntax as an atomic syntactic feature, but is instead a derivative notion which results from the semantic composition of more primitive components, which are in turn in a one-to-one correspondence with syntactic features. This leads to the unification of apparently disparate phenomena, such as Clause typing, Focalization and Topicalization, by potentially revealing primitive features that various clauses share with Topic and Focus, that have been shown to be 'composite' in a similar way. This kind of analysis has consequences for the theoretical choice between the assumption that each morpho-syntactic feature corresponds to an independent syntactic head, and the assumption that multiple syntactic features syncretically coexist on one syntactic node.

In 'Function without content. Evidence from Greek subjunctive na' Christina Christodoulou and Martina Wiltschko observe that the subjunctive marker *na* in Greek is used in a variety of seemingly distinct environments, including clauses embedded under future oriented predicates, *realis* and counterfactual conditionals, as well as in main clauses which are used as requests, orders, wishes or desires. The authors aim to develop a unified analysis of *na*. They assume that INFL is intrinsically associated with an unvalued coincidence feature, which must be valued in the course of the derivation. In the absence of substantive morpho-syntactic feature valuation, INFL may be valued by the embedding predicate. It is proposed that *na* spells out an unvalued coincidence feature in INFL in the absence of morpho-syntatic valuation from below. The dependent character of subjunctive *na* derives from INFL's requirement to be valued. Since the unvalued coincidence feature must be valued, it requires external valuation. But there is neither restriction on the category or content of the embedding predicate nor on the positive or negative value of the coincidence feature. This flexibility is claimed to be responsible for the seemingly distinct interpretations associated with *na*.

In 'The patterns of associating sounds with meanings: the case of telicity' Atsushi Fujimori relies on a feature based approach to lexical aspect, in which telicity takes the form of binary features, as discussed in Di Sciullo (2005), and related works. The author addresses the relation between vowel quality and telicity features in Japanese monosyllabic verbs. A verb containing the vowel /e/ or /u/ denotes a telic event while a verb containing the vowel /i/ or /o/ denotes an atelic event. The relation holds between existing verbs and nonce verbs, as shown in two experiments with native speakers. The author establishes some relations with causatives and telicity alternations in other languages (Arabic, Malagasy and Russian) to sketches the beginnings of a typology.

These chapters are related to one another as they assume a feature based derivation and interpretation. They also aim to define grammatical systems where feature economy prevails. Independently needed features combine to check imperative Force according to Isac's proposal. INFL consistently functions as an anchoring category via its intrinsic coincidence feature, while its substantive content varies across constructions. However, while there is a one-to-one mapping between syntactic and semantic features in Isac's account of the featural analysis of Force, there is no one-to-one correspondence between the syntactic contexts and the semantic interpretation in Christodoulou and Wiltschko's analysis of the subjunctive marker *na* in Greek. These papers, while developing a feature checking approach to syntactic derivations provide different view points on the properties of the syntax-semantic interface. Further work is needed to understand these properties and how language variation follows from a featural approach. The last chapter of this section links the feature analysis of lexical aspect to vowel alternations in Japanese as well as in other languages.

The chapters of the second section of this book address the question of the elements of the computational procedure enabling interpretable features to be legible by the interfaces. Feature checking/valuation as a formal property of the computational procedure of FLN opens new biolinguistic questions. One of these questions concerns the role of features versus the role of categories in derivations, and what would their biological correlate be. A biolinguistic approach to the issues related to features and labels may illuminate the debate on either category-free syntax or feature-free derivations.

3. Phonology, syntax

The nature of the relations between phonology and syntax is also a topic of interest in current Biolinguistic research. The chapters in this section take different views. The first chapter, by Charles Reiss, considers phonology on a par with syntax and argues for a theory of phonological typology that relies on feature underspecification. The arguments are based on simplicity and coverage. The second paper, by Bridget B. Samuels, takes the view that syntax emerged when the building blocks of the phonological system were already in place.

In 'Towards a bottom up approach to phonological typology', Charles Reiss presents two arguments that bear on the typological adequacy of current phonological theory. Reiss argues that a model with underspecification could be thought of as simpler than a model without. Underspecification may allow phonological theory to include fewer features than a phonological theory where all the features have to be specified. Furthermore, the author argues that a phonological theory including underspecification should be preferred over a theory that dispenses with this device on the grounds of simplicity. These arguments in favor of underspecification in phonology comply with Chomsky's (2007) bottom-up approach of Minimalism, where a simple theory of UG provides for a greater richness of descriptive power than previously suspected. Furthermore, they are compatible with the biolinguistic program, according to which the reduction of the role of the genetic endowment in the development of an organism, here UG, can ease the study of its development.

The purpose of 'Phonological forms: from ferrets to fingers', is to situate phonology within this emerging picture of the language faculty, the emergence of syntax, and specifically to investigate how much of phonological operations/representations can be explained by properties of general cognition and the sensorimotor system. The author endorses the conception of phonology as a highly abstract, modality independent computational system consisting of a few primitive operations, namely searching, copying, and concatenation, which are shared with narrow syntax and other cognitive domains. Samuels' approach comes from two different angles: from behavioral and physiological studies on animal cognition, and from sign language phonology. The author provides evidence from sign language and from animal cognition that the perception of a discrete phonological signal relies heavily on abilities humans share with other mammalians. These arguments would support the view that the building blocks of the phonological system, features and categories, were present prior to the emergence of syntax.

The chapters of the third section of this book address the question of the simplicity of the phonological system from a biolinguistic perspective. They contribute to the understanding of the nature of human language phonological system, and what elements of the phonological signal would have preceded syntax.

4. Language development

The two chapters of this section aim to contribute to the understanding of language development and variation from a biolinguistic perspective.

In 'Non-native acquisition from a biolinguistic perspective", Calixto Aguero addresses the question of whether the Critical Period Hypothesis (CPH) (Penfield & Roberts 1959; Lenneberg 1967) is or not undermined by the fact that humans may acquire a second language latter on in life. The CPH has been questioned in the field of non-native acquisition. In some cases the L2 speakers' knowledge of the L2 cannot be attributed to their knowledge of the L1, and in the case of typologically very different languages, neither can this knowledge be attributed to the nature of the input of the L2. The implication of these studies is that non-native acquisition must be constrained by UG without the mediation of the L1, contra the CPH. Aguero argues that the effect of the Overt Pronoun Constraint (OPC) in an L2 by speakers whose L1 lacks overt pronouns, that has been claimed to be a central argument against the CPH, actually falls into the set of third-factor principles, which are language independent (Chomsky 2005). He argues that in an architecture of the language faculty in which parametric variation is restricted to certain aspects of the lexicon, it is quite possible to defend the Lenneberg's version of the CPH, once we factor out the effect of language independent principles in constraining knowledge of an L2.

In 'Interface ingredients of dialect design: Bi-*x*, socio-Syntax of development, and the grammar of Cypriot Greek' Kleanthes Grohman and Evelina Leivada focus on the syntax of first language development targeting the child's acquisition of the morpho-syntactic properties of the mother-tongue, here the Cypriot variety of Modern Greek (Cypriot Greek). Assuming, as it is the case in Generative Grammar, that dialects are languages, i.e. a system of abstract rules that govern a speaker's I(nternalized)-language, Greek Cypriot children typically grow up acquiring their native variety, and it is only at the onset of formal schooling, around the ages 5 to 6, that the 'proper' language is being used, largely through instruction. The developmental part of this talk presents some systematic research carried out with a special emphasis on the socio-syntax of development hypothesis applied to the acquisition of clitic placement, drawing from experimental data with typically developing children aged 2 to 7 and children with (specific) language impairment.

Notwithstanding the fact that they address issues related to first language acquisition on the one hand and second language acquisition on the other, these chapters are related in that they both focus on the role of external factors reducing complexity in language development. Aguero's chapter addresses the question whether second language acquisition presents a challenge to the Critical Period Hypothesis. The author argues that this is not the case, showing that revisiting the nature of a grammatical constraint on the second language acquisition of pronouns as being language independent, and thus falling into the set of third-factor principles in the sense of Chomsky (2005), not only allows for a better understanding of the facts, but also maintains the Critical Period Hypothesis. Grohman and Leivada's paper considers the continuum that informs the process of first language acquisition in a dialectal context. The acquisition of clitic placement in Cypriot Greek is approached from the point where language-external factors affect the way language is put to use through choosing one out of a range of gradient syntactic variants that belong to different varieties existing in a continuum.

5. Experimental studies

Brain imaging studies and computer-based experiments on language processing and parsing provide measurable brain and computer-based data bearing on the computational procedure of FLN as well as on the properties of the interfaces with the external systems. Experimental studies provide valuable results for the biolinguistic understanding of the Faculty of Language and its interfaces.

In 'Experimental evidence from sign languages for a phonology-syntax-semantics interface'. Evie Malaia and Ronnie B. Wilbur report results from motion capture experiments and fMRI indicating that sign language provides insights into neurobiology of language. The experiments show that sign languages utilize physical properties of movement to represent event structure at the syntax-semantics-phonology interface, as evident from verb sign production and neural activity during comprehension. Grammaticalization of distinctions in physical/action characteristics for lexical purposes enables learners to use existing visual system capabilities and fine-tune them through experience with signed input, thus permitting rapid and early neural, cognitive, and linguistic development to proceed on schedule, despite the use of the visual modality.

In 'Indeterminacy and coercion effects: minimal representations with pragmatic enrichment' Roberto De Almeida and Levi Riven discuss sentences such as 'John began the book', often said to license an interpretation that includes a predicate such as 'reading', which is 'interpolated' in semantic representation, thus yielding 'John began reading the book'. Several psycholinguistic and neurolinguistic experiments have shown that sentences with aspectual verbs such as 'begin' engender longer reading times. De Almeida and Riven discuss fMRI data suggesting that coercion effects are the products of pragmatic inferences. The authors defend a view of semantic interpretation guided by structural properties of token sentences, with structural markers operating as pragmatic triggers for inferences that occur largely outside the linguistic domain.

In 'Computation with doubling constituents: Pronouns and antecedents in Phase Theory', Sandiway Fong and Jason Ginsburg develop a computational implementation of Binding theory compatible with basic assumptions of the Minimalist/Biolinguistic Program. One of these assumptions is that the operations of the Faculty of Language are reduced to the minimum. Another assumption is that the computational procedure is efficient. Inspired by Chomsky's probe-goal system (2000, 2001) and Kayne's (2002) doubling constituent proposal for pronoun-antecedent coreference relations, Fong and Ginsburg develop a computational implementation for pronoun-antecedent coreference relations and show how the computational implementation can derive the classic asymmetry in distribution between pronouns and anaphors for mono- and bi-clausal sentences, ECM, picture NPs and other constructions.

In 'Concealed reference-set computation: how syntax escapes the parser's clutches' Thomas Graf raises the question whether trans-derivational constraints add to the computational load of syntactic derivations. According to Graf, syntax does not necessarily have to obey interface requirements yet must not violate them, either. He demonstrates that Fewest Steps, which is a transderivational constraint introduced in Chomsky (1995), can be modeled by rational relations. The author argues that some reference-set constraints do not increase the power of the syntactic machinery, which entails that they can be replaced by local constraints. This kind of concealed reference-set computation is allowed to persist in syntax despite opposing interface requirements.

The experimental results assembled in this last section are telling with respect to the properties of the interfaces, and they address the biolinguistic question on the properties of the principles reducing derivational complexity. Motion capture experiments and fMRI data indicate that naturally-evolved sign languages are shown to be perfectly adapted to the human visual system. Psycholinguistic and neuroimaging (fMRI) data support the view that the sentence enrichment occurs beyond linguistic computations per se, at the interface between syntax and pragmatics. Computer-based parsing experiments show that the Last Resort variant of Merge maintains the computational efficiency of the probe-goal system in that it operates precisely at the limit of probe-goal search domains and it does not introduce any additional choice points into the instruction stream. Moreover, it might be the case that certain kinds of concealed reference-set computation, such as Fewest Steps, does increase computational complexity as well as they do not violate interface locality requirements.

Taken as a whole the chapters of this book constitute a unified set. They address interface issues related to the formal properties of the computational procedure, as well as they discuss the role of external factors reducing complexity in language development and parsing. They contribute to our understanding of the notion of interfaces from a biolinguistic perspective.

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PART I

Syntax, semantics

Single cycle syntax and a constraint on quantifier lowering*

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Since May (1977), the ambiguity of sentences with raised quantifiers has been a major concern. There have been many different approaches to the 'lowered' readings of quantifiers. One that is particularly interesting in light of developments in Minimalism is that of Sloan & Uriagereka (1988), who propose that quantifier scope is determined cyclically, as part of the syntactic cycle, an obvious precursor of the multiple spell-out of Uriagereka (1999), itself an immediate precursor of single-cycle syntax. However, it has long been known that 'lowered' readings are often unavailable. Partee (1971) already pointed out that (1) cannot be paraphrased by (2)

1. Nobody is (absolutely) certain to pass the test
2. It is (absolutely) certain that nobody will pass the test

The constraint is not limited to negatives. Lasnik (1999) gives examples with universal quantifiers that also fail to display lowered readings. In fact, lowering seems only to occur with indefinites. I present an account of failure of lowering, attributing it, ironically, to single cycle syntax, in particular its interaction with QR and the ban on 'improper movement'. I then argue that apparent lowered readings of indefinites follow from the fact that indefinites can be assigned their scopes via existential closure, as in Reinhart (1997), hence without QR.

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1. Quantifier lowering: Some history

Quantifier Lowering (QL), the fascinating phenomenon whereby a quantificational expression that has undergone A-movement has its scope interpreted as if it were in a pre-moved position, has been a major topic of investigation at least since May (1977). (1) is May's original example.

(1) Some politician is likely to address John's constituency

May observes that "[(1)] may be taken as asserting either (i) that there is a politician, e.g. Rockefeller, who is likely to address John's constituency, or (ii) that it is likely that there is some politician (or other) who will address John's constituency." (May 1977: 189) May also gives (2).

(2) Many people were thought to have sold IBM shares

This time May gives no explication or paraphrases, but (2) does seem to have both kinds of readings that May indicates for (1). May's final example is (3).

(3) Everyone seems to like Cecil's playing

May again gives no explication. This time the meaning differences, at least with respect to truth conditions, are considerably harder to pin down. I will return to this fact.

May proceeds to provide an account of QL: "... the reason that sentences like [(1), (2), (3)], containing raising predicates, are ambiguous is that they can be associated with two distinct logical forms." (May 1977: 189) One arises from a standard (raising) instance of May's Quantifier Rule (QR):

(4) $[_S$ [some politician]$_\alpha$ $[_S$ α is likely $[_S$ t to address John's constituency]]]]

Another, the QL reading, arises from a lowering instance of QR, as QR "applies freely":

(5) $[_S$ α is likely $[_S$ [some politician]$_\alpha$ $[_S$ t to address John's constituency]]]]

May proposes that "In [(4)] and [(5)] *α* and *t* represent occurrences of the same variable, since they both arise from movement of the same noun phrase; hence they are both bound by this phrase." (May 1977: 192) Then,

> In [(4)], the quantifier *some* has scope wider than the matrix predicate *likely*; it corresponds to the (i) reading of this sentence as described above. In [(5)], on the other hand, the quantifier has scope narrower than *likely*; this logical form corresponds to the (ii) reading above. (May 1977: 192)

Finally, in effect, *α* in (5) can be ignored as it is not an argument position.

May (1985) returns to the phenomenon of QL, discussing (6).

(6) A hippogryph is likely to be apprehended

The explication of the quantifier ambiguity this time is somewhat curious:

> On [one] interpretation, [(6)] can be truthfully uttered without any supposition regarding the existence of hippogryphs. This contrasts with another construal under which it could not be truthfully uttered without this supposition.
> (May 1977: 97–98)

Apparently, the claim is that (6) can be truthfully uttered with a (pre?)supposition of the existence of hippogryphs or without such a presupposition. Is that a scope ambiguity? Is that an ambiguity at all, rather than, say, a vagueness? It's hard to say.

May's (1985) account is very like the (1977) one, just slightly modernized in terminology:

> LF-movements are instances of 'Move *α*,' and thus their application is free, in the sense that derivationally a moved phrase may be adjoined to any S node. In particular, there is nothing to prevent the derivation of [(7b)] alongside [(7a)]; the former is derived by 'raising' the S-Structure matrix subject to the matrix S, the latter by 'lowering' it to the complement S:
>
> [(7)] a. a hippogryph$_2$ [e$_2$ is likely [e$_2$ to be apprehended]]
> b. e$_2$ is likely [a hippogryph$_2$ [e$_2$ to be apprehended]]
>
> It is apparent that the structures in [(7)] represent the relevant ambiguity, at least as far as scope of quantification is concerned. In [(7a)] the quantified phrase stands outside the scope of the matrix predicate *likely*; in [(7b)] it is inside the predicate's scope. (May 1985: 99)

Finally, the matrix e_2 in (7a) is an expletive, while the embedded e_2, being locally Ā-bound by an operator, is a variable.

2. QL: Some alternative treatments

Sauerland and Elbourne (2002) suggest another sort of account of the phenomenon of Quantifier Lowering. Discussing (8)

(8) [An Austrian]$_i$ is likely to t$_i$ win the gold medal.

they propose that

> The analysis of the narrow scope interpretation of [(8)] we argue for is that *an Austrian* undergoes movement from the trace position *t*, but that this movement operation is purely phonological and therefore does not affect interpretation.
> (Sauerland & Elbourne 2002: 286)

This is a PF analogue of the LF movement widely assumed in Principles and Parameters theorizing. LF movement (potentially) affects semantic interpretation, but never phonetic interpretation. The 'purely phonological' movement proposed by Sauerland and Elbourne (potentially) affects phonetic interpretation but never semantic interpretation.

Another kind of account, implicit in much minimalist work and explicit in Hornstein (1995), relies on the copy theory of movement. In Hornstein's specific approach, a lower copy of an A-moved quantifier can be activated and used to determine the scope of that quantifier. For Hornstein, that essentially completes the analysis as he eschews QR, relying instead on A-positions alone for scope. A variant analysis might rely on a lower copy, but have it undergo QR.

Sloan and Uriagereka (1988) suggest another interestingly different account of the phenomenon. Rather than having a lowering operation largely undoing the effects of raising, or a movement with no semantic effect, or activation of a copy left behind by movement, they propose, roughly in the spirit of Lasnik (1972), that quantifier scope is determined cyclically, but as part of the syntactic cycle, not as part of a later LF cycle. This is an obvious precursor of the multiple spell-out of Uriagereka (1999), which shortly led to single-cycle syntax. I will return to this sort of approach and try to show that, contrary to initial appearances, it actually blocks QL, and, further, contrary to usual assumptions, that this is an empirically desirable outcome.

3. The empirical difficulty: QL is much less general than it is expected to be

None of these accounts predicts any limitation on lowered interpretations. Whenever there is a raising construction involving a quantifier, a 'lowered' reading should be possible. But, as first observed by Partee (1971), and as discussed in detail in Lasnik (1998) and Lasnik (1999) among other places, such readings are very often unavailable, as indicated by the standard test of paraphrase by the *it* … [finite clause] alternant. Below, I provide a sampling of examples from those works, as well as some new ones, and some brief discussion. (I use ≠ to indicate that the first example cannot be paraphrased by the second.)

The first example I discuss was first presented by Partee (1971) in a paper concerned with whether transformations 'preserve meaning', that is, with whether a pair of sentences differing only in the application of a particular transformation invariably have the same meaning. Based on several examples, Partee's tentative conclusion is that they do not always. One of her examples is directly relevant to the point at issue here:

(9) a. Nobody is (absolutely) certain to pass the test ≠
b. It is (absolutely) certain that nobody will pass the test (Partee 1971: 18)

Partee's observation is that subject-raising here clearly has an effect on interpretation, assuming that the underlying form of (9a) is much like (9b). That is, (9a) is true of a test that is at least moderately difficult and/or a class that doesn't include any geniuses. (9b), on the other hand is true of an impossibly difficult test. This paradigm clearly illustrates that QL is not available in (9), pretty much the modern analogue of Partee's point.

I presented a variety of additional examples in Lasnik (1998), Lasnik (1999), and Lasnik (2001). Some of them involve negative quantifiers, like Partee's example. Consider (10).

(10) a. No large Mersenne number was proven to be composite ≠
 b. It was proven that no large Mersenne number is composite

(10a) asserts that there is no large Mersenne number (a number of the form 2^n-1) such that that number was proven to be composite (false in fact), while (10b) asserts that there is a proof that no large Mersenne number is composite (wildly false). (11) is very similar to Partee's example. (11a) describes a situation where the problem under discussion is of at least middling difficulty, and the potential problem solvers aren't omniscient. (11b), on the other hand, is a sentence about either an impossible problem or a hopelessly inept group of solvers.

(11) a. No one is certain to solve the problem ≠
 b. It is certain that noone will solve the problem

Failure of QL doesn't just show up with negative quantifiers. In (12), if we have 5 coins, the b. reading (i.e. the lowered one) would be far more plausible. That is, if the coins are fair, (12b) is true (after rounding to the nearest per cent). Yet it is unavailable as a reading for (12a), which has only the wildly improbable reading that each coin is absurdly unbalanced.

(12) a. Every coin is 3% likely to land heads ≠
 b. It is 3% likely that every coin will land heads

There is a possible interfering factor. Boeckx (2001) argues that unlike *likely*, *3% likely* is not a raising predicate. Then the only source for (12a) would be control, and lowering is not expected with a control structure. Boeckx presents (13) as evidence.

(13) *There is 30% likely to be a man in the garden (Boeckx 2001: 541)

If (13) involves a raising predicate, nothing should block the example, given that it is standardly accepted that expletives can raise.[1] In fact, Partee had used exactly

1. But see Boškoviæ (2002) for an argument against this standard assumption.

the same line of reasoning to argue that *certain* in her (9a) is a raising predicate, given the acceptability of (14).

(14) There is certain to be an argument over that.

In fact, a number of my consultants agree with Boeckx's judgment on (13). But not all of them do. Yet even the ones who accept (13) still strongly reject the lowered reading for (12a). Further, there are examples abstractly like (13) that are judged acceptable by many speakers (in fact, nearly all of my consultants). (15a) is one such, and (15b), using the 'idiom chunk' test provides further confirmation.

(15) a. There is quite likely to be an investigation
b. The cat is quite likely to be out of the bag

Significantly, here again we find failure of lowering:

(16) a. Every student is quite likely to pass the exam ≠
b. It is quite likely that every student will pass the exam

That is, (16a) could easily be true while (16b) is false. The same obtains with a negative quantifier.

(17) a. Few students are quite likely to pass the exam
b. It is quite likely that few students will pass the exam

Additional examples with the same cluster of properties are as follows:

(18) a. There is fairly certain to be a storm today
b. The shit is fairly certain to hit the fan (when this news breaks)

(19) a. Everyone is fairly certain to pass the exam ≠
b. It is fairly certain that everyone will pass the exam

(20) a. Noone is fairly certain to pass the exam ≠
b. It is fairly certain that noone will pass the exam

Another phenomenon plausibly described as failure of 'lowering' comes from an observation about scope that Zubizarreta (1982) in a footnote attributes to Chomsky, and which is discussed again by Chomsky (1995). It is a standard, even if ill understood, observation that clausal negation in English (and, I expect, many other languages) can scope over a universal quantifier in subject position. Chomsky gives the following example, in which a very salient reading is the one where not everyone is there.

(21) (it seems that) everyone isn't there yet (Chomsky 1995: 327)

(22) is a very familiar example, an ancient proverb used by Shakespeare in *The Merchant of Venice*.

(22) All that glisters [glitters] is not gold

The intended meaning, obviously, is that not everything that glitters is gold (rather than the outlandish "if something glitters it isn't gold"). Note, in passing, that whatever this universal-negative scope inversion is, it does not seem to be a straightforward reconstruction (or Q-lowering) effect, as it is limited to universal quantifiers. (23) doesn't have a reading like "Not many people are there yet".

(23) Many people aren't there yet

Nor does (24) have a reading like "No students are there yet".

(24) Some student isn't there yet

With this much as background, we can now see the additional kind of QL failure I alluded to above. Chomsky's observation was that raising examples, like (25), with a raised universal quantifier don't allow readings with the quantifier inside the scope of clausal negation in the lower clause.

(25) Everyone seems [*t* not to be there yet]

Chomsky (1995: 327) reasons as follows: "Negation can have wide scope over the Q in [(21)]... but not in [(25)]", concluding that "...reconstruction in the A-chain does not take place, so it appears." This kind of example might still be compatible with May style literal lowering (as, in fact, Chomsky suggests), but would still be incompatible with purely PF raising or with activation of a lower copy in a movement chain (a point that Chomsky also makes).

It must be acknowledged that Hornstein (1995), in effect, rejects Chomsky's line of reasoning, claiming that the missing reading of (25) has nothing to do with any kind of failure of lowering because "There is an empirical flaw in this argument."[2] (Hornstein 1995: 239) The purported empirical flaw is centered around Hornstein's examples (26a) and (26b).

(26) a. John would prefer for everyone not to leave
b. John wanted very much for everyone not to leave

Hornstein states that

> These sentences do not allow neg to scope over *everyone* either. But if these do not allow this, we do not expect [Chomsky's example "Every one seems not to have left"] to allow it either. Thus, even if lowering is permitted, the ambiguity Chomsky and Lasnik (1991) point to is not expected. (Hornstein 1995: 239)

2. Hornstein attributes the argument that he criticizes to Chomsky & Lasnik (1991). To the best of my knowledge, there is no such publication, and this reference does not appear in Hornstein's bibliography. Chomsky (1991) does appear, but there is no such argument in that work. I will assume that Hornstein actually intends to refer to Chomsky (1995), the only place I am aware of where Chomsky discusses this phenomenon.

It is not clear what Hornstein takes to be involved here, but, possibly, he is assuming that the scope inversion of (21) arises only in finite clauses. While this might be true for some speakers, it certainly isn't true for all. As a matter of fact, Chomsky in his discussion provided an infinitival version of the complement in (21), claiming that it does allow the same scope inversion found in the finite one. His example is (27).

(27) I expected [everyone not to be there yet]

Many of my consultants agree with Chomsky's judgment on (27) while still agreeing with his judgment on (25). Thus, at least for those speakers, the key property of (25) cannot be that the complement is infinitival. The best guess at present is then Chomsky's: A-movement is crucial.

Kayne (1985) first discussed a very interesting verb-particle construction, later analyzed by Johnson (1991) in terms relevant to the present discussion. Johnson provides an insightful account of examples like (28) involving overt raising of the ECM subject *John*.

(28) Mary made John out to he a fool

Both Kayne and Johnson convincingly treat (28) as an infinitival counterpart of (29).

(29) Mary made out that John is a fool

The question now arises as to the behavior of ECM constructions with respect to universal-negation interaction. The *make-out* ECM construction behaves exactly as now expected. When the word order makes it clear that a universal ECM subject has raised, that subject cannot be interpreted inside the scope of negation in the complement clause, as seen in (30).

(30) The mathematician made every even number out not to be the sum of two primes

The only reading is the highly implausible one where the mathematician was engaged in the futile activity of trying to falsely convince someone that no even number is the sum of two primes (and not the far more plausible one where she is merely trying to convince someone that Goldbach's conjecture is false). Thus, even with strong pragmatic bias towards wide scope for the negation, it still isn't available, consistent with the raising analysis combined with Chomsky's claim. The alternative word order for (30), with *every even number* unraised, does allow narrow scope for the universal, for many of those speakers who accept the word order in the first place:

(31) The mathematician made out every even number not to be the sum of two primes

For them (31) has the plausible reading missing in (30).

Examples abstractly like Chomsky's (27) show the same pattern. As mentioned already, many speakers allow the scope inversion in examples with that structure:

(32) I believe everyone not to have arrived yet

(33) I proved every Mersenne number not to be prime

Those same informants (along with everyone else, I believe) disallow narrow scope for the universal when it undergoes passive/raising to subject position:

(34) Everyone is believed not to have arrived yet

(35) Every Mersenne number was proved not to be prime

In (35), there is strong pragmatic bias towards narrow scope, but it is still not available. Only the wildly false wide scope reading exists.

4. Towards a theory?

Before actually attempting a theory, we must see what we want a theory of. There seem to be at least two possibilities:

(36) QL exists, as it would under any of the accounts alluded to earlier. Then we need an account of why it is so often blocked (basically, with anything except indefinites).

or

(37) QL doesn't exist. Then we need an account of why it doesn't. And we also need an account of why it looks like it does with indefinites.

In some of my earlier work referenced above, I proposed that A-movement, unlike Ā-movement, doesn't leave a trace/copy. Then classic literal lowering would leave the Q with no variable to bind. And copy activation would obviously be impossible, there being no copy. As for the indefinites, I noted two things. First, in the standard examples, even though there is the strong feeling of two readings, it is very difficult to separate them in terms of truth conditions. On the other hand, in the negative and universal examples, where lowering fails, the two sets of truth conditions for each example are relatively easy to distinguish.

Second, I appealed (vaguely) to known special properties of indefinites that might provide two readings without an actual scope difference – for example, the specific/non-specific ambiguity discussed in detail by Fodor and Sag (1982). Taking this second point first, Wurmbrand and Bobaljik (1999) justifiably observe that while the Fodor and Sag approach to indefinites might allow us to explain apparent *wider* than expected scope (exactly what it was designed to do), it can't possibly tell us anything about *narrower* than expected scope (i.e. 'lowered' readings).

Returning to the first point, there are some examples in the literature that are intended to highlight the semantic difference between lowered and non-lowered readings. One famous example is due to Fox (1999):

(38) Someone from New York is very likely *t* to win the lottery

Fox explicates the situation as follows.

> One interpretation results when the quantifier takes scope in the final landing site. For the sentence to be true under this interpretation, there must be a person from New York who is very likely to win the lottery (e.g. a person who bought enough tickets to make winning a likely outcome). Under the second interpretation, in which the quantifier has scope in the position of *t*, the truth conditions are much less demanding; they merely require that there be enough ticket buyers from New York to make it likely that the city would yield a winner. (Fox 1999: 160)

As is so often the case, the discussion suggests that one of the readings entails the other. That also seemed to be true in May's discussion of his hippogryph example, (6) above. I will put that equivocation aside. Instead, consider strengthening the situation in Fox's example, changing likelihood to certainty:

(39) Someone from New York is certain t to win the lottery

Now imagine that a particular New Yorker bought *all* the tickets. Or, alternatively, imagine that only New Yorkers bought tickets. (39) is a good description of either situation, parallel to what was seen with the Fox example. And, as in that example, it is tempting to implement the second reading via lowering, with *someone from New York* below *certain* at LF. But now imagine the exact same pair of situations concerning ticket purchasers (and the speaker's knowledge thereof). And suppose the drawing has taken place, but the winner has not yet been announced. Suppose the speaker were to utter (40).

(40) Someone from New York won the lottery

It seems to me that (40) could be an accurate and felicitous report of *either* situation, just as in the case of Fox's (38) or my modification in (39). Recall that for (38) and (39), the standard story about the situation where most/all of the tickets were bought by New Yorkers has *someone* lowering to a position below *likely/certain* (or else a low copy being activated). But (40) is a completely transparent extensional context. If the 'lowered reading' is to be instantiated by lowering of *someone*, what operator does that expression lower below?

Another phenomenon often claimed to implicate syntactic lowering of some sort is 'trapping', where a bound pronoun in the matrix precludes a lowered reading. May (1985) presented an early example:

(41) No agent$_i$ was believed by his$_i$ superior to be a spy for the other side

May observes that (41) cannot be paraphrased by (42), concluding that lowering is syntactic; the lowered reading here would result in failure of binding of the attempted bound variable pronoun.

(42) *It was believed by his$_i$ superior that no agent$_i$ was a spy for the other side

There are, however, two interfering factors here: Negatives don't lower in the first place, as discussed above. Even controlling for that, what can we really conclude from the fact that a particular sentence cannot be paraphrased by an ungrammatical sentence (one violating weak crossover)?

(43) a. Some agent$_i$ was believed by his$_i$ superior to be a spy for the other side ≠
b. *It was believed by his$_i$ superior that some agent$_i$ was a spy for the other side

Hornstein (1995) gives a similar example:

(44) Someone$_i$ seemed to his$_i$ boss to be reviewing every report (∀ cannot scope over ∃)

The same point is again relevant: What can we conclude from the fact that a certain paraphrase is itself ungrammatical? Thus, one of the most promising (and most influential) potential tests for lowering is generally unavailable. However, Fox (1999) has a paradigm that possibly evades this problem:

(45) a. [A student of David$_1$'s] seems to him$_1$ to be at the party
b. [A student of his$_1$] seems to David$_1$ to be at the party

Fox claims that in (45a), there is no lowered reading (i.e. where the surface subject takes scope under *seem*). In (45b), on the other hand, the reading is reported to exist. The point is that in the former example, but not the latter, lowering of the subject would put *David* in the c-command domain of *him*, thus triggering a Condition C violation. And in this instance, a paraphrase might potentially be as in (46).

(46) It seems to David$_1$ that a student of his$_1$ is at the party

The logic of the argument seems exactly correct, but I have to confess that I have no clear judgments. I am willing to believe that Fox is right, but I just can't tell. I am even less sure that (45a) contrasts with (47), where the pronoun is embedded in a larger NP, in the predicted way (i.e. with the lowered reading available in the latter, since *his* would not c-command out of *his colleague*).

(47) [A student of David_1's] seems to [his_1 colleague] to be at the party

Another widely reported argument for lowering involves potential scope ambiguities. May (1977) presents the following examples and associated judgments:

(48) Some politician is likely [t to address every rally in John's district] (∀ can scope over ∃)

(49) Some politician promised [PRO to address every rally in John's district] (∀ cannot scope over ∃)

Aoun and Li (1993) present a very similar pair:

(50) Someone seems [*t* to love everyone] (∀ can scope over ∃)

(51) Someone wants [PRO to kiss everyone] (∀ cannot scope over ∃)

Only in (50) is reconstruction expected, since only in that example was there raising. The assumptions, fairly common ones articulated by May (1977), are that scope is clause bound and that, subject to this, quantifiers freely interchange in scope. It actually does not seem to me entirely clear that the first assumption is correct. That is, it is not clear to me that ∀ can scope over ∃ even in a simple example like (52).

(52) Someone loves everyone

Further, to the extent that scope inversion is possible with (52) and (50), it is not clear that it is impossible with (51). This is another issue that I will put aside here, accepting the standard judgments at face value.

Note that for the issue at hand, it does not suffice to show that ∀ can scope over ∃. Rather, it must also be true that *seem* scopes over both of them. I am willing to believe that that is true, but again I am not certain. The following example is relevant:

(53) Two women seem to each other to be expected to dance with every senator (Lebeaux 1998: 3)

The idea is that raising of the predicate *seem* (instead of lowering of the subject) couldn't explain why there is no lowered reading in (53). (May (1985) had already made exactly the same point about (41)). As I observed above, there is an interfering factor in that example, but the point carries over to the modified version in (53).) *Two women* must be high (to license *each other*). ∀ cannot scope over *Two women*. Thus, one should conclude that in (49) also, the scope of ∀ is limited to the embedded clause, and hence that the scope of ∀ is the lower clause. Of course, the classic test for lowering once again cannot really be run. If paraphrase by *It* … S is the test (and it is the only one standardly offered) definitely lowering fails:

(54) *It seems to each other that two women are expected to dance with every senator

But the devil is in the *. It is not merely that (53) cannot be paraphrased as (54). *Nothing* can be paraphrased as (54), since (54) is ungrammatical, a difficulty we have seen before.

For the remainder of this discussion, I will put aside the difficulties I have noted for establishing lowering, and provisionally adopt the standard view, that the phenomenon of lowering does exist. The question then will be how to block lowering in general, but to allow it in the very few circumstances where it is does seem to exist.

5. A new approach (one excluding lowering in general, but allowing genuine low scope in limited circumstances)

Recall the Sloan & Uriagereka (1988) approach to lowering phenomena, one that fits particularly neatly into single cycle syntax. And suppose, in accord with almost all approaches except that of Hornstein, that scope is generally achieved via QR, where QR is an Ā raising operation. Then, to get embedded scope, QR would have to operate on the embedded cycle. Consider the derivation of Partee's example (9a), repeated as (55).

(55) Nobody is (absolutely) certain to pass the test

QR on the embedded clausal cycle would yield something like.

(56) [$_{\text{IP}}$ nobody [$_{\text{IP}}$ *t* to pass the test]]

But then subsequent raising to matrix subject position would constitute an instance of 'improper movement' from Ā-position (adjoined to lower IP) to A-position (Spec of matrix IP):

(57) [$_{\text{IP}}$ __ is certain [$_{\text{IP}}$ nobody [$_{\text{IP}}$ *t* to pass the test]]]

Matrix scope would cause no such problem. Its derivation would involve perfectly standard A-movement (raising) from A-position to A-position, followed by Ā-movement (QR):

(58) [$_{\text{IP}}$ nobody [$_{\text{IP}}$ *t* is certain [$_{\text{IP}}$ *t* to pass the test]]]

But what of the low readings of indefinites in raising constructions (assuming they exist)? For these we can rely on a special property of indefinites (that Mamoru Saito reminded me of): that they are, or can be, variables rather than quantifiers, an idea developed by Heim (1982). These variables are then provided with binders by existential closure, with no movement at all involved (in particular, no QR, so no danger of improper movement). Following Reinhart (1997) among others, I would take existential closure to be available in all clausal domains, not just the matrix. If closure is introduced in the lower clause in the examples at issue (the standard QL cases), we get low scope. And no constraint on improper movement would prevent subsequent A-movement of the indefinite up to subject position of the higher clause (though the raising would be semantically vacuous, rather in the spirit of Sauerland and Elbourne (2002), though without their technology). An alternative derivation would have subject raising to subject position, then closure in the higher clause. This gives high scope.

The May, Lebeaux, and Hornstein type of examples with high binding and no possibility of low scope fall out as well, as low scope implicates low closure. But then the high pronoun or variable could not be in the scope of the introduced existential.

The remaining task (possibly a big one): Find a principled theory of improper movement that would be effective here. Many traditional theories ban at least some instances of improper movement outright, either directly, as in Chomsky (1973), or indirectly (via constraints on the ultimate output of derivations involving improper movement), as in May (1979) or Chomsky (1981). Any of these would have the desired effect of excluding the derivations leading to lowered interpretations of quantifiers (other than indefinites, which, as discussed above, have another route for low interpretations). What is less clear is whether they can be stated in a way consistent with minimalist assumptions.

There is another class of approaches that potentially allow certain instances of improper movement. These are worth thinking about because a number of promising accounts of *tough*-movement involve improper movement, among them Hornstein (2001), Hartman (2008), and, in effect, Brody (1993). Richards (1998), Richards (2001) excludes improper movement by his theory of the interaction between PF and strong features:

(59) a. PF must receive unambiguous instructions about which copy in a chain to pronounce.
b. A strong feature instructs PF to pronounce the copy in a chain with which it is in a feature-checking relation.

Richards argues that in a typical configuration resulting from improper movement, there will be at least two strong feature positions in the chain, one driving the Ā-movement, another driving the final A-movement, resulting in a PF crash. Notice, though, that there is a potential way of repairing the violation. Chomsky (1991) indicates that the only legitimate LF objects are operator-variable pairs and uniform chains (those chains all of whose members are heads, or A-positions, or Ā-positions). He then proposes that members of chains can potentially be deleted (but, by economy, only to turn an illegitimate object into a legitimate one). Consider, then, a chain of the form A-Ā-A. This is not a legitimate object, but deleting the Ā link will turn it into a uniform A-chain. Interestingly, though, this arguably would still not allow the low readings of quantifiers blocked above by an outright ban on improper movement. This is so as the deleted trace would actually be the quantifier in its low scope position.[3] Fukui (1993) also offers an account of improper movement that is adaptable to the position adopted here. Fukui suggests that chain formation fails if the attempted chain is non-uniform. For Fukui, the prohibition is explicitly derivational, but it could be reconstrued as representational, as in Chomsky (1991). If so, the above remarks would be relevant here as well.

Note that either of these accounts has the capability of permitting 'improper' derivations for *tough*-movement. The typical *tough* construction would involve A-Ā-A; the intermediate Ā-trace could then be deleted rendering the chain legitimate. It is significant that under this kind of approach to improper movement in *tough* constructions, most instances of low readings of quantifiers would still be banned, since it is exactly the intermediate copy that is crucial for low readings, but that intermediate copy must be deleted. This prediction is clearly correct, as shown by (60), pointed out by Postal (1974), and (61).

(60) Few girls would be difficult for Jim to talk to

(61) Every problem is rather easy to solve

(61), for instance, clearly cannot be paraphrased by "It is rather easy to solve every problem". So far so good. However, the scope possibilities of *tough* sentences are actually even more limited than those of raising sentences. Even indefinites can't have low scope in *tough* constructions, unlike the situation with raising. Postal (1974) observed this for (62), which, as Postal points out, isn't paraphrasable as "It will be easy for me to find some girls".

(62) Some girls will be easy for me to find

3. Whether this result actually still obtains within single cycle syntax is unclear, as it might be that scope has already been determined before the relevant trace is deleted. However, under that circumstance, it is plausible to assume that the deletion would violate recoverability.

Earlier, Postal (1971) had worried about a somewhat similar problem and proposed a constraint on *tough*-movement barring indefinites from undergoing that transformation. Lasnik & Fiengo (1974) used this phenomenon as part of their argument against a movement analysis of *tough* constructions, and for base generation of the subject in its surface position. The argument, still a pretty good one, carries over to the issue at hand here: If the *tough* subject didn't originate in the lower clause, there is no reason to expect a low reading when that subject is an indefinite (or other quantifier). At the moment, I can't think of a good way to block existential closure in a *tough* complement, which would allow low readings of indefinites if *tough*-movement exists, so I will have to leave the absence of these readings in this unsettled state.

6. Concluding remarks

As might have been expected, single cycle syntax turned out to have important potential consequences for quantifier lowering. Perhaps contrary to expectations, though, on reasonable assumptions about improper movement, single cycle syntax actually *prevents* quantifier lowering rather than *allows* it, and, again perhaps contrary to expectations, this turned out to be an empirically desirable result. Obviously, much further investigation of improper movement (and of *tough*-movement) is called for. I hope that this small study will be a spur to such investigation.

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A constraint on remnant movement*

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The aim of this paper is to assess the empirical fit of a constraint on remnant movement that is derived as a consequence of a certain reformulation of the mechanisms underlying syntactic movement. The constraint arises from the similarity between remnant movement configurations, on the one hand, and configurations of the sort that produce "freezing effects" on the other; the reformulated system disallows the latter, and imposes a condition on the former that appears quite restrictive. I show here, however, that a large portion of the uses of remnant movement in the literature work within the bounds predicted by this unusual constraint, including analyses of data concerning VP-fronting, German "incomplete category fronting", verb-second, and SOV and VSO word orders.

1. Introduction

The aim of this paper is to begin to assess the empirical fit of a constraint on remnant movement that is derived as a consequence of the system proposed by Hunter (2010), the main focus of which was a unification of adjunct island effects and freezing effects. As well as ruling out all extraction from adjuncts and from moved constituents, the constraint proposed in this previous work has the effect of imposing a relatively strict limitation on remnant movement configurations, because of their similarity to freezing configurations. The compatibility of this limitation with the various ways in which remnant movement has been used in the literature has not yet been explored in detail.

The rest of the paper is organised as follows. In Section 2 I briefly introduce remnant movement and discuss the derived constraint on it, the "Just Outside Constraint" (JOC). In Section 3 I discuss the empirical fit of the JOC with one of the original, and canonical, uses of remnant movement, namely in analyses of German "incomplete category fronting" phenomena; these analyses turn out to be

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by and large consistent with the constraint, but there are exceptions, which I present in Section 4. I then turn to some less canonical uses of remnant movement: a collection of proposals which, very broadly speaking, use remnant movement to produce certain word orders that traditionally were thought to require syntactic machinery that (arguably) is best avoided in minimalist grounds (e.g. head movement, covert movement, underlying head-final word order). The idea in these works is essentially that since remnant movement is just a combination of "good old-fashioned" overt phrasal movement steps, we should prefer a theory that renders this more elaborate machinery redundant by using remnant movement to emulate its effects. In particular, these proposals address covert movement (Section 5), head movement and SVO/SOV/VSO word orders (Section 6), and verb-second word order (Section 7). I summarise and draw some tentative conclusions in Section 8.

The analyses that I will be reviewing form a relatively disparate group: they are unified only by their use of remnant movement, and do not necessarily share all the same framing assumptions. The reader should therefore be aware that certain basic assumptions underlying the analyses being discussed will necessarily change from one section of this paper to the next. For example, some of the works discussed assume that OV is the underlying pre-movement word-order in languages such as Japanese and German, but certain proposals discussed in Section 5 and Section 6 assume universal VO underlying order (following Kayne (1994)); and in Section 3 I review some analyses of German data that adopt a relatively traditional approach to verb-second word order, involving head movement to the C position, whereas a distinct analysis of verb-second is discussed in Section 7. This is a consequence of the fact that the topic being investigated is not a particularly obvious natural class of linguistic data (e.g. verb-second sentences, SOV sentences), but rather a *tool* from the syntactician's toolbox which has been applied in a number of varied contexts.

2. Remnant movement and the JOC

There are two distinct configurations that can arise when one constituent moves out of another constituent that also moves: I will call these the *freezing configuration* and the *remnant movement configuration*. What distinguishes a remnant movement configuration from a freezing configuration is the relative height of the two movements' target positions; see Figure 1. In each case some constituent α moves, and a subconstituent β moves out of α. In freezing configurations, the final position of α is below that of β; by cyclicity/extension this means that movement of the entire constituent α occurs first. In "remnant movement" configurations, the final position of β is below that of α; by cyclicity/extension this means that movement of the subconstituent β occurs first (followed by the movement of the remnant α with a trace of β inside it).

The freezing configuration is often taken to be disallowed, following Wexler & Culicover (1981), giving rise to a range of island-like effects (for review see Corver 2005). For example, subject island effects such as the contrast in (1) can be construed as instances of freezing effects because of the fact that their surface position in specifier of TP is not their base position.[1] The prohibition on extraction from NPs that have undergone "heavy NP shift", as shown in (2), is another canonical example. (This involves rightward movement of the larger constituent α, rather than leftward movement as illustrated in Figure 1.)

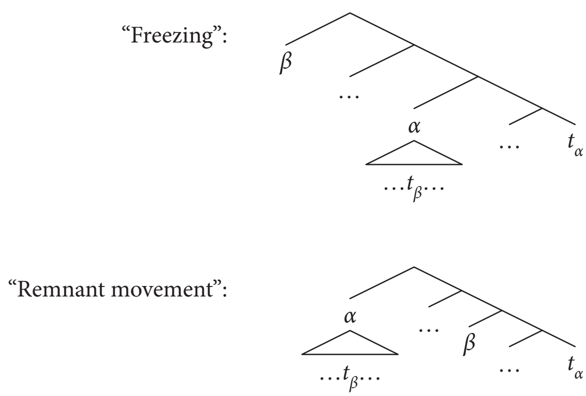


Figure 1. Schematic diagrams of freezing and remnant movement configurations

(1) a. Who$_\beta$ did you buy [a picture of t_β]?
b. *Who$_\beta$ was [a picture of t_β]$_\alpha$ bought t_α (by you)?

(2) a. Who$_\beta$ did you send [a big heavy picture of t_β] to London?
b. *Who$_\beta$ did you send t_α to London [a big heavy picture of t_β]$_\alpha$?

The traditional intuition here is that when the larger constituent α – the subject in (1), or the heavy NP in (2) – is moved, it becomes "frozen" and so subsequent extraction from it is disallowed.

Remnant movement configurations are the reverse of freezing configurations in the sense that extraction *from within* the larger constituent α happens first,

1. Whether subject island effects can be *entirely* reduced to freezing effects is a matter of some debate (Stepanov 2001, 2007; Jurka 2010), but is of no relevance to the concerns of this paper.

followed by subsequent movement of the "remnant" α, which is intuitively "incomplete". A relatively straightforward example in English is the fronting of a VP out of which a subject has moved.[2]

(3) a. [Arrested t_β by the police]$_\alpha$, [John]$_\beta$ was t_α
b. [Seem t_β to be tall]$_\alpha$, [John]$_\beta$ does t_α

Note that here movement of the extracted subconstituent β (in each case in (3), 'John') targets a position *below* that of the larger constituent α out of which it moves, and therefore derivationally precedes it. Hence these are instances of remnant movement, rather than illicit extraction from frozen constituents.

Hunter (2010) imposes a constraint on movement that rules out freezing configurations; and, since remnant movement shares the basic property of involving "movement out of a mover", the large majority of imaginable remnant movement configurations are ruled out as well. But when the details are carefully considered, a limited degree of remnant movement is predicted to be possible. While I can not provide here the full explanation of *how* this conclusion is reached, it turns out that remnant movement is constrained according to the statement in (4).

(4) The "Just Outside" Constraint (JOC)
Remnant movement is permitted only if the base position of the remnant is in the same maximal projection as the target position of the extracted subconstituent.[3]

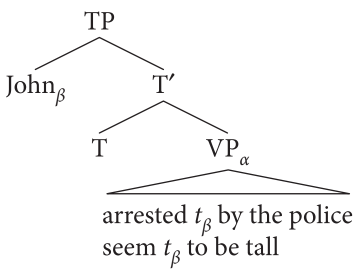
With respect to the diagrams in Figure 1, this means that t_α (the base position of the remnant) and β (the target position of the extracted subconstituent) must be in the same maximal projection. Intuitively, while it is the fact that β moves to a position outside (the still-to-be-moved) α that characterises the remnant movement configuration, the JOC requires that β moves "only just outside" α. The JOC seems to be a rather severe limitation, but it turns out to permit a good portion of the cases where remnant movement is used in the literature – though certainly not all, as will be discussed below.

2. If external arguments originate VP-internally, then *any* instance of VP-fronting will involve remnant movement, but for simplicity I use clearer cases of passivisation and raising.

3. Note that, on this usage, being *in* a maximal projection is not the same as being *dominated by* a maximal projection: a constituent will, in general, be dominated by many different maximal projections, but it is only "in" one maximal projection, in the relevant sense. To be in a particular maximal projection XP, in the relevant sense, is to be a complement of XP, or a specifier of XP; or, roughly, adjoined to XP, although there are some subtleties here resulting from the novel treatment of adjunction in Hunter (2010) that we can put aside for most of this paper.

As a first example, consider the VP-fronting examples from before in (3). The relevant positions for the JOC are (i) the target position of the movement of the subconstituent 'John', namely specifier of TP, and (ii) the base position of the remnant VP, namely complement of TP. Since these are within the same maximal projection (namely TP), these examples satisfy the JOC and are therefore predicted to be grammatical, as we would hope. The relevant facts are illustrated in (5), which shows the point in the derivation immediately *before* the second of the two relevant movements: the subconstituent 'John' has been moved, but the remnant VP has not. Hence we see clearly that the target position of the former and the base position of the latter are in the same maximal projection, as required.

(5)



Note that the JOC does not impose any restriction on how deeply embedded inside the larger constituent α the subconstituent β originates; nor does it impose any restriction on how far the larger constituent α moves. All that matters is that the target position of β and the base position of α be sufficiently close (specifically, within the same maximal projection).

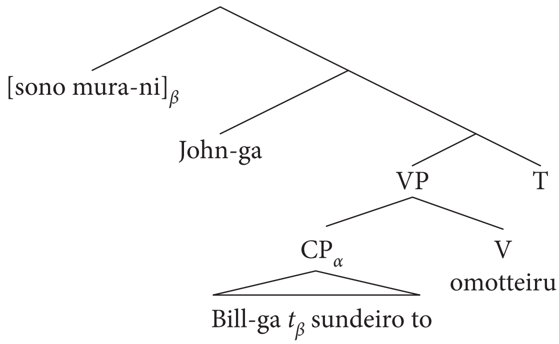
If the subconstituent β ('John') had moved to a position outside the TP projection in (5), then remnant movement of α (the VP) would have been disallowed by the JOC. An example of remnant movement in Japanese that exemplifies this sort of illicit configuration is given in (6).

(6) *[*Bill-ga* t_β *sundeiro* *to*]$_\alpha$ [*sono* *mura-ni*]$_\beta$ *John-ga* t_α *omotteiru*
Bill live that that village in John think
John thinks that Bill lives in that village (Takano 2000: 143)

Again, it is useful to consider the structure immediately *before* movement of the remnant α applies. This will be approximately as given in (7); this is the structure of the acceptable sentence in (8) (Akira Omaki p.c.) where only movement of β, and not the remnant movement of α, has taken place.[4]

4. For now I assume that head-final order is "base-generated", not derived by movement.

(7)



(8)

[*sono*	*mura-ni*]$_\beta$	*John-ga*	[*Bill-ga*	t_β	*sundeiro*	*to*]$_\alpha$	*omotteiru*
that	village in	John	Bill		live	that	think

John thinks that Bill lives in that village

On the assumption that the subject 'John-ga' is in a specifier of T, the constituent β 'sono mura-ni' must have moved at least into the projection of T. This violates the requirement that its target position be in the same maximal projection (VP) as the base position of α – ruling out the remnant movement of α in (6).

In the case of these two illustrative examples, the predictions of the JOC appear to be correct: the acceptable (3) is allowed, and the unacceptable (6) is disallowed. The open question that the rest of this paper addresses is to what extent the uses of remnant movement in the literature conform to the JOC. Before turning to this question in detail, however, it is useful to make a few brief comments on the JOC that will bear on the the kinds of ways we might respond to finding analyses in the literature that are inconsistent with it.

First, the significance of maximal projections as the relevant measure of locality stems from an underlying assumption that these are interpretive cycles. Hunter (2010) develops a theory of the syntax-semantics interface based around a restrictive theory of neo-Davidsonian semantic composition[5] (Parsons 1990; Schein 1993; Pietroski 2005), with particular attention paid to the differing ways in which arguments and adjuncts contribute to event-based logical forms (following intuitions from Hornstein & Nunes (2008)). In this setting, it makes sense to take each maximal projection to be an interpretive cycle, since each maximal projection corresponds to one phrase which other

5. Most fundamentally, this theory is restrictive in that it predicts only conjunctive meanings for adjectives and adverbs (e.g. a 'red ball' is something that is both red *and* a ball). It also dovetails with the idea that thematic relations are determined by structural relations (Baker 1988; Hale & Keyser 1993), and restricts the way in which the resulting predicates are combined (i.e. they are necessarily conjoined). See Hunter (2010:§1.6) for an overview.

things can be arguments of or be adjoined to – at least, if we are relatively conservative about the number of functional projections we posit, as Hunter (2010) is. But the more a clause is decomposed into a large number of fine-grained functional projections, the less reasonable this assumption of one-to-one correspondence becomes: if we go down this route, then taking an interpretive cycle to be something along the lines of an extended projection (Grimshaw 2005) would appear to be a more appropriate basis for the underlying conception of semantic composition.

The importance of this for now is that the constraint stated in (4) should be understood as the conjunction of the two statements in (9).

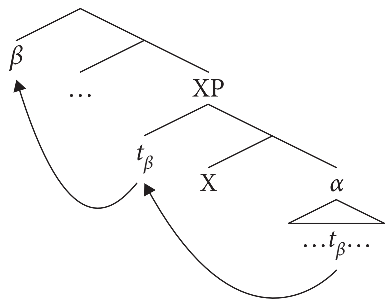
(9) a. Remnant movement is permitted only if the base position of the remnant is in the same interpretive cycle as the target position of the extracted subconstituent.
b. Interpretive cycles are (all and only) maximal projections.

The constraint in (9a), for *some* specification of what counts as an interpretive cycle, is an inevitable consequence of the restriction imposed by Hunter (2010) to enforce adjunct island effects and freezing effects. The choice of interpretive cycles stated in (9b) is the one made in Hunter (2010), but other alternatives may be worth considering.[6] To the extent that the JOC as stated in (4) turns out to make incorrect predictions, the relevant counterexamples constitute evidence that can inform subsequent revisions of (9b). Any adjustment to (9b) will of course require some modifications to the theory of cyclic interpretation proposed in Hunter (2010), but the details of that theory (although unfortunately beyond the scope of this paper) make some conceivable adjustments more plausible (i.e. less likely to require particularly drastic modifications) than others: modifying the system to work with extended projections as the interpretive cycles, for example, is relatively feasible; taking only clauses, for example, as the interpretive cycles is less so. Accordingly, when we find an instance of remnant movement that violates the JOC as stated in (4), it will be of little comfort to note that the violation could be avoided by adjusting (9b) to take clauses as interpretive cycles, for example, but it will be promising to note that it could be avoided by taking extended projections as interpretive cycles.

6. Adjustments to (9b) will also have some effect on the prohibitions against movement out of adjoined constituents and moved constituents: for example, movement out of an adjunct to a position in the same interpretive cycle as the adjunct will be permitted. (When maximal projections are the interpretive cycles, this is a very strict limitation that covers seemingly all the empirically necessary cases.) I leave this issue aside for the purposes of this paper.

Second, there is a question left open by the statement of the JOC in (4) and the brief discussion of it in Hunter (2010): what if β moves first to a position within the same maximal projection as the base position of the remnant α, and then moves further to a position outside this maximal projection? The relevant pattern immediately before the movement of the remnant α is illustrated in (10).

(10)



If β moved only to its intermediate position, within XP, then remnant movement of α would be permitted, just as it was in (5). And if β moved directly to its final position outside XP, then remnant movement of α would be disallowed, just as it was in (7). The question of whether or not the configuration in (10) is allowed depends on whether it is the *first* landing site[7] of β that is relevant, or the *final* landing site of β. We can therefore identify two variants of the JOC, a weak version and a strong version, as given in (11) and (12) respectively.

(11) The JOC (weak version)
Remnant movement is permitted only if the base position of the remnant is in the same maximal projection as the first (remnant-external) landing site of the extracted subconstituent.

(12) The JOC (strong version)
Remnant movement is permitted only if the base position of the remnant is in the same maximal projection as the final landing site of the extracted subconstituent.

Put differently, the choice between the weak and strong versions is the choice of whether the intermediate landing site of β in the XP projection "rescues" movement of α in the configuration in (10) or not: (10) is permitted by the weak JOC, but not by the strong JOC. Importantly, the choice between the weak and strong versions is independent of the principles of the rest of the system in Hunter (2010)

7. More precisely, the first landing site of β that is not contained in α. Movements of β that are wholly inside α are not relevant.

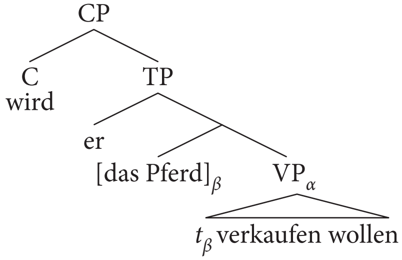
which derive freezing effects from adjunct island effects: deriving freezing effects in this way will necessarily also impose at least the weak JOC, but the strong version does not follow automatically, and it is not immediately obvious which is the more "natural" choice. These distinct possibilities were not noticed in the earlier work, but below I will present evidence that the strong JOC is probably untenable. In much of what follows, however, I will simply refer to "the JOC" because in many contexts the distinction between the two versions is not relevant.

3. Early motivation: German "incomplete category fronting"

Early motivation for remnant movement came from analyses of "incomplete category fronting" in German where a non-constituent appears to have been fronted (den Besten & Webelhuth 1990), as in (13).

(13) [t_β *Verkaufen wollen*]$_\alpha$ *wird er* [*das Pferd*]$_\beta$ t_α
sell want will he the horse
He will want to sell the horse (De Kuthy & Meurers 1998)

Here the object has moved out of the head-final VP 'das Pferd verkaufen wollen', before the VP is fronted. In order for the JOC to permit this movement, we require that the final position of the object 'das Pferd' is not outside the TP. This seems likely to be true, on the assumption that 'wird' is in the verb-second C head position. Specifically, the structure immediately before the fronting of the VP will be roughly as in (14).[8]

(14)


It is similarly possible to leave behind a constituent more deeply embedded in the VP, such as a complement of the object as in (15).

8. If 'das Pferd' is adjoined to VP, rather than in a specifier position of T, this also does not cause any problems: the way such "stranded" adjuncts are treated in the system from which the JOC emerges is essentially to consider them a part of the next maximal projection up. See Hunter (2010) for details.

(15)

[*Ein*	*Buch*	t_β	*schreiben*]$_\alpha$	*will*	*niemand*	[*darüber*]$_\beta$	t_α
a	book		write	want	no one	about that	

No one wants to write a book about that (De Kuthy & Meurers 1998)

Again, for such movement to not violate the JOC, we require that the moved PP 'darüber' not be outside the TP; and again, this seems reasonable since 'will' is in the verb-second C head position here.

The complement of an object can also be left behind, as in (15), in cases where only the object itself is fronted, as shown in (16). We can derive this as long as 'über Syntax' is not outside the VP, which seems safe to assume.

(16)

[*Ein*	*Buch*	t_β]$_\alpha$	*hat*	*Hans*	*sich*	[*über*	*Syntax*]$_\beta$ t_α	*ausgeliehen*
a	book		has	Hans	himself	about	syntax	borrowed

Hans borrowed a book about syntax (De Kuthy & Meurers 1998)

In other cases, the remnant VP consists of only the verb itself:

(17)

[t_β *Gelesen*]$_\alpha$	*hat*	[*das*	*Buch*]$_\beta$	*keiner*	t_α
read	has	the	book	no one	

No one read the book (Takano 2000: 147)

Having fronted a remnant VP, the JOC requires that 'das Buch' is not outside the TP, which seems correct. (Takano assumes it is adjoined to TP.)

Note that in (13), (15) and (16), the position in which β surfaces is immediately adjacent to t_α. That these should be close to each other is exactly what the JOC requires. (In (17) they are not immediately adjacent, but are still close enough, as just discussed.) It is also precisely this closeness that gives these examples the initial puzzling appearance of having fronted a "nonconstituent" or an "incomplete category": when β and t_α are separated, as in (17) for example, the fact that β has moved out of α is relatively clear. Intuitively, remnant movement analyses that posit movement of β out of α "just so that" α can be moved without bringing along β will generally satisfy the JOC, because such an analysis will tend to move β only just out of α, as illustrated in (14), for example.

3.1 The JOC and Müller's UD

Müller (1998) proposes Unambiguous Domination (UD) as a constraint on remnant movement: essentially, this says that remnant movement is allowed if and only if the movement of α and the movement of β are different sorts of movement (perhaps they check different features). Many of the contrasts that motivate this constraint also fit reasonably well with the JOC. For example, Müller (2002: 226) writes that "middle field-external remnant wh-movement is impossible if the antecedent of the unbound trace has also undergone wh-movement, and possible if it has undergone another type of movement, e.g. scrambling", on the basis of the following contrast:

(18) a. *[*Was für ein Buch* t_β]$_\alpha$ *fragst du dich* [*über wen*]$_\beta$ *du* t_α
what for a book ask you REFL about whom you
lesen sollst?
read should
What kind of book do you wonder about whom to read?
(Müller 2002: 226)

b. [*Was für ein Buch* t_β]$_\alpha$ *hast du* [*über die*
what for a book have you about the
Liebe]$_\beta$ t_α *gelesen ?*
love read
What kind of book about love did you read? (Müller 2002: 226)

But one could also suppose that the relevant difference here is not the *kind* of movement that β undergoes, but the *length* of this movement: in the bad case β has moved all the way to SpecCP, but in the good case it has moved only to somewhere high in VP, and the latter is close enough to be permitted by the JOC.

Hinterhölzl (2006: 24) gives an example of remnant movement which is predicted to be grammatical by Müller's UD constraint, because the two movement steps are of different kinds (wh-movement vs. topicalisation), but which nonetheless is ungrammatical (importantly, worse than the "mild subjacency-like violation" in the latter non-remnant example).

(19) a. *[*daß Fritz* t_β *liebt*]$_\alpha$ *weiß ich nicht* [*wen*]$_\beta$ *er* t_α *gesagt hat*
that Fritz loves know I not whom he said has
I don't know who he said that Fritz loves (Hinterhölzl 2006: 24)

b. ??[*daß Fritz Peter liebt*]$_\alpha$ *weiß ich nicht wer* t_α *gesagt hat*
that Fritz Peter loves know I not who said has
I don't know who has said that Fritz loves Peter (Hinterhölzl 2006: 24)

The JOC correctly predicts the (extra) ungrammaticality of this remnant movement configuration: the fronted remnant is the complement of the embedded VP, so the target position of 'wen' would need to be within this VP, which it is not.

4. Apparent counterexamples: The VP/TP domain

While the JOC fares relatively well for many "incomplete category fronting" examples as discussed above, it is violated by the acceptable sentence in (20).

(20) [*Ein Buch* t_β]$_\alpha$ *hat* [*darüber*]$_\beta$ *keiner* t_α *gelesen*
a book has about that no one read
No one read a book about that (Hinterhölzl 2002: 130)

Here the remnant originates in object position, but 'darüber' has moved to a position to the left of the subject 'keiner'. Assuming the subject is in the TP projection, then 'darüber' must be at least that high as well, and therefore outside the VP projection in which the remnant object originates. Notice the crucial difference between this example and (17): in (17) the extracted subconstituent β has also moved to the left of the subject and presumably into the TP projection, but the fronted remnant was a VP and therefore originated in the TP projection. In (20) the fronted remnant is not the entire VP but just the object DP, and so the JOC imposes a stricter requirement on how high the extracted subconstituent β can move.

It appears then that in (20) we have licit movement into the TP projection that is, according to the JOC, "too high". Recall that one degree of freedom that is potentially available is adopting a more nuanced theory of interpretive cycles, which would entail replacing the reference to maximal projections in the JOC with some other chosen domain. One way to accommodate the problematic (20), then, would be to suppose that the combination of a T head with its complement VP does not trigger a fresh interpretive cycle in the way that the combination of a V head with a complement or specifier does. This would be consistent with the idea that it is roughly *extended* projections that are relevant, rather than simply maximal projections; where, following Grimshaw (2005), an extended projection consists of the projection of one lexical head (e.g. VP), plus any number of functional projections (e.g. TP) stacked immediately on top of it.

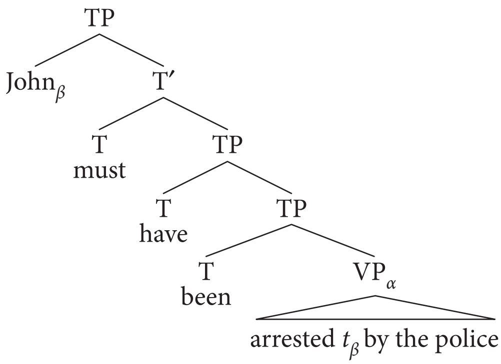
Supposing that T heads do not introduce a new domain of the relevant sort would also accommodate a variant of the earlier English VP-fronting examples that appears to be problematic for the JOC. On the assumption that modals and auxiliaries all head their own projections, the JOC as stated will disallow the VP-fronting in (21).[9]

(21) [Arrested t_β by the police]$_\alpha$, [John]$_\beta$ must have been t_α

The reason for this is that the base position of the fronted VP will be the complement of the lowest auxiliary, 'be(en)'. The position to which the subject has moved, however, will be outside the projection of 'be(en)'; it will be in the projection of some higher auxiliary/tense head, as shown in (22). This should not be allowed.

9. Thanks to Juan Uriagereka for pointing out this example.

(22)



Under standard assumptions about endocentricity and selection, the syntactic structure in (22) lets us account for the ordering of auxiliaries and modals that we observe ('have' selects 'be', etc.), so the idea that every auxiliary projects a phrase is well-motivated. The most reasonable response therefore seems to be to reject the simple hypothesis of a one-to-one correspondence between maximal projections and interpretive cycles, and suppose that T heads merely extend the interpretive cycle that precedes them; on this assumption the structure in (22) would all be part of the same cycle, and no JOC violation would occur. Although the semantic details are beyond the scope of this paper, note that on at least one simple account of tense in (neo-)Davidsonian semantics, tense heads are plausibly analysed as contributing a simple event predicate (e.g. $\lambda e.\mathbf{past}(e)$) that is applied to the same event variable that VP-internal arguments and modifiers apply to.[10] I leave for future work the question of whether this idea grounded in semantics can be integrated meaningfully with Grimshaw's structurally-oriented notion of extended projection.

5. Negative preposing (Kayne 1998)

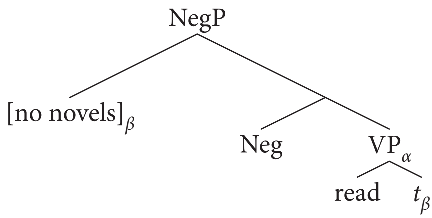
As part of a larger project to emulate the effects of covert movement using only overt movement, Kayne (1998) introduces a "negative phrase preposing" analysis of sentences like (23). On this analysis, 'no novels' is moved leftward out of the VP, followed by remnant movement of the VP. The position to which 'no novels'

10. For the sort of thing I have in mind here, see the account of quantification in Hunter (2010), where semantic composition of a T head and a VP complement is significantly different from that of a verb and its arguments; although no modifications are made there to the interpretive cycle, in the relevant sense.

moves is specifier of NegP, and while Kayne is not completely explicit about this, it is consistent with his analysis that NegP is immediately above VP. In this case this instance of remnant movement obeys the derived restriction: the base position of the remnant VP and the target position of the remnant-creating movement are both in the NegP projection.

(23) John [reads t_β]$_\alpha$ [no novels]$_\beta$ t_α

(24)



In order to account for the kind of scope ambiguities that are otherwise often thought to arise from different covert movements, Kayne proposes that the fronted remnant VP sometimes contains more than just the verb itself. This variation does not conflict with the derived constraint on remnant movement. The relevant example is (25); Kayne proposes that the "narrow scope negation" reading is derived as in (25a), with the embedded clause essentially treated analogously to (23), and that the "wide scope negation" reading is derived as in (25b).

(25) I will force you to marry no one
   a. I will force you to [marry t_β]$_\alpha$ [no one]$_\beta$ t_α
   b. I will [force you to marry t_β]$_\alpha$ [no one]$_\beta$ t_α

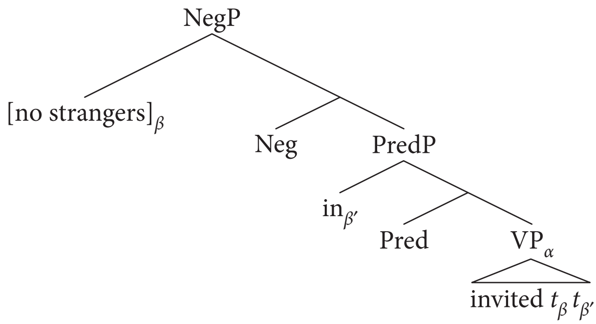
The two derivations differ in how deeply 'no one' (β) is embedded inside the VP that is eventually moved (α) . This difference is not relevant to the constraint under discussion: all that matters is that the position to which 'no one' moves is sufficiently close to the base position of the VP that is eventually moved. In (25a) 'no one' moves to the specifier position of a NegP in the embedded clause, and it is the embedded clause VP that is fronted; in (25b) 'no one' moves to the specifier position of a NegP in the matrix clause, and it is the matrix VP that is fronted. In each case 'no one' moves, in effect, "just far enough" for it to not be included in the fronted VP, however big this VP is, and so in each case the JOC is satisfied.

Assuming this to be correct, any VP-internal constituents that surface to the right of the negative DP must also be moved out of the VP before this remnant movement occurs. Thus (26) requires movement of a "double remnant": both 'no strangers' and 'in' are moved out of the VP before it moves.

(26) John [invited t_β $t_{\beta'}$]$_\alpha$ [no strangers]$_\beta$ [in]$_{\beta'}$ t_α

This sort of situation puts more stress on the JOC: both 'no strangers' and 'in' must move to positions not outside the projection above VP, whatever that is. Kayne assumes that in such cases there is a PredP in between NegP and VP, and that 'in' raises to the specifier of PredP and 'no strangers' raises to the specifier of NegP as in (23). The latter movement, however, now violates the JOC, since the specifier of NegP is no longer in the same maximal projection as the base position of the VP, as shown in (27).

(27)

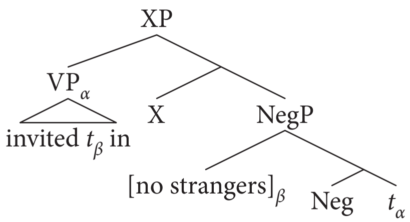


Like those discussed in Section 4, this violation would plausibly be avoided if we take the relevant domains to be extended projections (since NegP and PredP here are presumably both functional projections). But let us ask also whether this apparent counterexample could be reanalysed in a way that is consistent with even the stronger, unmodified JOC based on simple maximal projections. There are at least two options that are worth considering.

First, one could attempt to reanalyse the data in a manner that maintains the basic pattern of movements illustrated in (26) but departs from Kayne's assumptions about the exact landing sites. This will necessarily involve 'no strangers' and 'in' moving to specifiers of or adjuncts to a single maximal projection, namely the one immediately above VP, whatever that is. Of course this is incompatible with the larger program of Kayne's research, where each maximal projection can contain at most one left-attached phrase (a specifier, or equivalently for him, an adjunct) (Kayne 1994). Very generally, this assumption forces Kayne to postulate a relatively large number of functional heads, since he requires a separate functional head to host each leftward movement; and this sort of result is not a good fit for the JOC as it stands, because it requires a certain closeness that is measured in terms of maximal projections. So while there is certainly a tension between the JOC and the Kaynian framework, one can easily imagine an analysis which is analogous to that in (27) in the basic pattern of movements but which departs from the assumption that requires distinct functional heads for each landing site. In Section 7 we will see examples of "double remnant" movement where this is not assumed, which makes it possible for the JOC to be satisfied.

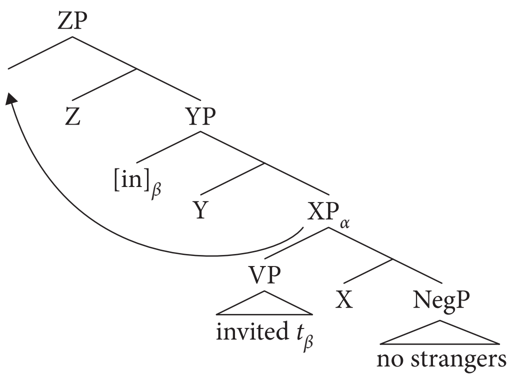
Second, one could maintain Kayne's assumption of one specifier/adjunct per projection and derive the appropriate word order via a more complex pattern of movement operations than (27).[11] In effect the idea is to first apply "normal" negative phrase preposing, analogous to that illustrated in (24), leaving 'invited' and 'in' together for now. The result is shown in (28).

(28)



This is what Kayne suggests for a straightforward example such as (23), and is consistent with the JOC. In order to derive the word order of (26), we must now somehow separate the particle 'in' and leave it in a sentence-final position. This can be achieved by extracting 'in' and then fronting the entire XP constituent in (28), as shown in (29).

(29)



This second remnant movement (the remnant being XP, out of which 'in' has moved) also satisfies the JOC, since both the relevant sites are inside the YP projection. So the JOC can be made consistent with the assumption that there can be only one specifier/adjunct per projection in such double remnant cases if we accept a more elaborate sequence of movements than Kayne's original suggestion in (27).

Besides these complications raised by movement of "double remnants", Kayne's proposal also provides reason to believe that the strong version of the JOC

11. Thanks to Bob Frank for pointing out this possibility.

is in fact too strong, and that only the weak one can be maintained. The analysis of (23) uses remnant movement for a relatively "neutral" sentence, in contrast to the marked sentences involving VP-fronting and scrambling seen earlier. It therefore makes available the possibility of further moving the extracted subconstituent β. While Kayne is not explicit about the position of subjects, it seems reasonable to assume that the derivation of (30) will begin by building the same structure as (24), with the underlying object 'no novels' subsequently moved to the surface subject position.

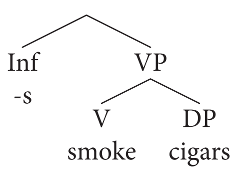
(30) No novels were read (by John)

We therefore have an instance of the pattern shown in (10): the *first* position outside the VP to which 'no novels' moves is inside the next maximal projection (i.e. NegP), but the *final* position to which it moves is further away. But since 'read' surfaces in its normal position in the acceptable (30), the leftward movement of the remnant VP is still allowed; this would not be permitted by the strong JOC. While certainly dependent on a number of other assumptions, this is exactly the kind of evidence that is required to argue for abandoning the strong version of the JOC and maintaining only the weak version.

6. SVO, SOV and VSO word order

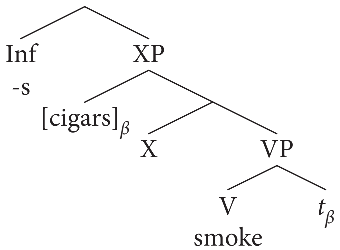
Another motivation for a similar configuration involving remnant VP movement is explored by Koopman & Szabolcsi (2000) and Jayaseelan (2010). The central idea is to give an account of how verbs combine with their inflections that (i) does not involve head movement and (ii) is consistent with the assumption from Kayne (1994) and others that heads uniformly precede their complements. Given the structure in (31), how can the final string 'smokes cigars' be derived if not (as often assumed) via head movement?

(31)



Koopman & Szabolcsi (2000) and Jayaseelan (2010) both adopt the idea that the verb 'smoke' ends up in a position immediately to the left of the inflection '-s' via *phrasal movement* of the VP to (say) the specifier position of Inf. But this requires that the verb 'smoke' be the rightmost pronounced element in the VP. This is not the case in (31), and so before the Inf head is merged, the VP-internal material that is to the right of the verb is "evacuated" to a position just above VP.

(32)



From this point, movement of the remnant VP produces the desired English word order. This is permitted by the JOC since the base position of the remnant VP is in the same maximal projection as the target position of 'cigars'; the leftward movement of the object is (at least structurally) analogous to Kayne's "negative phrase preposing", with XP corresponding to NegP.

(33) [smoke t_β]$_\alpha$ -s [cigars]$_\beta$ t_α

Part of the attraction of this account is that this derivation of head-initial English word order differs from the derivation of head-final word order only in the size of the constituent that undergoes the second movement step: instead of moving the remnant VP, a head-final language like Japanese moves the XP constituent that hosts the object in its new position.

(34) [[cigars]$_\beta$ smoke t_β]$_\alpha$ -s t_α

Note that this is not an instance of remnant movement at all: the object does not move out of the constituent α that is subsequently fronted. The advantage of the account is that the need to move the object out of the position to the immediate right of the verb is constant across the two language types, given the phrasal-movement analysis of how the verb picks up its inflection. Moving the object somewhere to the left of the verb is necessary to derive the correct word order in the case of head-final languages, but if inflection were picked up via head movement there would be no independent explanation for this movement, or why it occurs in some languages (e.g. Japanese) and not others (e.g. English).

Koopman & Szabolcsi (2000) analyse certain Hungarian constructions that appear to involve a mixture of head-initial and head-final orders via, in effect, a mixture of the two configurations in (33) and (34). The relevant difference from one clause to the next is therefore whether the VP pied-pipes additional structure or not when it moves to pick up inflection, rather than a difference between the presence of leftward movement over the verb in head-final cases and its absence in head-initial cases. Koopman & Szabolcsi also derive non-trivial restrictions on how head-initial and head-final configurations can and cannot be mixed in a single sentence.

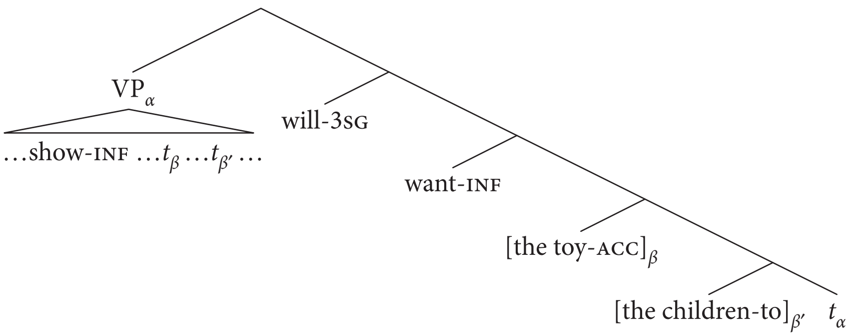
As in the case of Kayne's negative preposing, this approach to word order will put extra strain on the JOC when there are two distinct parts of VP that need to be moved leftwards across the verb, if we follow Kayne (1994) in assuming that each projection can host at most one left-attached constituent. For the Hungarian sentence in (35), Koopman & Szabolcsi (2000) give the abstract structure in (36), where both the direct object and indirect object have been moved leftwards out of the VP, analogous to the movements of 'no strangers' and 'in' in (27).

(35)	*Mutogatni*	*fogja*	*akarni*	*a*	*játékot*	*a*	*gyerekeknek*
	show-INF	will-3SG	want-INF	the	toy-ACC	the	children-to

(He/She) will want to show the toy to the children

(Koopman & Szabolcsi 2000: 23)

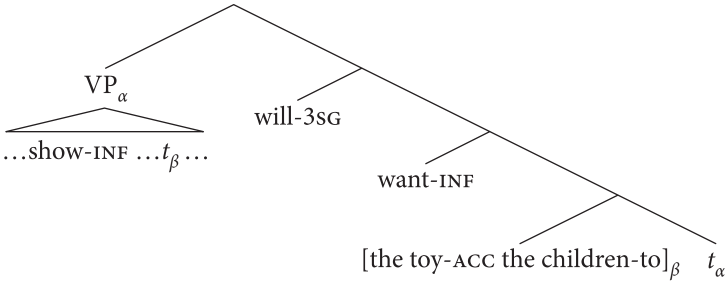
(36)



Since both the direct object and the indirect object have been extracted from the fronted remnant VP, the JOC requires that they both have moved to positions inside the maximal projection immediately above the base position of VP, which is not possible under the Kaynian assumptions that Koopman & Szabolcsi adopt. Again, we could work around this "double remnant" problem by moving the VP in two distinct steps, just as (28) and (29) provide a way around the problematic pattern in (27). But in this case there is also an independently motivated revision of (36) that has been suggested, which avoids the problem altogether.

Jayaseelan (2010: 303) notes that Koopman & Szabolcsi must stipulate that extraction of these VP-internal elements must happen in an order that respects their linear order inside the VP – the rightmost element must be extracted first, to the lowest position, and the leftmost element last, to the highest position – such that their VP-internal linear order is preserved. This stipulation would be eliminated if it were assumed that everything to the right of the verb were a single constituent (say, the complement of the verb). Then the order of the elements in (36) would be straightforwardly maintained, and furthermore we would no longer be forming a "double remnant", because only a single constituent is extracted from VP. The general structure of the suggestion is illustrated in (37).

(37)



Here the JOC requires only that the single constituent 'the toy-ACC the children-to' has moved to a position within the same maximal projection as t_α, which does not conflict with Kaynian assumptions about phrase structure.

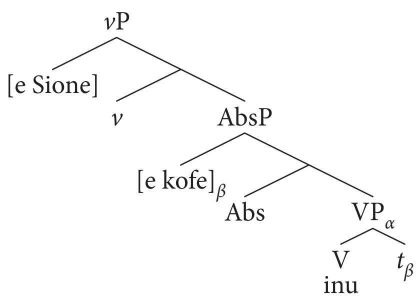
Finally, I note briefly that in addition to these reanalyses of the difference between SVO and SOV word orders in terms of remnant movement, there have also been recent proposals to derive VSO word order from underlying SVO structures via remnant movement (Massam 2000; Lee 2000; Rackowski & Travis 2000). The idea, as in the previous analyses discussed in this section, is to remove overt material (in particular, the object) from the VP and then front it.

A simple illustrative example is given in (38). Massam (2000) derives this VSO sentence from an underlying SVO structure by first raising the object 'e kofe' out of the VP and then fronting the VP to a position higher than the subject.[12] Specifically, the object moves to a specifier of AbsP for absolutive case, as shown in (39).

(38)	*Ne*	*[inu*	$t_\beta]_\alpha$	*e*	*Sione*	*[e*	*kofe]*$_\beta$ t_α
	PAST	drank		ERG	Sione	ABS	coffee

Sione drank the coffee

(39)



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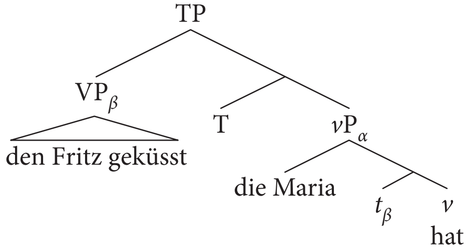
12. Massam calls the position to which the VP moves the specifier of Infl, such that this movement is parallel to the movement of subjects to specifier of Infl, but these details are not important for our purposes.

This is an instance of a now-familiar pattern: the movement of the object goes "just far enough" to permit phrasal movement that appears to only move the verb itself, and is therefore consistent with the JOC. The proposal has much in common with that of Koopman & Szabolcsi (2000), in that it reanalyses what at first glance appears to be movement of only a verb as movement of a remnant VP, eliminating the need for head movement.

7. Verb-second as remnant *v*P-fronting

Müller (2004) presents a novel analysis of verb-second (V2) word order involving remnant movement. Under the conventional account of V2 phenomena, the phrase that appears pre-verbally is fronted (or "topicalised") to a specifier of CP, and the finite verb undergoes head movement to C. Müller, following ideas from Nilsen (2002), proposes that instead of arising via a combination of two distinct movement operations, V2 constructions are produced by fronting a *v*P that has been emptied of everything except the finite verb and one phrase in a specifier position. Thus a simple subject-initial V2 sentence is derived as shown in (40), where β is the VP that is moved to (Müller assumes) a specifier position of TP, and α is the remnant *v*P that is moved to specifier of CP. The structure derived before the movement of the remnant *v*P is shown in (41).

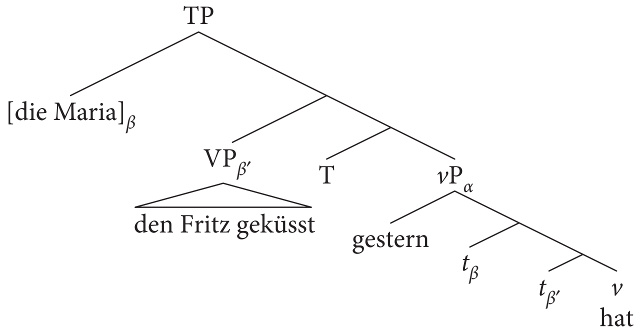
(40) $[_{\text{CP}}$ [*Die Maria* t_β *hat*$]_\alpha$ $[_{\text{TP}}$ [*den Fritz geküsst*$]_\beta$ t_α]]
the Maria has the Fritz kissed
Maria kissed Fritz

(41)


In this simple case, the remnant movement clearly satisfies the JOC because the target position of the VP 'den Fritz geküsst' and the base position of *v*P 'Die Maria hat' are both in the TP projection.

When the pre-verbal element is something other than the subject, what differs is which part(s) of the *v*P are "evacuated" before it is fronted. In order to derive an adverb-initial sentence, the subject and the VP (containing the non-finite verb and the object) are both moved into specifier positions of TP before the *v*P is fronted, leaving only the adverb and verb in *v*P, as shown in (42); here α is the *v*P as above, and the two evacuated subconstituents β and β' are the subject and the VP respectively.[13] Again, the structure derived before the fronting of *v*P is shown in (43).

(42) $[_{CP}$ $[$*Gestern* t_β $t_{\beta'}$ *hat*$]_\alpha$ $[_{TP}$ $[$*die Maria*$]_\beta$ $[$*den Fritz gekusst*$]_{\beta'}$ $t_\alpha]]$
Yesterday has the Maria the Fritz kissed
Maria kissed Fritz yesterday

(43)


This is once again a case where two distinct subconstituents vacate the remnant, and so both of them must move to positions inside the same maximal projection. As discussed above, this causes problems for the JOC under the assumption of Kayne (1998) and Koopman & Szabolcsi (2000) that each projection can host at most one left-attached phrase. Müller does not adopt this assumption, however, and so it is possible for him to give an analysis that is consistent with the JOC; and indeed he does, suggesting that both 'die Maria' and 'den Fritz geküsst' move into the TP domain.

The case of an object-initial sentence is essentially analogous – the subject and the verb (and anything else, e.g. adverbs) are evacuated from the *v*P, and then the *v*P is fronted – but involves an extra movement operation in order to get the object to the left edge of the *v*P. This can be straightforwardly analysed as an instance of scrambling, but there is an interesting consequence: with the object scrambling out of its VP-internal position, the movement of the VP into the TP domain (analogous to that of 'den Fritz geküsst' above) is now *another* instance of remnant movement, as well as the fronting of the *v*P that we have seen in the previous two examples. It turns out, however, that these two intertwined remnant movement configurations both satisfy the JOC.

I will present the analysis of the sentence in (44) in two steps.

(44) Den Fritz hat die Maria geküsst

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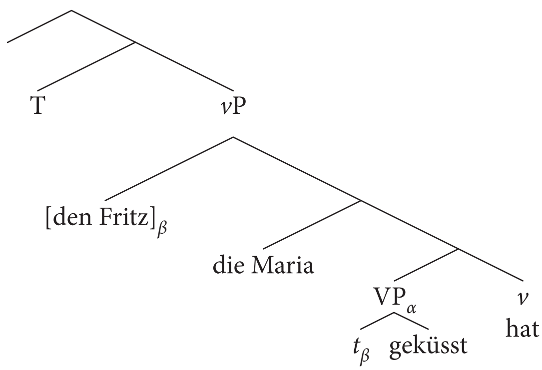
13. Müller assumes that adverbs are merged as specifiers of *v*P. If we instead assumed that some *v*P-internal movement were necessary to place the adverb at the left edge, there would be no difference for present purposes.

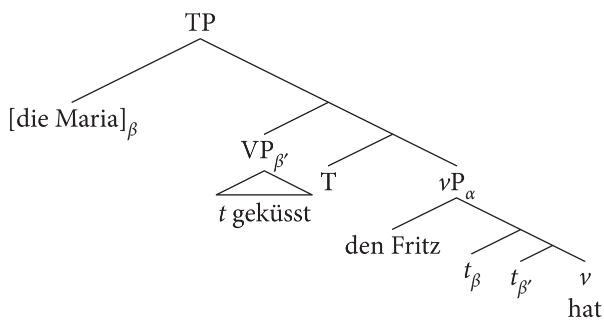
First consider the movement of the VP into the TP domain. Unlike in the previous examples, this is an instance of remnant movement because the object has moved out of it. The movement of the object is shown in (45). The next operation to apply to this structure will be the remnant movement of the VP (labelled α) into the TP domain. This is consistent with the JOC because the extracted subconstituent 'den Fritz' has only gone into the *v*P projection, which is where the remnant VP originates.

(45)



Having constructed a *v*P constituent 'den Fritz hat' via this remnant VP movement and then movement of the subject 'die Maria' into the TP projection, (46) shows the structure derived immediately before the movement of *v*P (this shows an equivalent point in the derivation to those shown in (41) and (43) earlier). Note that the labels α and β have been reassigned here to maintain the convention that the evacuated subconstituent is β and the remnant constituent is α.

(46)



The *v*P (labelled α) that is fronted to specifier of CP is a "double remnant", as in the case of (42). Here the two evacuated subconstituents are the subject 'die Maria' and the "emptied" VP 'geküsst', but as in (42) these are both moved into the TP domain and therefore close enough to the base position of the *v*P to satisfy the JOC.

This derivation therefore invokes a kind of “nested” remnant movement: the VP is the moved remnant (hence labelled α) in the configuration discussed in (45), and is the extracted subconstituent (hence labelled β) in the configuration discussed in (46). The fact that the JOC permits this “nested” remnant movement configuration is significant, since Kobele (2010) has shown that unboundedly nested remnant movement, in this sense, is a necessary condition for minimalist grammars (as formalised by Stabler (1997)) to be able to generate non-context free languages. Hence a restriction that ruled out such unboundedly nested remnant movement would rule out the possibility of analysing phenomena such as the cross-serial subordinate clause construction in Swiss German (Shieber 1985) which are provably beyond the bounds of context-free grammars.

8. Conclusion

I have presented an investigation of the implications of a constraint on remnant movement that emerges from an independently-motivated proposal concerning the basic operations of grammar. If the account of adjunct islands and freezing effects in Hunter (2010) is correct, then the JOC (in either its weak or its strong form) must also hold, but the empirical plausibility of this constraint had not previously been assessed in any depth. While the cases considered here are far from exhaustive, the findings thus far appear to be by and large positive.

A large number of the analyses considered here were found to straightforwardly satisfy the constraint, and those that did not fell into one of two groups. First there were examples of movement into TP domains that the JOC would predict should only be able to move into lower (say, VP) domains. A reasonable hypothesis seems to be that this is due to the fact that the semantic relationship between T heads and their complements is relevantly different from one of “argument taking”, which is the concept underlying the domains referred to by the JOC (assumed for now to be maximal projections). As I have noted, this seems suggestive of a connection to Grimshaw’s (2005) extended projections, although the details remain to be worked out; this provides a clear direction for future research. The second kind of analysis that conflicted with the JOC were those of “double remnant” movement in the context of Kayne’s assumption that each projection can host at most one left-attached phrase. I tentatively take these to be less consequential counterexamples: given that the underlying nature of the relevant domains is semantic as just discussed, the conflict appears to be an artefact of the differing uses of the theoretical notion “maximal projection”; and furthermore, the conflict can be circumvented by hypothesising a more complex sequence of movement steps, as discussed in Section 5.

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Language and conceptual reanalysis

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In my view, phrasal meanings are instructions for how to build conjunctive monadic concepts. But phrasal concepts like 'chase cows' are not *merely* conjunctive. The idea is that open class lexical items fetch monadic concepts like CHASE(_), while some grammatical relations introduce thematic concepts like PATIENT(_, _) and a restricted form of existential closure. I grant that animal cognition employs singular and polyadic concepts. But I think lexicalization is often a formally creative process in which nonmonadic concepts are used to *introduce* concepts like CHASE(_). In defending this view, I draw on Frege's conception of logic and Chomsky's conception of linguistics. My aim, in the spirit of Chomsky's minimalist program, is to reduce the stock of composition operations that semanticists appeal to. Much of the paper focuses on the requisite conjunction and closure operations, distinguishing them from more general operations that theorists often invoke.

In a series of papers, I have argued that phrasal meanings are instructions for how to build conjunctive monadic concepts whose conjuncts correspond to the phrasal constituents.[1] On this view, modification by relative clause is a paradigm of semantic composition: a relative clause, as in 'cow which sneezed' or 'dog that chased cows', calls for construction of a monadic concept that is to be conjoined with another. Many cases of adjectival/adverbial modification are similar. Of course, many phrasal concepts are not *merely* conjunctive: 'chase cows' does not direct construction of a concept that applies to things that are both chases and cows. But if a cow was chased, some event was a chase that involved a cow. And the idea is that open class lexical items fetch monadic concepts like CHASE(_), even if the concepts lexicalized were not monadic, while some grammatical relations introduce thematic concepts like PATIENT(_, _) and a restricted form of existential closure. The verb phrase $[\text{chase}_V\ [\text{cow+PL}]_N]_V$ is thus understood as

1. See Pietroski (2005a, 2005b, 2010, 2011, 2012), Hornstein and Pietroski (2009). I take concepts to be composable mental representations that exhibit "valences" or adicities; see, e.g. Fodor (1975, 1986, 2003).

an instruction for how to build a concept like CHASE(_) & ∃x[PATIENT(_, x) & [COW(x) & PLURAL(x)]].[2] I grant that animal cognition employs singular and polyadic concepts in complex representations like CHASE(FIDO, BESSIE). But I think lexicalization is often a formally creative process in which nonmonadic concepts are used to *introduce* concepts like CHASE(E), which can be systematically conjoined with others, given a few thematic concepts and a suitable kind of existential closure.

In Section one, I review some motivations for this claim about the expression-generating procedures that humans naturally acquire. In describing these procedures as tools for introducing and assembling concepts, as opposed to mere tools for communication, I'll also draw on Frege's (1879, 1884, 1892) conception of logic and Chomsky's (1965, 1986, 1995) conception of linguistics. But while Frege introduced higher-order polyadic concepts to make claims about the foundations of arithmetic, my proposal concerns the human language faculty and the mental representations with which this faculty ordinarily interfaces. My aim, in the spirit of Chomsky's (1995, 2000a) minimalist approach to the study of natural language syntax, is to reduce the stock of composition operations that semanticists regularly appeal to – see, e.g. Montague (1974), Higginbotham (1985), Larson and Segal (1995), Heim and Kratzer (1998) – if only to make it more plausible that our innate endowment supports these operations, and perhaps to help identify the uniquely human aspects of this endowment; cp. Hauser et al. (2002).

In Section two, I focus on the requisite conjunction/closure operations, distinguishing them from more general operations that theorists often invoke. For certain purposes, semanticists can employ any computational descriptions that seem adequate to the facts concerning how linguistic expressions are understood. But I think the study of natural language meaning, conceived as part of a broader biolinguistic study of human language, has progressed far enough to pursue the kind of reduction urged here in the broader context of asking which composition operations are fundamental and hence actually implemented; cp. Poeppel and Embick (2005), Hornstein and Pietroski (2009), Berwick et al. (2011), Pietroski et al. (2011).

2. Cp. Castañeda (1967) on Davidson (1967); see also Carlson (1984), Higginbotham (1985), Taylor (1985), Parsons (1990), Dowty (1991), Krifka (1992), Schein (1993, 2002). More precisely, I think the direct object introduces the formal concept INTERNAL(E, X); the verb specifies that Internals of chases are Patients. In any case, a phrase need not *merely* conjunctive. A big ant is an ant and big for one. An alleged criminal is a person such that some event was an allegation and one whose content is that the person is a criminal; see Higginbotham (1985).

1. Human languages as instruction generators

If one wants to compare the languages that children acquire with the languages that logicians invent, or with various systems of animal communication, it is useful to begin with a generous conception of what languages are. Then one can ask what sort(s) of languages humans naturally acquire. This highlights the need to distinguish conventionally determined sets of expressions from biologically implemented procedures that generate expressions. Children certainly acquire the latter. So whatever languages are, we face questions concerning the mental representations that expression-generating procedures interface with.[3] In particular, if at least some of these representations are conjunctive, semanticists face questions concerning the *form(s)* of potential conjuncts and the *kind(s)* of conjunction that can be invoked by generable expressions. As we'll see, plausible answers invite the independently motivated and defensible hypothesis that phrasal meanings are quite generally instructions for how to build conjunctive monadic concepts.

1.1 'I' before 'E'

At the risk of boredom for some readers, I want to be explicit about some terminology and background assumptions, which other readers may find tendentious.

Let's be overgenerous, and count as a language anything that associates signals of some kind with interpretations of some kind. Let's also say that an expression of a language pairs a signal (type) with an interpretation (type), allowing for abstract signals/interpretations and mediated pairings. An expression might pair a certain sound or gesture or inscription with a certain object or property or concept. A complex sound, of a sort that can be produced by a mezzo soprano or a basso profundo, might be paired with a complex concept via some algorithm. A slightly different kind of expression might pair an instruction for how to generate a complex gesture with an instruction for how to generate a complex concept, thereby pairing

3. One can stipulate that procedures and expressions are abstracta that do not interface with mental representations. But then 'acquire' and 'generate' should be understood accordingly, allowing for acquisition and generation of abstracta. One can say that children acquire a capacity to generate certain *representations of* expressions. Then the question is how the (acquired, abstract but somehow implemented) capacity to generate expression-representations is related to other aspects of human psychology, including various nonlinguistic mental representations that interface with generated expression-representations. I find it simpler to say that children acquire expression-generating procedures, and ask how expressions (lexical and complex) are related to (other) mental representations.

an instruction-relative gesture type with an instruction-relative concept-type.[4] This allows for bee languages, languages of thought, mathematical languages with gothic scripts, and various conceptions of human phonology/semantics. It also allows for languages of various ontological sorts: *sets* of expressions; *procedures* that generate expressions; physical *implementations* of such procedures; classes of similar sets, procedures, or implementations; etc.

A language can have finitely many expressions. But children acquire languages that are "finite-yet-unbounded" in the sense of having endlessly many complex expressions that can be characterized recursively. Let a *naturally acquirable human language* – henceforth, a Naturahl – be a finite-yet-unbounded language with two further properties: its signals are overt sounds or gestures, as in spoken English or ASL; and it can be acquired by any biologically normal child given an ordinary course of human experience. While 'Naturahl' inherits the vagueness of its defining terms, the initial point is to set aside any languages of thought whose signals are all mind-internal, along with any overt languages that children cannot acquire without special talent or training. In the end, one may want a more refined notion of human language, partly described in terms of the interpretations that children pair with sounds or gestures. And the natural kind in this vicinity may include some distinctively human languages whose signals are all covert. But instead of starting with substantive assumptions about linguistic interpretations, I want to *discover* what they are, in part by asking which operations are employed to combine them.

Framing the issue this way does suggest that expressions of a Naturahl link phonological representations to semantic representations. But this mentalistic perspective allows for the externalist idea that expressions (thereby) pair represented signals with represented aspects of the environment.[5] My own suspicions are more internalist: minds are related to the rest of reality in complicated ways that make word-world relations theoretically intractable; see Pietroski (2005b, 2008, 2010) drawing on Chomsky (1977, 2000b). I find it hard enough to say how words are related to human concepts, much less the things we can have concepts of. But I won't argue here against construing semantic theories externalistically.

4. For these purposes, instructions include strings of '1's and '0's used in a von Neumann machine to access other such strings and perform certain operations on them: '0100110101' might be executed by performing *operation two* (010) on the *number* (0) *fifty-three* (110101), while '1101011010' calls for *operation six* (110) on the *number stored in* (1) register *twenty-six* (011010) And instead of arithmetic operations performed on accessible/generable numbers, one can imagine operations like conjunction on accessible/generable concepts.

5. See Higginbotham (1985), Larson and Segal (1995), Ludlow (2011). In perceiving cows, perceivers are related to cows *via* representations. Perhaps understanding 'cow' is similar.

We should just be clear that such construal is not required by the fact that speakers communicate and use language to coordinate activities.

Let's grant that Naturahls link phonological representations of some kind to semantic representations that permit adequate triangulation on communicatively important aspects of the environment that speakers share. By using language, we can arrange to look for a missing cow tomorrow after breakfast. But nothing yet follows about whether spoken expressions like 'cow' ('brown', 'breakfast', 'look', 'missing', 'justice', 'unicorn', etc.) pair sounds with things. Even if many *concepts* pair certain representational forms with language-independent objects or properties, the phenomenon of polysemy suggests that lexical items are related to concepts in complex ways. A word like 'book' (or 'France') may indicate a family of representations that include a concept of spatiotemporal things and a formally distinct concept of intentionalia. In which case, it distorts the facts to say that 'book' expresses the concept BOOK, which is satisfied by an entity e if and only if e is a book. So let's at least leave room for the idea that expressions of a Naturahl pair phonological instructions with instructions for how to access and assemble certain concepts; where this neither implies nor denies that such expressions pair signals with language-independent entities in the fashion of a standard model for an invented language.

Returning to the point that Naturahls are finite-yet-unbounded, a child who acquires a Naturahl evidently acquires a *procedure that generates* expressions. So following Chomsky (1986), I'll take Naturahls to *be* the expression-generating procedures that children can naturally acquire, absent good reasons for taking Naturahls to be distinct (yet intimately related) things acquired. From this perspective, the study of Naturahls includes – at its core – the study of certain biologically implementable operations employed to form expressions. In which case, specifying these operations is a fundamental task of linguistics; cp. Chomsky (1995, 2000a).

Let me briefly address the contrasting idea that children acquire *sets of* expressions, which pair signals with interpretations in conventionally governed ways; see, e.g. Lewis (1975).

Even if each child acquires an infinite set of expressions by acquiring a generative procedure, and actual children converge on similar procedures despite variance in experience, one might prefer to focus on generated expressions. For one might be interested in communication, as opposed to Naturahls or human nature; and perhaps possible minds that form the same expressions via different procedures could, other things equal, communicate as well as minds that form the same expressions via the same procedure. Correlatively, one might hope to specify expression interpretations that communicators can agree on, abstracting from how humans assign these publicly available construals to linguistic sounds/gestures.

But this is not yet any argument that linguistic communication is supported by shared (languages that are) sets of expressions, as opposed to biologically implemented procedures. One can stipulate that speakers "share a language" if and only if they can communicate linguistically. But then positing shared languages does not *explain* successful communication; and appeal to Naturahls, which may not be languages in the stipulated sense, may be required to explain how humans can share languages.

One can imagine a Naturahl that differs from yours or mine only in that the sound of 'beech' is linked to the concept ELM, while the sound of 'elm' is linked to BEECH; where by hypothesis, these concepts differ only in what they are concepts of, and this difference is rooted in factors external to us (cp. Putnam 1975). One can also insist that the imagined Naturahl is not an idiolect of English, since it violates the following convention: 'beech' (expresses BEECH, which) applies to beeches; 'elm' (expresses ELM, which) applies to elms. Perhaps anyone who speaks an idiolect of English is somehow bound by some such social norm, modulo polysemy. But then 'idiolect of English' may classify Naturahls in an arbitrary way. Conventional differences may reflect theoretically unimportant differences in how a generative procedure gets used; cp. Chomsky (1977, 1986, 2000b), Pietroski (2008). And if children acquire expression-generating procedures that exhibit striking commonalities not due to the environment – for reviews, see Berwick et al. (2011), Pietroski and Crain (2012) – then one needs reasons for ignoring the commonalities and identifying Naturahls with alleged sets of generated expressions.

In thinking about whether such reasons are likely to emerge, it is useful to follow Chomsky (1986) in applying Church's (1941) intensional/extensional distinction – regarding mappings from inputs to outputs, as discussed by Frege (1892) – to the study of Naturahls and the aspects of human cognition that support acquisition of these languages. We can think of functions as *procedures* (intensions) that determine outputs given inputs, or as *sets* (extensions) of input-output pairs. Consider the set of ordered pairs $\langle x, y \rangle$ such that x is a whole number, and y is the absolute value of $x - 1$. This infinite set, $\{\ldots (-2, 3), (-1, 2), (0, 1), (1, 0), (2, 1)\ldots\}$, can be characterized in many ways. One can use the notion of absolute value, and say that $F(x) = |x - 1|$. But one can instead use the notion of a positive square root: $F(x) = {}^{+}\sqrt{}(x^2 - 2x + 1)$. These descriptions of the same set correspond to different procedures for computing a value given an argument. And a mind might be able to execute one algorithm but not the other.

In Church's idiom, one can use lambda expressions to indicate functions-in-intension, saying that $\lambda x.|x - 1|$ and $\lambda x.{}^{+}\sqrt{}(x^2 - 2x + 1)$ are distinct but extensionally equivalent procedures; or one can use lambda expressions to indicate functions-in-extension, saying that $\lambda x.|x - 1|$ is the same set as $\lambda x.{}^{+}\sqrt{}(x^2 - 2x + 1)$.

Though as Church noted, one needs to talk about procedures in order to specify the space of *computable* functions. And given the procedural construal of lambdas, which lets one say that Extension[$\lambda x.|x - 1|$] = Extension[$\lambda x.^{+}\sqrt{(x^2 - 2x + 1)}$], the set-theoretic construal is dispensible.[6] Marr (1982) likewise distinguished "Level One" descriptions, of functions computed, from "Level Two" descriptions of the algorithms employed to compute those functions. And while Level One descriptions can have a certain primacy in the order of discovery, making it fruitful to ask what a system does before worrying about how the system does it, a function cannot be computed without being computed in some way. So one must not confuse the methodological value of Level One descriptions, in characterizing certain cognitive systems, with any suggestion that the corresponding extensions are themselves targets of inquiry.

Echoing Church, Chomsky contrasted I-languages with E-languages: an I-language is a procedure that pairs signals with interpretations; an E-language is a set of signal-interpretation pairs. This distinction applies to invented languages, even those with finitely many expressions (cp. Evans 1981), and languages of thought. But the distinction is especially important, for two related reasons, with regard to Naturahls. First, to *specify* a set with endlessly many elements, one must somehow specify a procedure that determines the set. (Earlier, I was able to talk about *the* infinite set {… (−2, 3), (−1, 2), (0, 1), (1, 0), (2, 1)… } only because the context included reference to a determining procedure.) Second, while many procedures determine sets – arithmetic procedures defined over numbers being paradigm cases, along with any invented procedure that generates a set of well-formed formulae – a biological system might pair sounds with interpretations, yet *not* determine any set of expressions, if only for lack of a fixed domain of inputs. As a familiar illustration, consider (1).

(1) *The child seems sleeping

Speakers of English know that this string of words is defective, but meaningful. In particular, even though (1) is presumably ungrammatical – and not hard to parse, or otherwise grammatical but unacceptable – speakers hear (1) as having the interpretation of (2) *and not* the interpretation of (3); see Chomsky (1965), Higginbotham (1985).

(2) The child seems to be sleeping

(3) The child seems sleepy

6. For Frege (1892), functions as procedures are logically prior to the more set-like *courses of values of* functions.

The defect does not preclude *understanding* (1), which is neither word salad like (4)

(4) *Be seems child to sleeping the

nor an expression like (5) that is grammatical but bizarre given what it means.

(5) Colorless green ideas sleep furiously

So a Naturahl can, qua implemented procedure, assign an interpretation to the sound of (1). But it seems wrong to say that (1) is therefore an expression of the Naturahl. One can and perhaps should introduce a graded notion of expressionhood, and speak of sound-interpretation pairs being more or less grammatical, with word-strings like (1) corresponding to sound-interpretation pairs that are generable in some second-class way. This does not threaten the idea of Naturahls as procedures, which apply to whatever they apply to with whatever results. But it does challenge the idea that such procedures determine sets of expressions, in any theoretically interesting sense.

If (1) is a second-class expression of my I-language, is (4) an especially degenerate expression, or not an expression at all? Are translations of (3), in Japanese or Walpiri, terrible expressions of my idiolect? The point here is not merely that the "expression of" relation is *vague* for Naturahls. The point is rather that absent stipulations, it is hard to see how theorists could ever specify what it is to *be* an expression of a Naturahl (to any given degree) without relying on a prior notion of Naturahls as implemented procedures that interface (via the inputs they can take, and the outputs they can deliver) with other cognitive systems. To even say which E-Naturahl a speaker has allegedly acquired, it seems that one must first say which I-Naturahl she acquired. This casts further doubt on the idea that there *is* any set of English expressions, somehow determined conventionally, that different speakers might acquire by acquiring different generative procedures. And if Naturahls are not languages that determine sets of well-formed formulae, which can be specified in multiple ways, theorists may have to focus on the implemented operations that permit generation of fully grammatical expressions like (2) and (3) – recognizing that these operations may be applied more widely with various effects.

1.2 Executable expressions

Focusing on generative operations as opposed to generated expressions has become increasingly common in the study of Naturahl syntax, especially in light of minimalist thinking and suspicion of grammatical "levels" (e.g. Deep Structure and Surface Structure) beyond those required by the following truism: Naturahls interface with other cognitive systems in ways that support articulation and perception of sounds/gestures that can be intentionally used to express concepts in contexts; cp. Chomsky (1995). But focusing on I-Naturahls not only highlights questions concerning how phonological representations (PHONs) are paired with semantic representations (SEMs), it also highlights questions concerning how SEMs are used to assemble whatever complex mental representations speakers do assemble in comprehension.

Given an I-perspective, semanticists cannot say merely that speakers associate expressions with entities/satisfiers/functions that can be represented in various ways. At best, this characterizes what speakers represent (cp. Marr's Level One), raising questions about how they represent it and how the relevant forms of representation are related to generable SEMs. And if there are no E-Naturahls for speakers to share, then even if humans unconsciously represent satisfaction conditions of the sort that Tarski (1933) represented explicitly, children who acquire a spoken language like English do not acquire sets of representation-neutral sound-interpretation pairs. Put another way, regardless of whether or not generable SEMs are used to assemble concepts that are individuated externalistically, semanticists face questions concerning the *forms* of these concepts. In particular, we face two related questions: what kinds of concepts can lexical items access; and which modes of conceptual composition can be invoked by phrasal syntax?

This extends the notion of I-Naturahl to include not just implemented procedures that generate PHON-SEM pairs, but also more inclusive procedures that (in contexts) generate sound-concept pairs; cp. Hauser et al. (2002). But the more restrictive notion remains available. Syntacticians may often set aside questions of the sort addressed here, and focus on I-Naturahls in the narrow sense, even if their data often concerns unavailable interpretations for word-strings. But semanticists, I assume, want the broader – though perhaps not yet externalistic – notion of I-Naturahl. This may well require a theoretical distinction between cases of a single PHON that can be paired with more than one SEM (narrow homophony), and cases of a single SEM that can invoke more than one concept (broad polysemy); see Hornstein and Pietroski (2002) for discussion in the context of scope ambiguities. But I'll assume that this distinction can be drawn, even if it is often hard to sort out the details in practice.

From this perspective, an obvious suggestion is that SEMs are instructions for how to assemble concepts, with concepts taken to be composable mental representations of some kind (see Note 1): lexical SEMs call for (copies of) concepts stored in memory at lexical addresses that are also associated with PHONs; phrasal SEMs call for assembly, via certain composition operations, of concepts accessed via lexical SEMs. In principle, a composition operation might be "direct" in the sense of calling for concepts to be combined without invocation of any *other* concept, or "indirect" in the sense of calling for concepts to be combined via some other concept (e.g. conjunction). One might imagine the direct operation **SATURATE**: given a "predicative" concept Φ(_) that can take some concept α as an "argument," applying **SATURATE** to Φ(_) and α yields the complex concept Φ(α), whose adicity is one less than that of Φ(_). Given COW(_) and BESSIE as inputs, applying **SATURATE** yields COW(BESSIE) – i.e. the thought that Bessie is a cow, ignoring tense for simplicity. For these purposes, polyadic concepts like CHASED(_, _) are also predicative. Applying **SATURATE** to CHASED(_, _) and BESSIE yields CHASED(_, BESSIE); applying **SATURATE** to this complex concept and FIDO yields CHASED(FIDO, BESSIE), the thought that Fido chased Bessie.[7]

As a potential indirect composition operation, consider **M-CONJOIN**: given two monadic concepts Φ(_) and Ψ(_) as inputs, applying **M-CONJOIN** yields +[Φ(_), Ψ(_)], which applies to whatever both Φ(_) and Ψ(_) apply to; +[__, __] is a second-order dyadic concept that can be saturated by a pair of monadic concepts, perhaps unordered, to yield a third. Applying **M-CONJOIN** to COW(_) and BROWN(_) yields +[COW(_), BROWN(_)]. So one can say, as a first pass idealization, that 'brown cow' calls for M-conjunction of concepts fetched with 'brown' and 'cow'. This assumes an underlying cognitive operation of saturating some concepts with others, but without yet positing the sophisticated operation **SATURATE**, much less positing it as the mode of semantic composition invoked by 'brown cow'; cp. Note 7. Though of course, Naturahls may invoke both direct and indirect

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7. This assumes that CHASED(_, _) takes *two* arguments in a fixed *order*, and that CHASED(_, BESSIE) is a formable concept. In this respect, CHASED(_, _) is like 'λy.λx.Cxy'. But then CHASED(_, _) may not be available for simple *labeling* in lexicalization, even ignoring tense. One can imagine a mind that would have to *introduce* CHASED(_, _) via some prior concept CHASED(⟨1, 2⟩) that must be saturated (all at once) by a concept of an ordered pair of things. If CHASED(⟨1, BESSIE⟩) is not a formable concept, yet 'chased Bessie' calls for saturation of a concept fetched with 'chase' (by a concept fetched with 'Bessie'), then lexicalization may require some conceptual reformatting even if **SATURATE** is the basic composition operation. If CHASED(⟨FIDO, BESSIE⟩) is a concept of a *truth value*, it is even clearer that CHASED(_, _) may have to be introduced as a concept of type ⟨e, eT⟩; cp. Church's (1941) use of Tarskian sentences like 'Cxy', which have no truth values, to specify functions like λy.λx.1 if Cxy and 0 otherwise.

Likewise, one can imagine a mind that would have to introduce any quantificational concept of type ⟨eT, ⟨eT, T⟩⟩ via independently available concepts like INCLUDES(⟨1, 2⟩), which must be saturated (all at once) by a concept of an ordered pair of sets. In general, any proposed bundle of composition operations may require reformatting of concepts available to infants. Of course, we know very little about the format of infant concepts. But it may be that neither the event concept CHASE(_) nor the ⟨e, eT⟩ concept CHASED(_, _) is available without some reformatting.

composition operations. Combining a predicative SEM with a (grammatical) argument SEM may call for the operation **SATURATE**, while combining a predicative SEM with an adjunct SEM calls for **M-CONJOIN**.[8]

1.3 Available operations

Elsewhere, I have stressed that the operation **SATURATE** does not itself impose any constraints on the kinds of concepts that can be fetched via lexical SEMs, and that this should make us wary of positing **SATURATE** as a basic composition operation for I-Naturahls; see Pietroski (2005, 2010, in press, forthcoming). The point is not merely that we lack words for many saturatable concepts of high order and high adicity. One expects there to be endlessly many potential concepts that humans do not have, and hence do not have words for. But humans seem to have many polyadic concepts, corresponding to actual words, that are not fetched with lexical items.

Prima facie, we have a concept BETWEEN(_, _, _) that could be saturated by singular concepts to form thoughts like BETWEEN(FIDO, BESSIE, REX). Yet to express this thought – that Fido *is* between Bessie *and* Rex – we use a copular phase that includes 'and', as opposed to a ditransitive verb 'betwixt' that could simply fetch BETWEEN(_, _, _) and combine with three grammatical arguments as in (6).

(6) Fido betwixts Bessie Rex

Such examples cast doubt on the idea that I-Naturahls invoke **SATURATE** to combine concepts that can be fetched with lexical items. And in my view, this kind of circumlocution – with polyadic concepts being expressed in indirect ways, instead of simply fetching and saturating the concepts – is ubiquitous. To take

8. See, e.g. Heim and Kratzer (1998). Their proposal is largely encoded in terms of functions-in-extension. But their treatment of relative clauses and quantifiers suggests an algorithm for assembling *mental representations* that have externalistic/extensional contents; see Pietroski (2011), which includes discussion of a minimal abstraction operation that accommodates relative clauses and quantifiers. Higginbotham (1985) appeals to event variables, speaking of theta-binding vs. theta-linking. This makes it clearer that at least in the first instance, the posited operations concern representation formation, not things represented – with the relevant analogy being manipulation of '1's and '0's by a Turing machine, not arithmetic operations that map abstracta to abstracta. One can say that 'brown cow' calls for *saturation* of a concept fetched with 'brown' (by a concept fetched with 'cow'), and that 'brown' can call for a concept of type ⟨eT, eT⟩ like $\lambda\Phi.\lambda x.+[\text{BROWN}(x), \Phi(x)]$; cp. Parsons (1970), Kamp (1975), Montague (1974). This assumes a cognitive operation that supports (M-)conjunction of some concepts with others, while maintaining that combining 'brown' with 'cow' calls for the operation **SATURATE**. Though it seems that the concept $\lambda\Phi.\lambda x.+[\text{BROWN}(x), \Phi(x)]$ would have to be introduced via some concept like $\lambda x.\text{BROWN}(x)$; cp. note 7.

another obvious example, we use comparative constructions like 'is bigger than Rex' instead of simply lexicalizing the presumably relational concept with a dyadic predicate 'bigs' that takes a subject and an object as in 'Fido bigs Rex'; see Note 13.

Moreover, inquiry suggests that the actual ditransitive construction (7)

(7) Chris gave Fido a bone

does not include a verb that simply fetches a triadic concept GAVE(_, _, _) that applies to triples consisting of a giver, a recipient, and a thing given; see Larson (1988) and references there. Here, I'll just assume that (7) has the same logical form as (8), with the prepositional phrase indicating a conjunctive adjunct as in (8a) or (8b) or (8c), still ignoring tense.

(8) Chris gave a bone to Fido
 (a) ∃E[GAVE(E, CHRIS, A BONE) & RECIPIENT(E, FIDO)]
 (b) ∃E[AGENT(E, CHRIS) & GAVE(E, A BONE) & RECIPIENT(E, FIDO)]
 (c) ∃E[AGENT(E, CHRIS) & GAVE(E) & THEME(E, A BONE) & RECIPIENT(E, FIDO)]

By way of comparison, consider (9–14), which invite the hypothesis that 'kick' fetches KICK(E),

(9) Chris kicked Fido a bone

(10) Chris kicked a bone to Fido

(11) Chris kicked a bone

(12) Chris kicked

(13) A bone was kicked

(14) Chris gets a kick out of Fido

which can be conjoined with PAST(E) and thematic concepts like those in (8c).[9]

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9. See Schein (1993, 2002, forthcoming) and other references in Note 2. Kratzer (1996) argues – stressing subject/object asymmetries in passivization and idioms (see Marantz [1984]) – that while agent variables are "severed" from the semantic contribution of verbs, this contribution remains polyadic: combination with a direct object indicates saturation of a variable, yielding a concept like KICK(E, X); see also Harley (2006). I return to this idea. But note that it still presupposes creative lexicalization, unless the hypothesis is that (i) concepts like KICK(E, X) are available for labeling, *and* (ii) concepts of higher adicity are not. So absent independent arguments for (i), one might accept arguments for severing all participant variables from the contributions of verbs, and blame any asymmetries on cognitive factors independent of semantic composition, instead of positing distinct composition operations for subjects and objects. Williams (2007, 2009) defends such a diagnosis, arguing that Kratzer's

If at least one variable position in GAVE(_, _, _) does not appear in the concept fetched with 'gave', one wants to know why, especially if combining a verb with a grammatical argument calls for direct saturation of concepts. Why not use 'gave' to fetch GAVE(_, _, _) – or some tetradic analog that adds an event variable – and eschew (8), letting 'Fido' in (7) indicate a saturater of the polyadic concept fetched with the verb, as in GAVE(CHRIS, FIDO, A BONE)? But as stressed below, those who analyze (7) as in (8) must say *which* conjunction operation the ampersand indicates. Recall that **M-CONJOIN** is defined (only) for pairs of monadic concepts.

One can say that I-Naturahls invoke a powerful Tarskian operation, **T-CONJOIN**, which can connect any (open or closed) sentences as in (15).

(15) COW(BESSIE) & BROWN(X) & DOG(Y) & KICKED(Y,Z) & BETWEEN(Z, Y, W)

But again, this does not constrain lexical concepts, and (15) may not be a naturally generable tetradic predicate. Moreover, concepts like AGENT(_, CHRIS) can be recast in terms of existential closure and conjunction: ∃X[AGENT(_, X) & CHRIS(X)]; where CHRIS(X) is a monadic predicate – perhaps introduced, complex, and akin to CALLED(X, 'CHRIS') & DEMONSTRATED(X) – that applies only to the individual thought about with the singular concept CHRIS; cp. Quine (1963), Burge (1973), Katz (1994), Elbourne (2005).[10] Since AGENT(_, _) and CALLED(_, _) are dyadic concepts, generating representations like (8c) still requires more than **M-CONJOIN**. But as we'll see, a minimally more sophisticated form of conjunction can allow for some dyadicity in a constrained way. For now, though, just let '&' signify a conjunctive operation that I-Naturahls can invoke, leaving further specification of this operation for Section two.

The more important point here is that if the verb in (7–8) is not used to fetch a concept that has a variable for recipients, but the concept lexicalized with 'give' has such a variable, then the concept fetched with a lexical SEM can differ formally from the corresponding concept lexicalized. Likewise, if the verb in (9–13) is not used to fetch a concept that has a variable for agents and/or themes, then on the assumption that the concept lexicalized with 'kick' does have such variables, the concept fetched with a lexical SEM can differ formally

claims to the contrary are unpersuasive for English and implausible when applied to good test cases in other languages.

10. I assume that such recasting is independently plausible, given predicative uses of proper nouns, as discussed by Burge (1973) and many others. But if proper nouns do not fetch singular concepts, one wants to know why, especially *if* **SATURATE** is available as a composition operation.

from the corresponding concept lexicalized. And it is not hard to imagine a mind that works this way.

The triadic concept GIVE(_, _, _) – which can be used to think about one thing giving a second to a third – might be available for lexicalization, but ill-suited for combination with other concepts via the available composition operations. Suppose in particular, that **SATURATE** is not available, but that event concepts like GIVE(_) can be easily combined with other fetchable concepts. And suppose that GIVE(_, _, _) can be used, along with some logical and thematic concepts, to *introduce* GIVE(_) along the following lines indicated below.

$$\text{GIVE}(\text{X}, \text{Y}, \text{Z}) \equiv \exists \text{E}[\text{GIVE}(\text{E}) \,\&\, \text{AGENT}(\text{E}, \text{X}) \,\&\, \text{THEME}(\text{E}, \text{Y}) \,\&\, \text{RECIPIENT}(\text{E}, \text{Z})]$$

Such introduction might be metaphysically dubious if the quantifier is read with its usual existential import. Nonetheless, a certain kind of mind might take it to be truistic that one thing gives a second to a third iff there is a give (or giving) by the first of the second to the third. Such a mind might also be able to introduce DONATE(_), perhaps as a special kind of giving, yet treat the verbs 'donate' and 'give' differently so that (16) is comprehensible but a little strange.[11]

(16) Chris donated Fido a bone

The moral is that in thinking about whether I-Naturhals invoke **SATURATE**, as an operation of conceptual composition, one needs to think about the adicities *not* exhibited by lexical items despite the apparent availability of relevant concepts. To take another familiar kind of example, one could invent a language in which (17) is a sentence with the meaning of (18).

(17) *Mrs. White sold a knife Professor Plum ten dollars

(18) Mrs. White sold a knife to Professor Plum for ten dollars

But in English, (17) is anomalous, and 'sold' can combine with *two* arguments as in (19).

(19) Mrs. White sold a knife

One can insist that 'sold' fetches a tetradic concept, and that (19) has two covert grammatical arguments. But then what is *wrong* with (17)? Similar remarks apply to 'bought'. Though note that (20) paraphrases (21), using 'for' to signify a beneficiary, in contrast with (22).

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11. Unless, say, Fido is a museum (the Florida Institute for Dismal Objects) specializing in ancient bones. In which case, it would be odd to say that Fido chased a cow – unless, say, the long dead cow belonged to a potential donor.

(20) Professor Plum bought Miss Scarlet a knife

(21) Plum bought a knife for Scarlet

(22) Plum bought a knife for ten dollars

Moreover, while (23) is acceptable, it is roughly synonymous with (24),

(23) Mrs. White sold Professor Plum a knife

(24) Mrs. White sold a knife to Professor Plum

suggesting a shared logical form in which 'Professor Plum' corresponds to a conjunct of the form ∃x[RECIPIENT(_, x) & **Π**(x)]; where **Π**(x) applies to the relevant professor called 'Plum'. In which case, 'sell' is not an instruction to fetch a triadic concept with a variable for recipients. One can say that 'sell' is an instruction to fetch a nonmonadic concept like SELL(E, X, Y) as opposed to a monadic concept like SELL(E). But if the concept lexicalized has variables for the recipient and/or the payment, one wants to know why the concept fetched differs in this respect.

My suggestion is that open-class lexical items fetch monadic concepts because **SATURATE** is not available as a composition operation. If compositional semantics is fundamentally conjunctive, then reformatting is required for many concepts lexicalized. But appeal to **SATURATE** may require its own kind of reformatting; see Note 7. And in any case, let me end this section by stressing that there is nothing new in idea that minds can use extant concepts to introduce new ones, thereby making new use of available composition operations. In section two, I'll return to logical forms like (8b/8c) and ask what the ampersand signifies.

(8) (b) ∃E[AGENT(E, CHRIS) & GAVE(E, A BONE) & RECIPIENT(E, FIDO)]
(c) ∃E[AGENT(E, CHRIS) & GAVE(E) & THEME(E, A BONE) & RECIPIENT(E, FIDO)]

1.4 Illustrating introduction

Frege (1879, 1884) invented his *Begriffsschrift*, which can be viewed an idealized language of thought that permits certain deductions, largely in order to introduce "fruitful definitions" of central arithmetic notions. Given such definitions, one can deduce (suitable encoded versions of) the Dedekind-Peano axioms for arithmetic from more general principles. To provide such deductions, Frege introduced some higher-order polyadic correlates of concepts like NUMBER(_). In this sense, he "analyzed" many apparently simple concepts in terms of logically complex concepts. By contrast, I think humans naturally introduce simple monadic correlates of polyadic concepts like SELL(_, _, _, _). On this view, lexicalizers introduce concepts that exhibit *less* formal variation than the concepts lexicalized. But Frege's project still illustrates two points that are important here: concept introduction, which need not follow the pattern of defining VIXEN(_) in terms of FOX(_) and FEMALE(_), can be cognitively useful; and complex polyadic concepts can be used to introduce simple monadic concepts.

Frege was especially interested in concepts that figure in proofs by induction – e.g. proofs that there are infinitely many primes, given the axioms of arithmetic, and derivations of these axioms from a more compact representation of any non-logical basis for arithmetic. One of his main insights, concerning such proofs, was that arithmetic induction is a special case of logical induction applied to entities of a special sort. To show this, he defined the (natural) numbers so that for any property Φ: if (i) zero has Φ, and (ii) if any given number has Φ, so does its successor, then (iii) every number has Φ. But to *derive* this arithmetic truth from more basic principles and definitions, Frege needed a way of thinking about numbers that let him go beyond thinking about them with a logically unstructured monadic concept of certain abstract objects.

Formally, NUMBER(_) is like COW(_). Yet replacing 'number' with 'cow' in (ii) and (iii) does not preserve the compellingness of the inference. So Frege introduced a relational concept, NUMBER-OF[_, Φ(_)], that applies to certain *object-concept* pairs. For example, 0 is (defined as) the number of (things that fall under) the concept NONSELFIDENTICAL(_) – a.k.a. ~[=(x, x)]; 1 is the number of the concept =(0, _); 2 is the number of OR[=(0, _), (1, _)]; etc. Frege also introduced **ANCESTRAL**-R(_, _) as a higher-order concept that can be saturated by a first-order relational concept like PREDECESSOR(_, _) to yield a concept like PRECEDES(_, _) whose extension is the transitive closure of the more basic concept. For any relation and any entities: if R(α, β) and R(β, γ), then **ANCESTRAL**-R(α, γ); and similarly for any "chain of R-links." Given these concepts, one can formulate the biconditional (25): _ is a number iff 0 *is or precedes* _.

(25) NUMBER(_) ≡ OR[=(0, _), **ANCESTRAL**-PREDECESSOR(0, _)]

Whether (25) counts as analytic depends in part on whether one allows for analysis by abstraction, as opposed to decomposition; see Horty (2007). But the suggestion is not that we naturally think about numbers via mental analogs of the right hand side of (25). Rather, (25) reflects Frege's attempt to say what numbers *are* – and how we *can* think of them – in a way that reflects our capacity to appreciate the validity of certain inductive inferences. In this sense, his *Begriffsschrift* is a language in which we can conduct recognizably human thought. But acquiring the relevant concepts requires intellectual work. Of course, we must entertain a thought – e.g. that every number is the predecessor of another – in order to analyze it. But we can use concepts like NUMBER(_) and PREDECESSOR(_, _) to think thoughts, and then introduce technical analogs of these more natural concepts, with the aim of re-presenting our initial thought contents in ways that let us describe more inferences as formally valid. We can use (25) to replace NUMBER(_) with a more structured relational concept, when this is useful in a proof, and then go back to NUMBER(_) when the further structure is irrelevant.

Frege went on to define/analyze the predecessor relation inductively, given his key concept NUMBER-OF[_, Φ(_)] and the central arithmetic concept of one-to-one correspondence, via the following generalization: two concepts have the *same* number if and only if the things that fall under them correspond one-to-one. (The key insight was that since 0 is the first number, each number *n* is also the number of numbers that precede *n*, making the predecessor of *n* the number of numbers apart from zero that precede *n*. For example, three numbers precede 3, two of which are not zero.) Frege thus showed how a mind furnished with certain concepts and logical capacities could reconstruct our concept NUMBER(), in a way that would permit agreement on the Dedekind-Peano generalizations. Initially, *we* might view NUMBER-OF[_, Φ(_)] as mental shorthand: *n* is the number of a concept iff *n* is a number such that the things falling under that concept correspond one-to-one with the numbers preceding *n*. But this takes the monadic concept of numbers as objects, NUMBER(_), as given. And for Frege, the point is not to reduce NUMBER-OF[_, Φ(_)] to more familiar numeric concepts. The point is to show how an ideal thinker might define NUMBER(_) – and the other concepts we initially use to entertain arithmetic principles – in terms of more logically basic concepts.

Given a mind that can introduce concepts in any such way, theorists can distinguish the (i) "first concepts" used to think about things and introduce new ways of thinking about things from (ii) "second concepts" that are introduced in terms of first concepts. It may be that animals have been introducing concepts, unconsciously, for a long while. So perhaps we'll need to speak of "third concepts," and so on. But in any case, we should at least consider the possibility that lexicalization often includes a process that is some respects like the process of an ideal Fregean mind introducing the formally simple concept NUMBER(_): a nonmonadic concept is used, along with other reformatting resources, to define a monadic concept that can figure in simple conjunctions like +[NUMBER(_), PRIME(_)]. Of course, infants do not have ideal Fregean minds. But there may be a sense in which infants "dumb their concepts down," to achieve a stock of concepts that are systematically combinable via the composition operations that I-Naturahls can invoke; see Pietroski (2010), drawing on Spelke (2002) and Carruthers (2002). And while revealing the foundations of arithmetic may require higher-order polyadic concepts that combine via saturation, understanding expressions of an I-Naturahl may require monadic concepts that combine via some form of conjunction. But which form?

2. Limited conjunction can do a lot

There are many ampersands, and correspondingly, many possible concepts of conjunction. We want to know which such concept figures in logical forms like (8b/8c),

(8) (b) ∃E[AGENT(E, CHRIS) & GAVE(E, A BONE) & RECIPIENT(E, FIDO)]
(c) ∃E[AGENT(E, CHRIS) & GAVE(E) & THEME(E, ABONE) & RECIPIENT(E, FIDO)]

taking these to reflect thoughts that can be assembled by executing SEMs; where concepts like THEME(E, A BONE) have further analyses as in ∃X[BONE(X) & THEME(E, X)], which has a dyadic conjunct. The idea will be that a severely constrained concept of conjunction, appeal to which is hard to avoid, can still let us characterize an indirect composition operation that makes appeal to **SATURATE** seem otioise. Though if I-Naturahls invoke this composition operation, we need to rethink the notions of variable and closure that are relevant for I-Naturahl semantics. In short, the Frege-Tarski notions may be far too powerful if the goal is to describe the concepts assembled by executing naturally acquirable biologically implemented procedures.

2.1 Varieties of conjunction

The ampersand of a propositional calculus, as in (25), can be characterized via *truth* tables.

(25) $P \underline{\&} Q$

But while humans may enjoy a corresponding concept – and perhaps an operation **P-CONJOIN**, implementable with AND-gates, that takes pairs of truth-evaluable sentences as inputs and yields sentences like (1) as outputs – this simple ampersand cannot combine constituents that have nonzero adicities as in (8b/8c).

In a first-order predicate calculus that includes open sentences like (26–29),

(26) Bx **&** Cx

(27) Bx **&** Cy

(28) Axy **&** Gx

(29) Fxy **&** Uzw

the ampersand can be characterized in terms of Tarski's notion of *satisfaction* by sequences, which assign values to variables. Then (25) can be described as a special case like (30a) or (30b),

(30) (a) Cb & Fab
(b) ∃xCx & ∀x∃yFxy

with truth characterized in terms of satisfaction. The corresponding operation **T-CONJOIN**, mentioned above, maps pairs of sentences (open or closed) onto their Tarskian conjunctions.

But the bold ampersand has a striking property illustrated with (27) and (29): it can be used to form an open sentence that has *more* free variables than any conjunct. And prima facie, combining expressions in a Naturahl cannot *increase* semantic adicity in this way. Note that 'brown cow' is not ambiguous, with (27) as a potential reading. Likewise, 'from under' cannot be understood as an open sentence like (29). So if one describes the meaning of 'brown cow' or 'gave Fido a bone' with the bold ampersand, one needs to say more about why conjunctive meanings are so limited in Naturahls.

Many things might be said, in this regard, and I won't try to rebut them here. My point is simply that the bold ampersand allows for great freedom: '&' can link sentences that have arbitrarily many free variables, and any number of shared variables. This raises the question of whether phrases like 'brown cow' and 'gave Fido a bone' invoke a conjunctive concept that also affords such freedom – or whether the bold ampersand lets theorists describe a space of logically possible construals for expressions, and then discover that I-Naturahl meanings reflect a proper part of that larger space. The latter suggestion will be attractive to anyone who finds it hard to believe that biology gave us Tarski-conjunction, much less that we regularly use this operation of semantic composition without exploiting its combinatorial power.

It is worth being explicit about why the adicity of a Tarskian conjunction can exceed that of any conjunct. Think of a Tarskian sentence as the result of "faux-saturating" each slot of an unsaturated Fregean concept with a variable, treating constants as special variables. Note that the slots in CHASED(_, _) cannot yet be bound by quantifiers; at best, '∃_' would bind both slots. Inserting variables yields an open sentence like CHASED(x, x′).[12] But a Tarskian language has endlessly many variables: x, x′, x″, etc. Each conceptual slot can be replaced with any variable; consider CHASED(x″, x‴) vs. CHASED(x″, x″). So for each predicative Fregean concept, there are endlessly many formally distinct Tarskian sentences. And a polyadic concept will correspond to open sentences that exhibit different adicities, since variables can be repeated. The flip side of this point is that the adicity of conjuncts will

12. Which might be abbreviated as 'Cxy'. But I-Naturahls may not let us build concepts like ∃x[CHASED(x, x′)], corresponding to 'thing that was chased', as opposed to ∃E{∃x[AGENT(E, x)] & CHASE(E) & THEME(E, A1)}; where 'A1' stands for an assignment relative value, but can also be a variable for quantification of assignment variants.

not determine the adicity of conjunctions, which depend on how many variables appear in *both* conjuncts. Consider the range of conjunctions that can be formed from CHASED(_, _) and CAUGHT(_, _): the dyadic CHASED(x, x′) & CAUGHT(x, x′); the triadic CHASED(x, x′) & CAUGHT(x′, x″); and the tetradic CHASED(x, x′) & CAUGHT(x″, x‴). Setting aside the possibility of using a variable twice in the same "primitive" open sentence – as in CHASED(x, x) or CAUGHT(x′, x′) – a Tarskian conjunction of CHASED(_, _) and CAUGHT(_, _) may have two, three, or four open variables.

While Tarski's conjoiner affords great freedom, one can also invent a restrictive language that does not generate any conjunctive sentences – much less sentences like (26–29) – but instead generates monadic predicates like (31), with each slot obligatorily linked to the other.

(31) B(_) *&* C(_)

This italicized ampersand, which might be characterized in terms of intersection, is a notational variant of the '+' used earlier to describe the operation **M-CONJOIN**. In an important sense, such a language lacks variables, even though there are predicative slots that allow for saturation by different saturaters. For within any predicate, no such slot can be bound or saturated independently of any other: necessarily, this restricted conjunction of B(_) with C(_) yields another one-slot predicate. By contrast, Tarskian variables and conjunction would permit endlessly many two-variable sentences: Bx & Cx′; Bx′ & Cx; Bx & Cx″; Bx′ & Cx″; etc. But again, even if humans have access to pure monadic predicate conjunction, this operation cannot be used to form concepts like ∃x[THEME(_, x) & BONE(x)] or ∃x[FROM(_, x) & CHICAGO(x)]; where at least one of the conjoined constitutents is dyadic. While relative clauses (e.g. 'cow that arrived') may call for simple conjunction of monadic concepts, other forms of modification (e.g. 'big ant') may call for a kind of conjunction that permits some relationality, as in ANT(_) & BIG(_, *ONE*); where BIG(_, __) is saturated by a concept and an object – cp. NUMBER-OF(_, __) – and the pronominal concept *ONE* stands in for the head concept ANT(_).[13]

We face a kind of "Goldilocks Problem." Some conjoiners are too restricted to do what I-Naturahls do. Others seem too permissive for purposes of I-Naturahl semantics. One suspects that the answer lies somewhere between **M-CONJOIN** and **T-CONJOIN**. And this at least suggests a research strategy: find a minimal modification of **M-CONJOIN** that will do the job.

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13. See Note 2 and Kennedy (1999). Developing this idea in detail would require a digression into Boolos' (1998) interpretation of the *second-order* monadic predicate calculus, in which a (capitalized) variable can have *many* values relative to one assignment of values to variables; see Pietroski (2005a, 2006, 2011) for discussion.

Another familiar conjoiner traffics in functions, types, and truth *values* as in (32);

(32) $^{\langle eT, \langle eT, eT\rangle\rangle}\&(\lambda x.1 \text{ iff } Bx, \lambda x.1 \text{ iff } Cx)$

where (32) describes the same function in extension as (33), which has (26) as a constituent.

(33) $\lambda x.1 \text{ iff } Bx \,\&\, Cx$

This superscripted ampersand does not itself accommodate any polyadicity. It can only take predicates of type ⟨eT⟩ as inputs. And this does not help with examples like (8b/c),

(8) (b) ∃E[AGENT(E, CHRIS) & GAVE(E, A BONE) & RECIPIENT(E, FIDO)]
(c) ∃E[AGENT(E, CHRIS) & GAVE(E) & THEME(E, A BONE) & RECIPIENT(E, FIDO)]

involving dyadic conjuncts. But one can posit other fixed-type conjoiners as in (34);

(34) $^{\langle\langle e, \underline{e}T\rangle, \langle eT, \langle e, \underline{e}T\rangle\rangle\rangle}\&$[λX.λE.1 IFF THEME(E, X), λX.1 iff BONE(X)]

where this superscripted ampersand, with '$\underline{e}$' suggesting an event variable, permits conjunction of THEME(E, X) and BONE(X) to form a dyadic concept that is extensionally equivalent to (35);

(35) λX.λE.1 iff THEME(E, X) & BONE(X)

cp. Kratzer (1996), Chung and Ladusaw (2003).

Likewise, this conjoiner permits (36), which is extensionally equivalent to (37);

(36) $^{\langle\langle e, \underline{e}T\rangle, \langle eT, \langle e, \underline{e}T\rangle\rangle\rangle}\&$[λX.λE.1 IFF AGENT(E, X), λX.1 IFF CHRIS(X)]

(37) λX.λE.1 iff AGENT(E, X) & CHRIS(X)

where as discussed above, CHRIS(X) is a potentially complex (and context-sensitive) monadic concept that applies to exactly one person (in any context of use). I think this suggestion is on the right track. But appealing to this particular ampersand raises the question of why other forms of type-restricted conjunction, as in (38), are not equally available.

(38) (a) $^{\langle\langle e, \underline{e}T\rangle, \langle \underline{e}T, \langle e, \underline{e}T\rangle\rangle\rangle}\&$[λX.λE.1 IFF AGENT(E, X), λE.1 IFF VIOLENT(E)]

(b) $^{\langle\langle e, eT\rangle, \langle\langle e, eT\rangle, \langle e, eT\rangle\rangle\rangle}\&$[λX′.λX.1 IFF FROM(X, X′), λX′.λX.1 IFF LIKES(X, X′)]

Moreover, one needs a sophisticated kind of existential closure to convert (37) into (39).

(39) λE.1 iff ∃x[AGENT(E, X) & CHRIS(X)]

The requisite quantifier is not of type ⟨eT, T⟩, but rather ⟨⟨e, $\underline{e}$T⟩, $\underline{e}$T⟩. One can get around this by positing suitable displacement and abstraction on variables. But for reasons that will emerge, I want to explore the idea that I-Naturahls let us build event concepts like (40);

(40) ∃X[AGENT(_, X)^CHRIS(X)]^GAVE(_)^∃X[THEME(_, X)^ BONE(X)]^∃X[RECIPIENT(_, X)^FIDO(X)]

where '^' stands for a conjoiner that permits one dyadic conjunct as in (34) and (36), but each open slot is necessarily linked to the others as in (31).

(31) B(_) & C(_)

Then (8c) can viewed as an existential closure of the *one* open slot in (40).[14]

Note that for these purposes, the difference between (8c) and (8b) is small. The choice concerns whether the variable corresponding to 'bone' is *separated* from the concept fetched via the verb; cp. Schein (1993, 2002), Kratzer (1996). But either way, a dyadic concept is conjoined with a monadic concept – BONE/BONES/GRASS() – that may itself be complex. Like Schein, I think there are good arguments for separation: verbs fetch monadic concepts like GAVE(_), which can conjoin with complex monadic concepts like ∃X[THEME(_, X)^BONE(X)], as opposed to dyadic concepts like GAVE(_, _) that can conjoin with complex monadic concepts like BONE(_); see Pietroski (2005, 2011, in press). But either way, the requisite *form* of conjunction is basically the same, since apparent polyadicity is handled by dyadic-monadic conjunction along with some form of existential closure. The crucial contrast is with GAVE(_, _, _) – which applies to *trios* consisting of some past event of giving, a giver, and a thing given – and the tetradic GAVE(_, _, _, _) which adds a variable for the recipient; cp Davidson (1967). The assumption here, increasingly common, is that 'gave' fetches a concept with at most two variables, at least one of which is an event variable; in which case, the variables corresponding to the grammatical subject and indirect object of (7) are separated from the concept fetched via 'gave'.

(7) Chris gave Fido a bone

14. And as discussed in Pietroski (2011), this simple kind of existential closure can be encoded as an operator that converts a given monadic concept into a special monadic concept that applies to everything or nothing. This echoes Tarski's insight that truth/falsity can be described as satisfaction by all/no sequences.

If this assumption is correct in general – and each verb fetches either a monadic concept or a dyadic concept whose second variable is for “internal” participants of the event-like values of the first variable – then inferences from (7) to (41) are instances of conjunction reduction,

(41) Fido was given a bone

much like inferences from (42) or (43) to (7).

(42) Chris gave Fido a red bone

(43) Chris gave Fido a bone yesterday

And if that’s right, one would like to blame the same underlying circuitry in each case.

2.2 Minimal dyadicity

As suggested by (40),

(40) ∃x[AGENT(_, x)^CHRIS(x)]^GAVE(_)^ ∃x[THEME(_, x)^ BONE(x)]^ ∃x[RECIPIENT(_, x)^FIDO(x)]

let ‘^’ indicate a conjoiner that differs minimally from the italicized conjoiner of (31).

(31) B(_) *&* C(_)

The idea is that ‘^’ can also link a single dyadic concept to a single monadic concept, subject to the following constraint: the second slot of the dyadic concept must be linked to the (slot of the) monadic concept; then the monadic concept must be existentially closed, immediately, yielding a complex monadic concept that can be conjoined with others. A system that permits this smidgeon of dyadicity, while remaining massively monadic, would permit (44) and (45),

(44) BROWN(x)^COW(x)

(45) ∃x[ABOVE(x′, x)^COW(x)]

but not (46) or (47), much less (48) or (49).

(46) ∃x[ABOVE(x, x′)^COW(x)]

(47) ∃x′[ABOVE(x′, x)^COW(x)]

(48) BROWN(x)^COW(x′)

(49) FROM(x, x′)^UNDER(x, x′)

Note that (40) can be recast as shown below,

∃[agent(_, _)^Chris(_)]^gave(_)^∃[theme(_, _)^bone(_)]^∃[recipient(_, _)^Fido(_)]

with the links reflecting constraints on '∃' and '^': '∃' must bind the monadic concept in its scope; and the second variable of any dyadic conjunct must link to the adjacent monadic concept. There is no choice about which conceptual slot '∃' binds, or which slot is left open. So there is no Tarskian quantifier binding a variable in an open sentence, and (40) can be rewritten as (40a).

(40a) ∃[agent(_, _)^Chris(_)]^gave(_)^
∃[theme(_, _)^bone(_)]^∃[recipient(_, _)^Fido(_)]

Despite the lack of variable letters, this is unambiguously a concept of events, each of which meets four conditions: its agent is Chris; it is a past event of giving; its theme is a bone; and its recipient is Fido.[15] Correlatively, (50) is not a notational variant of the more sophisticated (51).

(50) ∃[agent(_, _)^Chris(_)]

(51) ∃x[agent(e, x)^Chris(x)]

Don't think of (50) as the result of applying a quantifier to an open sentence, with a tacit understanding about how the variable slots are linked. Think of (50) as the mental representation that results when agent(_, _) is ^-conjoined with Chris(_); where **^-CONJOIN** is a biologically implemented operation that creates a certain monadic concept, given a dyadic and monadic input. In (50), '∃' targets Chris(_) because '∃' must target a monadic concept, not because '∃' is somehow indexed with a variable that faux-saturates Chris(_) as in (51).

One can say that **^-CONJOIN** incorporates a kind of existential closure, as a way of describing the end result. But the suggestion is not that **^-CONJOIN** is a complex operation that can be decomposed into Tarskian conjunction and closure. On the contrary, the suggestion is that biochemistry can create concepts

15. This simplifies: give(_) may be "number neutral" in a way that lets many events *together* satisfy the concept; cp. Boolos (1998), Schein (1993, 2001), Pietroski (2005, 2006, 2011). And (40a) may be satisfied, plurally, by some events that together were/constituted past events of giving in which Chris was the agent, a bone was the theme, and Fido was the recipient; where bone(_) may turn out to be like trio(_), in that satisfying the concept may be a matter of some things together falling under the concept, as opposed to some one thing falling under the concept.

like (50) *without* implementing Tarskian conjunction and closure. I don't know *how* ^-**CONJOIN** is implemented. But I don't see how I-Naturahls could do what they do without invoking this operation, one way or another. By contrast, we can begin to see how I-Naturahls could do what they do without invoking **T-CONJOIN** or **SATURATE**; see Pietroski (2005a, 2011) for details concerning relative clause, quantificational, causal, and attitude-ascribing constructions. So perhaps we should try to reduce semantic composition operations to a small bundle that includes ^-**CONJOIN**, or some such relatively simple operation of conjunction, but not the more traditional and more powerful operations.

On a more straightforwardly empirical note, suppose that the "participant slot" of each thematic concept invoked – by a grammatical argument or prepositional phrase – is indeed linked to a monadic concept that is (in effect) existentially closed via the operation ^-**CONJOIN**. Then the indefinite article in (7) marks 'bone' as a singular count noun (cp. Borer 2005),

(7) Chris gave Fido a bone

but 'a' does not itself call for an existential quantifier; cp. Higginbotham (1987). I mention this not because the semantic status of indefinites is easily resolved, but to stress that appealing to ^-**CONJOIN** has real consequences. Plural and mass noun analogs, as in (52–53), can also be analyzed as simple existential closures of the event concepts;

(52) Chris gave Fido (sm) bones
(a) ∃[AGENT(_, _)^CHRIS(_)]^GAVE(_)^∃[THEME(_,_)^BONE(_)^PLURAL(_)]^∃[RECIPIENT(_, _)^FIDO(_)]

(53) Chris gave Bessie (sm) hay
(a) ∃[AGENT(_, _)^CHRIS(_)]^GAVE(_)^∃[THEME(_,_)^HAY(_)]^∃X[RECIPIENT(_, _)^BESSIE(_)]

where the existential force of bones/hay need not come from any lexical constituent.

In this regard, note that the untensed (54)

(54) Chris give Bessie (sm) hay

can be embedded as in (55), which can initially be analyzed as in (55a),

(55) hear Chris give Bessie (sm) hay

(55) hear Chris give Bessie (sm) hay
(a) HEAR(_) & ∃E{THEME(_, E) & ∃X[AGENT(E, X)^CHRIS(X)]^GAVE(E)^∃X[THEME(E, X)^HAY(X)]^∃X[RECIPIENT(E, X)^BESSIE(X)]}

with an event as the "thing" heard; cp. Higginbotham (1983). This event analysis captures an otherwise puzzling ambiguity of (56), since 'in the barn' could modify 'heard' or 'give'.

(56) I heard Chris give Bessie (sm) hay in the barn

The relevance is that the clausal direct object of 'hear' carries a kind of existential force, as indicated with (55a), which can be rewritten as (55b).

(55b) HEAR(_) & ∃{THEME(_, _) & ∃[AGENT(_, _)^CHRIS(_)]^GAVE(_)^ ∃[THEME(_, _)^HAY(_)]^∃[RECIPIENT(_, _)^BESSIE(_)]}

But if this existential force is not plausibly due to any lexical constituent, perhaps we should say the same about (57) and (52–53).

(57) I heard cows

Again, my point is not that these implications of appealing to **^-CONJOIN** are obviously correct; cp. Chierchia (1998). But a very simple conception of semantic composition, motivated by various empirical considerations, has testable consequences that are not obviously wrong. And that seems promising.

2.3 Final remarks

In thinking about what makes humans linguistically special, it is tempting to focus on how spoken/signed languages are used for interpersonal communication. So one might stress the fact that humans can generate articulable/perceivable expressions that are in some sense conventionally governed, while treating intrapersonal uses of the human language faculty as somehow secondary or derivative on this faculty's role in communication. I have been urging a different perspective according to which humans have a capacity to generate expressions that are distinctively meaningful/comprehensible. Expressions can be used in speech. But meanings are instructions for how to build concepts, not abstractions from communicative situations.

I have also suggested that lexicalization is a large part of what makes humans linguistically special, and that lexicalization is a formally creative process that lets us make productive use of relatively simple composition operations. Specifically, the indirect composition operation **^-CONJOIN** may allow for enough nonmonadicity to accommodate verb-argument (as well as verb-adjunct) combinations in I-Naturahls, without being as sophisticated as **SATURATE** or **T-CONJOIN**. Indeed, **^-CONJOIN** does not even require variables in the Tarskian sense. And if the goal is to describe biologically implementable composition operations, as opposed to doing interesting logic, lack of sophistication may be a virtue.[16]

16. My thanks to the many students and audience members who commented on earlier versions of this material. But I owe a special debt to Norbert Hornstein for many conversations, over many years, that triggered and then helped refine the ideas presented here.

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PART II

Features and interfaces

Decomposing force

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This paper proposes that the semantics of imperative clauses is not correlated with a unique morpho-syntactic (imperative) Force feature (as traditionally assumed), but can be derived from finer grained components, which are independently needed, such as a Modality feature and a 2nd Person feature. These features are shown to be instrumental for explaining not only the formal properties of true imperatives, but also of surrogate ones. Assuming several finer grained features rather than a unique Force feature offers a useful framework for characterizing both the similarities and the differences between the various types of imperatives.

1. Introduction: Decomposition

Much of the previous work on clause types that falls within the generative tradition argues that clauses contain a *Force feature* and that, depending on the value assigned to it, the clause will be interpreted as a declarative, interrogative, exclamative, or imperative (Baker 1970; Cheng 1991; Rivero & Terzi 1995; Rizzi 1997, 1999; Han 1998, etc.).

In this paper I will take a different stand and pursue the hypothesis that *Force* is not encoded in the syntax as a syntactic feature, but is instead a derivative notion which results from the semantic composition of *more primitive components*, which are in turn in a one-to-one correspondence with more atomic syntactic features. To illustrate, consider the following examples from Quebec French, which contain four different types of clauses: interrogative–(1a), exclamative–(1b), declarative–(1c), imperative–(1d,e).

(1) a. *Il fait **-tu** assez beau?*
3.SG makes -TU enough nice
'Is the weather nice?'

b. *Il fait **-tu** assez beau!*
3.SG makes -TU enough nice
'Isn't the weather nice!' (Morin 2006)

c. *Il fait (*-**tu**) assez beau.*
3.SG makes (-TU) enough nice
'The weather is nice enough'

d.	*Fais*	(*-***tu***)	*tes*	*devoirs!*
	Make.2.SG	-TU	your.SG	homework
	'Do your homework!'			
e.	*Faites*	(*-***tu***)	*vos*	*devoirs!*
	Make.2.PL	-TU	your.PL	homework
	'Do your homework!'			

One striking difference between these clauses is that interrogatives and exclamatives allow the morpheme *tu*, while declaratives and imperatives don't. This morpheme is homophonous with the second person singular pronoun in Quebec French, but has different properties. To see this, notice that if *tu* were a pronoun in (1a,b), it could only be the subject of the impersonal verb *faire*. However, the subject in these examples is a 3rd person singular overt pronoun, as shown in (1a,b). Moreover, in (1c), which does not allow *tu*, *tu* is not the subject either; (1c) is grammatical without *tu* and the subject is again the 3rd person pronoun *il*. Finally, (1d) does not offer clear evidence that *tu* is not the subject, since imperatives in Quebec French are incompatible with overt subjects and thus it is not clear whether what is disallowed in (1d) is the 2nd person singular pronoun *tu* or some other *tu*. In spite of this, (1e) does offer clear evidence that imperatives exclude not the 2nd person singular pronoun *tu*, but the other morpheme *tu*. Notice that the imperative verb in (1d) is inflected for 2nd person plural. Given subject-verb agreement, the subject can only be 2nd person plural, and not singular, and thus, the excluded *tu* can only be the non-pronominal morpheme.

Whatever role this morpheme *tu* is playing in the types of clauses that allow it, it can't simply encode the interrogative or the exclamative *Force* feature, since it can occur in both types of clauses. Rather, it is more plausible to assume that *tu* is the overt realization of a finer grained feature, that both interrogatives and exclamatives share. The challenge under this view is to discover these more primitive features that constitute the ingredients of the force of a clause. In this paper I will focus on imperative clauses and argue that at least two features contribute to the imperative force of a clause: the modality feature and the 2nd person feature. Even though I will not consider other types of clauses, the suggestion is that these features are also potentially relevant for deriving the force of other clause types, such as exclamatives or interrogatives.

A similar research agenda was adopted by Zanuttini and Portner 2003; Poletto and Zanuttini 2003; Portner 2004; Speas and Tenny 2003; Truckenbrodt 2006, among others. The arguments presented in this paper are novel in that new evidence is presented for the existence of these primitive features, and also because the paper attempts to provide a unified account of the similarities, as well as of the differences between various types of imperatives in terms of these primitive features. On an empirical level, the paper discusses data from a variety of languages including Greek, Romanian, Spanish, Italian, Serbo-Croatian, Bulgarian, and others.

The rest of the paper is organized as follows: in Section 2, I will briefly present the general properties of imperative clauses and the various types of imperatives described in the literature; in Section 3, I will introduce modality as a possible feature relevant for imperatives; in Section 4, I will consider the person feature of imperative verbs and imperative subjects; in Section 5, I will discuss how assuming a modality feature and a person feature can account for the properties of imperatives; and in Section 6, I will draw the conclusions and mention some of the consequences of the view assumed in this paper.

2. Imperatives

2.1 General properties

One way of distinguishing imperatives from other types of clauses is to define them as sentences that express orders or commands. Even though virtually any sentence can be used to express an order or a command given the right context, there is a number of sentences that can only be used as commands, no matter what the context is.

To illustrate this difference, consider the following example:

(2) The door is open.

If the speaker's room mate just came in and left the door open, and the speaker utters (2) while pointing at the door, the speaker's intention is probably to get the room mate to close the door. Hence the speaker *is using* (2) as a command. On the other hand, if (2) is uttered in a different context – say the speaker just left the house and then meets the room mate in the street going towards the house and the speaker has the only key to the apartment – then the speaker's intention is plausibly different when uttering (2), namely to simply inform the room mate that the door is open.

Our use of the term 'imperative' will disregard clauses such as (2), whose interpretation as orders depends exclusively on the intention of the speaker. In doing this, we want to restrict our discussion to clauses that are unambiguously imperatives and that contain some formal marking of their type. Our approach will thus side with the tradition which assumes that imperatives have specific syntactic properties (Schmerling 1982; Pollock 1989; Beukema & Coopmans 1989; Zhang 1991; Platzack & Rosengren 1998), and will differ from the post generative semantics treatment in which imperatives denote a certain type of proposition whose directive illocutionary force is generated via pragmatic inference (Bolinger 1977; Huntley 1982; Davies 1986; Wilson & Sperber 1988).

2.2 Two types of imperatives: *true* vs. *surrogate*

As proposed initially by Joseph and Philippaki Warburton 1987, imperatives can be divided into two classes: *true* imperatives and *surrogate* or *suppletive* imperatives.

Morphologically, in *true* imperatives, the verb is drawn from a distinct verbal paradigm, which is used exclusively for giving orders, while in *surrogate* imperatives, the verb is taken from a morphological paradigm which can express an order or command, but not necessarily so, for example the subjunctive, the indicative or the infinitive. When these latter forms occur in an embedded clause, they can express both commands and non-commands. However, when these forms occur in a main clause, the expressed meaning is always an order or a command.

(3) True Imperatives

a. *Inchide usa!* (Romanian)
Close.IMP.2S door.the
'Close the door!'

b. *Pijene!* (Greek)
Go.IMP.2S
'Go!'

c. *Fige!* (Cypriot Greek, Rivero & Terzi 1995 example (46))
leave.IMP.2S
'Leave!'

d. *Citajte!* (Serbo Croatian)
read IMP 2P
'Read!'

e. *Ceti!* (Bulgarian)
read.IMP.2.SG
'Read!' (Rivero 1994)

(4) Surrogate Imperatives

a. *Sã închizi usa!* (Romanian)
SUBJ.PRT close.SUBJ.2SG door.the
'Close the door!'

b. *Na pas!* (Greek)
SUBJ.PRT go.SUBJ/IND.2.S
'Go!'

c. *Da cetes!* (Bulgarian)
SUBJ.PRT read.IND.2.SG
'You should read!' (Scatton 1984)

Syntactically, *true* imperatives are assumed to have distinct structural properties – they undergo raising to a high functional head, which precedes the position of clitics (as shown in (5a)) and they are incompatible with the negative marker (as shown by the ungrammaticality of (5b)), while *surrogate* ones adopt the structural properties of their source morphological paradigms (Rivero 1994; Rivero & Terzi 1995). In particular, the verb inflected for subjunctive in (6) follows both pronominal clitics and the negative marker, as shown in (6a) and (6b), respectively.

(5) True Imperatives

a. *Diavase to!* (Greek)
Read.IMP.2s CL.3.SG
'Read it!'

b. **Den/mi diavase!*
NEG read.IMP.2s
'Don't read!'

(6) Surrogate Imperatives

a. *Na tu to stilis!* (Greek)
NA(SUBJ.PRT) CL.3.SG.MASC CL.3.SG send.SUBJ.2SG
'You should send it to him!'

b. *Na min tu to stilis!*
NA(SUBJ.PRT) NEG. CL.3.SG.MASC CL.3.SG send.SUBJ.2SG
'You should not send it to him!'

2.3 Two classes of true imperatives

Rivero and Terzi 1995, Postma and van der Wurff 2007, etc. notice that not all true imperatives are incompatible with the negative marker and thus propose that a further distinction should be made within the class of true imperatives between Class I imperatives, which cannot be negated, and Class II imperatives, which can. Among languages that have true imperatives but disallow negative imperatives are Greek, Romanian, Spanish, Italian, Portuguese, Catalan, Sardinian, Hungarian, Latin, Hebrew. Class II languages include Serbo Croatian, Bulgarian, Macedonian, Russian, Polish, Czech, Albanian, Slovenian, Berber, Basque, Yiddish, Norwegian, Swedish, German.

(7) Class 1 True Imperative

a. **Den/mi diavase!* (Greek)
NEG read.IMP.2s
'Don't read!'

b. **En/mi fige!* (Cypriot Greek)
not leave.IMP.2s
'Don't leave!' (Rivero & Terzi 1995 example (46b))

(8) Class 2 True Imperatives
Ne ceti! (Serbo-Croatian)
NEG read.IMP.2s
'Don't read!'

Moreover, this distinction is matched by a difference regarding the relative position with respect to clitics: Class I true imperatives always precede clitics, as illustrated in (9)–(12), whereas Class II true imperatives may either precede or follow clitics, as illustrated in (13).

(9) a. *Citeste-le!* (Romanian)
Read.IMP.2.SG-them.CL
'Read them!'

b. ****Le*** *citeste!*
Them.CL read.IMP.2.SG
'Read them!'

(10) a. *Telefona le* (Italian)
call.IMP.2s her.CL
'Call her!'

b. ****Le*** *telefona!*
her.CL call.IMP.2s
'Call her!'

(11) a. *Lee lo!* (Spanish)
Read.IMP.2.s it.CL
'Read it!'

b. ****Lo*** *lee!*
it.CL read.IMP.2.s
'Read it!'

(12) a. *Faites* ***le!*** (French)
Do.IMP.2.PL it.CL
'Do it!'

b. ****Le*** *faites*!
it.CL do.IMP.2.PL
'Do it!'

(13) a. Č*itajte* ***je!*** (Serbo-Croatian, Rivero & Terzi 1995)
read.IMP.2P it.CL
'Read it!'

b. *Knjige* ***im*** *citajte!* (Serbo-Croatian)
Books to-them.CL read.IMP.2P
'Read books to them!'

For reasons of space, I will leave aside any discussion about the Class I vs Class II distinction, for which what seems to be relevant is not the syntax of imperative verbs, but the properties of the negative marker or the specific properties of clitics in the respective language.

As to the contrast between true imperatives (Class (I) and surrogate imperatives, several analyses have been proposed (Laka 1990; Rivero 1994; Rivero & Terzi 1995; Zanuttini 1991, 1994, 1997; Han 1998; Tomic 2001; Isac & Jakab 2004; Miyoshi 2002; Bošković 2004, 2008, etc).

One type of analysis proposes *different syntactic locations for the imperative features*: with true imperatives it is CP that hosts imperative features and thus the verb needs to raise to C, whereas with surrogate forms the imperative features are located in a lower position, say an FP. Such a view can be found in Rivero 1994, Rivero and Terzi 1995, Zanuttini 1994, 1997, Han 2000. Zanuttini 1994, 1997 attempts to motivate this split by proposing that the default location of imperative force features is the lower location – FP, and that true imperatives are defective and lack the projection FP. Given that FP is lacking in true imperatives, the verb raises to the next projection up that hosts relevant imperative features. This higher projection is assumed to be a Polarity Phrase in Zanuttini's 1994 view and a CP in Zanuttini 1997.

(14) a. $[_{CP}\ [_{\cancel{PolP}}\ \cancel{Pol^0}\ [_{FP}\ \mathrm{F}^0\ [_{VP}\ V^0]]]]$ (surrogate imperatives)
b. $[_{CP}\ [_{PolP}\ Pol^0\ [_{\cancel{FP}}\ \cancel{\mathrm{F}^0}\ [_{VP}\ V^0]]]]$ (true imperatives)

Another type of analysis attempts to *unify true imperatives and surrogate ones* (Isac & Jakab 2004; Miyoshi 2002; Bošković 2004, 2008; Postma & van der Wurff 2007): all imperatives, be they true or surrogate, are assumed to check an imperative feature in a head which is higher than the Infl head and than negation.[1]

Cross linguistic variation follows in this view from the particular properties that clitics and negative markers have across languages, as well as from the particular mechanism by which the imperative Force feature is checked (by merging a free morpheme in the head of the projection hosting imperative features; by moving the imperative verb to this head; or by moving the Negative marker to the same head).

1. Miyoshi 2002, Bošković 2004, 2008 simply mention a unified analysis as a possibility, along with the alternative of assuming that surrogate imperatives do not have an imperative feature at all.

Under the view adopted in this paper, the differences between true imperatives and surrogate ones will emerge from the finer grained feature system that we propose in order to characterize imperative clauses.

3. A modality feature

In this section I will argue that one of the features that are relevant for the syntax and semantics of imperatives is a modality feature.

The starting observation is that the position occupied by true imperatives – the position immediately preceding the clitic in the examples below – can also be taken by other lexical items: the negative marker, the subjunctive particle or the infinitive particle.

(15) a. *Diavase* *to!* (Greek)
Read.IMP.2s it.
'Read it!'

b. *Mi(n)* *to* *grafis!*
NEG it write.SUBJ.2.SG
'Don't write it!

c. *Na* ***tu*** ***to*** *stilis!* (Greek)
SUBJ.PRT CL.3.S.DAT CL.3.S.ACC send.SUBJ.2.S
'Send it to him!' (Philippaki-Warburton 1998)

(16) a. *Du* *-**te!*** (Romanian)
carry.IMP.2.SG -CL.REFL.2.SG
'Go!'

b. *Nu* ***te*** *duce*
NEG IMP.REFL.2.SG carry.INF
'Don't go!'

c. *Sã* ***te*** *duci!*
SUBJ.PRT IMP.REFL.2.SG carry
'Go!'

d. *A* ***se*** *manevra* *cu* *grijã!*
INF.PRT IMP.REFL handle with care
'Handle with care!'

Crucially, all the sentences that contain an item in the pre-clitic position have a similar interpretation, i.e. they are all interpreted as expressing orders.

It doesn't seem likely that what all these items share is an *Imperative Force* feature, since subjunctive particles like *sã/na* or infinitive particles like *a*, or the negative marker can show up without an imperative interpretation when embedded.

(17) a. *Le* *place* ***sã*** *se* *tundã* *scurt.*
CL.3.PL.DAT like.IND SUBJ.PRT REFL.ACC hair-cut.IND.3.PL short
'They like to cut their hair short' (Romanian)

b. *E* *posibil* (*ca* *Ion*) ***sã*** *fie* *la* *servici.*
be.3SG.PRES possible (that Ion) SUBJ.PRT be.SUBJ at work
'It could be that Ion is at work' (Romanian)

c. ***A*** *gresi* *e* *omeneste* (Romanian)
INF.PRT err.INF is human
'To err is human'

d. *Fandazome* *ton* *Kosta* ***na*** *tighanizi* *psaria.*
imagine.1S.PRES ACC Kostas PRT fry.3S.IND fishes
'I visualize Kostas frying fish' (Greek, Iatridou 1993)

e. *Bori* ***na*** ***min*** *exun* *kimiθi* (Greek)
can.3.SG SUBJ NEG have.3.PL slept
'It is possible that they haven't gone to bed yet'.
(Janda & Joseph 1999, p. 4, example (4a))

f. ***Min*** *iδes* *to* *peδi* (Greek)
NEG saw.2.SG the child
'Did you perhaps (happen to) see the child'
(Janda & Joseph 1999, p. 4, example (4f)

I propose that the feature hosted by the relevant head that precedes the clitics and shared by all the items illustrated above is a *Modality feature*. The semantic import of a modality feature is to present a proposition as a possible and desirable state of affairs. This proposal is in line with other researchers who claim that imperatives have a modal dimension (Huntley 1982; Huntley 1984; Davies 1986; Wilson & Sperber 1988; Ninan 2005; Han 2000; etc.).[2]

3.1 Negation and modality

If the feature that is checked in a pre-clitic position is Modality, then it must be that all the items that raise to this position have this feature. In particular, the modality feature is shared by true imperative verbs, subjunctive particles, infinitive particles and negative markers. It is relatively easy to see how a Modality feature could be semantically justified for true imperatives, subjunctives and infinitives: all of these are interpreted as potential, possible events, that are not actualized. On the other hand, the negative marker is less obviously expressing modality. However, the claim that negation is modal is supported by two observations.

2. For a different view, see Portner 2007.

i. First, as pointed out by Sasahira 2007, negative sentences do not express a commitment to the existence of the situation described by the clause that is being negated and as such they are modal. In particular, negative sentences are compatible with a *whatever* phrase, which lacks any commitment to the existence of the members of the domain of quantification. Such expressions have been dubbed by Dayal 1998 as essential quantifiers. The following examples are from Sasahira 2007.

(18) *Whatever the situation was*, Peter didn't eat Mary's cookies.

Moreover, a predicate like *happen to*, which does commit itself to the existence of the members of the domain of quantification, and thus cannot be interpreted within the scope of a modal operator, must be interpreted outside the scope of negation when the two co-occur, as expected if negation is indeed modal.

(19) Peter didn't *happen to eat* Mary's cookies.
  i. It happened to be true that Peter didn't eat Mary's cookies.
  ii. *It is not the case that Peter happened to eat Mary's cookies.

ii. Another piece of evidence in favor of a modal analysis of negation is the acceptability of negative sentences in examples involving intersentential anaphora. As first pointed out by Roberts 1989, a successful anaphoric linkage is possible across a sentential boundary if the mood of both sentences is non-assertive, i.e. it does not commit the speaker to the existence of the referents introduced in the sentences. This phenomenon is known as modal subordination. The examples below are from Sasahira 2007.

(20) a. If John bought a book$_i$, he'll be home reading it$_i$ by now.
  b. #It$_i$'s a murder mystery.

(21) a. If John bought a book$_i$, he'll be home reading it$_i$ by now.
  b. It$_i$'ll be a murder mystery.

In both (20a) and (21a) the antecedent for the pronoun *it* is introduced in a non-assertive, non-factual context, i.e. in the antecedent of a conditional. If the continuation in the (b) sentence is in the same non-factual mood, as in (21b), anaphoric linkage is possible, but if it is in an assertive mood, as in (20b), anaphoric linkage is not possible. Going to negative sentences now, the examples below show that they can host successful anaphoric linkage, which in turn shows that they pattern with non-factual, non-assertive modal sentences.

(22) a. John didn't buy *a mystery novel*$_i$.
  b. He would be reading *it*$_i$ by now.
  c. #He is reading *it*$_i$ now.

The pronoun in (22b) can be interpreted as anaphorically related to the indefinite a *mystery novel* in (22a), but it can't in (22c).

Given the discussion above, I will assume that negative markers bear a modality feature. The immediate advantage is that we can now propose that the syntactic head to which all the forms in (15) to (16), as well as all the subjunctive particles, infinitive particles, and negative markers in the non-imperative contexts in (17) raise hosts a *modality feature*. This allows for a unified analysis of both true and surrogate imperatives, a welcome result.

3.2 More on modality

The view on modality that I adopt originates in Kratzer 1981, 1991, who proposes that the semantic core of modality is relational. A modal verb like *must* in (23), for example, expresses a relation between *what is known* and a proposition – *They have arrived*. (23) can thus be paraphrased as 'In view of what is known, they have arrived'.

(23) They must have arrived.

(24) Relational modal:
must in view of *what is known* *They have arrived*

The many tinges of modality expressed by *must* (or any other carrier of modality, for that matter) is the result of the fact that modality is context dependent, in Kratzer's view. Depending on the context, a modal sentence can be evaluated against what is known, as in (24), but also against a set of norms or laws, or against what is desirable, for instance. The relevant subpart of the context that is relevant for a particular modal judgment is called the *modal base*. The various tinges of meaning for a modal sentence thus ultimately depends on the choice of the modal base. To illustrate, consider the following sentences, all of which include the modal *must*.

(25) a. All Maori children *must* learn the names of their ancestors.
b. The ancestors of the Maoris *must* have arrived from Tahiti.
c. When Kahukura-nui died, the people of Kahungunu said: Rakaipaka *must* be our chief.

The *must* in sentence (a) is deontic, as it is evaluated with respect to a set of norms, and it invokes a duty. The *must* in sentence (b), on the other hand, relates to a piece of knowledge or evidence, and is evaluated against an epistemic modal base. The *must* in (c) is again different: it relates to preferences or wishes ('bouletic' must) The various context related meanings of modals can be divided into two main types: root and non-root. The examples below are from Hacquard 2006.

(26) a. *Pour aller au zoo, Jane a pu prendre le train.*
for go.ing to-the zoo, Jane has could take.INF the train
(Root: ability)
'In order to go to the zoo, Jane was able to take the train'

b. *Pour aller au zoo, Jane a dû prendre*
for go.ing to-the zoo, Jane has must.PAST.PRT take.INF
le train (Root: goal oriented)
the train.
'In order to go to the zoo, Jane had to take the train'

c. *Jane doit brosser ses dents.* (Root: deontic)
Jane must brush.INF her teeth
'Jane must brush her teeth'

(27) a. *Je crois que pour aller au zoo, Jane a dû*
I think that for go.INF to-the zoo, Jane has must
prendre le train. (Non-root: epistemic)
take.INF the train
'I think that in order to go to the zoo, Jane had to take the train' must have taken the train

b. *Tu dois brosser tes dents!* (Non-root: deontic)
You must brush.INF your teeth
'You must brush your teeth'

At first blush there seems to be an overlap between the meanings of root modals and the meanings of non-root ones. For example, one and the same modal verb can be interpreted as a root, goal oriented modal, or as an epistemic modal (compare (26b) and (27a)). Similarly, the modal verb *devoir* can be interpreted as root deontic or a non-root deontic (compare (26c) and (27b)). As mentioned above, this can be explained by taking into account the context, or the *conversational background*, which is a major ingredient of modality. Depending on the modal base, one modal verb could be interpreted in various ways. However, both (26b) and (27a) are evaluated according to what is known, and both (26c) and (27b) are evaluated against a modal base consisting of a set of norms, so a finer distinction is needed. One important difference between the modal bases of the two types of modals is that the modal base of root modals is circumstantial, while the modal base of non-root modals is more general.

Thus, in order to utter (26b) we take into account Jane's knowledge of the relevant circumstances, i.e. her knowledge of the distance to the zoo, of the availability of other means of transportation, of the time when she wanted to go to the zoo, etc. Hence the modal base is circumstantial. The proposition is true or false depending on whether the evidence available to Jane in the particular circumstances in which Jane is placed is conducive to the decision of taking the train. In contrast, in uttering (27a) what counts is the *complete* evidence available to the speaker, and the proposition may turn out to be true or false depending on whether this evidence is compatible with going to the zoo by train. Apart from differences related to the modal base, root modals can also be distinguished from non-root modals by considering a number of other properties.[3] The following discussion is based on Hacquard 2006.

The first property I will discuss has to do with whether or not a particular modal is subject orientd. Root modals are subject oriented. i.e. they express the ability, goal or obligation/permission affecting the subject, and not the speaker or the addressee (on the distinction between subject oriented deontics and addressee oriented deontics, see Feldman 1986). Thus, the deontic root modal *should* in (28) expresses an obligation that rests with the subject: a third person plural subject in (a) or a second person singular one, in (b).

(28) a. *They* should sit down.
b. *You* should sit down.

In contrast, non-root modals are keyed to a participant of the speech act (either the speaker or the adressee). More specifically, if the non root modal has an epistemic interpretation, the epistemic state is that of the speaker, while non root modals with a deontic interpretation describe a deontic state of the addressee.

(29) a. John must be happy. (non-root, epistemic)
b. John must go to bed at 8. (talking to the babysitter) (non-root, deontic)

What (29a) means is that it must be the case that John is happy given the evidence available to *the speaker*. On the other hand, (29b) states that the babysitter (i.e. *the addressee*) should see to it that John should go to bed at 8. Notice that this difference also underlies the contrast between (26b) and (27a). The differences between these two examples can be accounted for not only in terms of the modal bases – the modal base of the root modal verb in (26b) is circumstantial, whereas the modal base of (27a) is not. On top of this, there are differences that have to do with the individual that has access to the evidence. (26b) is evaluated against a modal base that includes the circumstances *available to Jane*, whereas the non-root epistemic modal in (27a) is evaluated against a modal base including all the evidence *available to the speaker*. The other property that reinforces the

3. The properties that I will discuss below include (i) subject orientation and (ii) temporal interpretation. Even though the set of properties that help distinguish between root and non-root modals is larger than this, for lack of space, I will limit myself to a discussion of these two properties.

distinction between root and non root modals has to do with the time at which the truth of the modal sentence is evaluated.

The time of evaluation of the root modals is the time provided by the tense. In contrast, the time of evaluation of non-root modals is the Speech Time–*now*. In order to illustrate this difference, consider again (26b) and (27a)), repeated below.

(30) *Jane a dû prendre le train.*
Jane has had-to take the train.
'Jane had to take the train.'

a. root, goal oriented: 'given *Jane*'s circumstances *then*, she had to take the train then'.
b. non-root epistemic: given *my* evidence *now*, it must be the case that Jane took the train then

Under a root, goal oriented interpretation, the modality is anchored to the time provided by Tense, i.e. the Past. Thus, a suitable paraphrase is as given in (30a). If the modal is interpreted as a non-root epistemic, on the other hand, the time of evaluation is the Speech Time and a suitable paraphrase is as in (30b). I will conclude that modals fall into two categories: root modals, which have a circumstantial modal base, are subject oriented and are anchored to the time provided by Tense, and non-root modals, which have an epistemic or deontic modal base, are oriented towards a participant to the speech event, and are anchored to the Speech Time (now).

3.2.1 *Modality in imperatives*

Given the distinction above between root and non root modals, it can be shown that imperatives pattern with non-root modals. The deontic interpretation of imperatives does not provide an unambiguous hint, since both root and non-root modals can be deontic, as shown in (26c) and (27b). However, on the basis of the other two properties discussed above, I will propose that imperatives pattern with non root modals – just as non root modals, imperatives are oriented to a participant to the Speech Event, and they are anchored to the Speech Time.

3.2.2 *Addressee orientation in imperatives*

Most researchers agree that true imperatives are oriented towards the addressee.

Moreover, even when the subject of the surrogate imperative is 3rd person, the interpretation still involves the addressee. The addressee can be overtly named, as in (31a), from Zanuttini 2008, or not, as in (31b) from Hacquard 2006.

(31) a. Nobody leave the hall, sergeant!
b. Kitty has to brush her teeth!

In (31a), the subject is the 3rd person *nobody* but it is the overtly expressed Addressee (the sergeant) that is asked to see to it that nobody leaves the hall. (31b) can be interpreted as a surrogate imperative only if the addressee is the one actually performing the event of brushing Kitty's teeth or the addressee is at least responsible for making Kitty brush her teeth.

The orientation towards the addressee is not simply a pragmatic implicature of these sentences.[4] Virtually any sentence, could have such an implicature if uttered in the right context, even in the absence of any (high) modality feature. For instance, if you said to the babysitter 'Kitty likes macaroni and cheese for dinner' or 'Kitty's bedtime is 9PM', there would be a pragmatic implicature about what the babysitter should do. Crucially, though, this implicature could be cancelled.

(32) a. Kitty likes macaroni and cheese for dinner, but you could give her whatever you want, she'll eat it anyway.
b. Kitty's bedtime is 9PM, but tonight she can go to bed later.

In contrast, imperatives such as (31a,b) have an entailment that the addressee is under the obligation to see to it that a certain state of affairs holds. This entailment, unlike implicatures, is not cancelable. Thus, continuations as in (33b) or (34b) are unacceptable.

(33) a. Nobody leave the hall, sergeant!
b. ??? Nobody leave the hall, sergeant! But you can let some of them go.

(34) a. Kitty has to brush her teeth!
b. ??? Kitty has to brush her teeth but you could put her to bed without brushing her teeth.

3.2.3 *Time of evaluation*

Just as observed with non-root modals, the time of evaluation for imperatives is the speech time, rather than the time provided by Tense. To see this, consider the following examples.

(35) a. Do try this!
b. *Did try this!

(36) They might (already) have won the game. (Hacquard 2006)

(35) shows that imperatives cannot be interpreted in the Past (and in fact at any other time but the time of utterance), while (36) shows that even though the epistemic possibility can be about a past time, it is evaluated at the time of

4. Thanks to an anonymous reviewer for making me clarify this point.

utterance. (36) can be paraphrased by saying that it is possible, as far as I (the speaker) know (right now), that (at some past time) they won the game.

4. Account

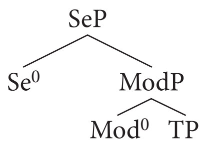
In order to account for the differences between root and non root modals, as well as for the fact that imperatives pattern with non-root modals, I will adopt two proposals that have been made in the literature. The first one concerns the existence of two syntactic positions for modals, rather than a single one (Avram 1999; Butler 2004; Hacquard 2006; etc):

(37) $\text{ModP}_{HIGH} > \text{TP} > \text{ModP}_{LOW} > \text{AspP}$

The two positions correlate with the distinction discussed above between root and non root modals: the high modality position hosts non root modals (epistemics and deontics), as well as imperatives, whereas the low modality position hosts root modals.

Second, in order to account for the anchoring of imperatives to a speech event participant, as well as to the Time of Speech, I will propose the following structure:

(38)



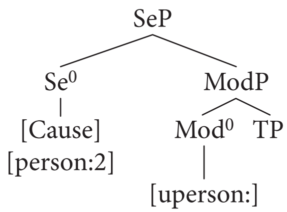
The representation above contains a syntactic projection higher than the high modality phrase which is labelled the Speech Event, following Speas and Tenny 2003, and Hacquard 2006.[5] The Speech Event head provides the individual anchoring of the high modals and of imperatives in the sense that it it able to capture the fact that high modals and imperatives are keyed to a participant of the speech act, rather than to the subject (see also Palmer 1986; Feldman 1986; Hacquard 2006). An additional advantage of assuming a Speech Event projection is that it can also account for the temporal anchoring of high modals and imperatives. In particular, it can account for the fact that the time of evaluation for imperatives and for high modals is always the speech time, rather than the time provided by Tense. One question that arises concerns the exact choice of speech act participant that various high modality carriers are keyed to. In particular,

5. See the discussion in Speas and Tenny 2003 on how this differs from Ross's 1970 proposal that the underlying structure of various types of clauses contains specific higher performative predicate.

epistemics are keyed to the speaker, high deontics are keyed either to the speaker or the addressee, while imperatives are always keyed to the addressee. What is of interest for this paper and what we need to explain is the consistent orientation of imperatives towards the addressee.

I propose that the Speech Event head comes in two varieties, one of which is causal, and the other one is not. The causal Speech Event is caused by the Speaker but the actor responsible for carrying out the caused event is the Addressee. This can be implemented by proposing that whenever the Speech Event head is causal, it also bears 2nd person features.

(39)



The 2nd person feature on the Speech Event head will enter an Agree relation with the uninterpretable person feature on the high Mod head and as a result, the latter will be valued as 2nd person. As discussed by Quer 1998, this causal feature seems to be at work in 'mood selection'. Quer proposes that the semantic structure of subjunctive-taking verbs is more complex than that of indicative-taking verbs. More specifically, subjunctive taking verbs do not directly select the subjunctive complement, but are co-ordinated with another VP headed by 'cause', which itself selects the subjunctive. The verb merely expresses a manner of causing. In other words a sentence like (40a) is roughly equivalent with (40b):

(40) a. The doctor said that the patient should be operated on.
b. The doctor caused it that the patient should be operated on by saying it.

The presence of the 'cause' component accounts for the exercitive meaning of these sentences, as well as for the selection of the subjunctive.

Similarly, in our view, the exercitive meaning of imperatives can be captured by the presence of a [Cause] feature in the Speech Event head, as in (39). An imperative like (41a) is thus interpreted as (41b).

(41) a. Brush your teeth!
b. The speaker causes it that the addressee brings it about that his/her teeth are brushed by uttering (a).[6]

6. Notice that there are two causal components: one involved in the act of utterance – the speaker causes the addressee to do something by uttering the imperative sentence – and one

Negation offers further evidence that the syntax of imperatives contains a 2nd person feature hosted by an independent functional head. It is well known that all suppletive imperative forms *can* be negated.

(42)	a.	*Să*	*vii!*			(Romanian)
		SĂ(SUBJ.PRT)	come.SUBJ.2.S			
		'Come!'				
	b.	*Să*	*nu*	*vii!*		
		SĂ(SUBJ.PRT)	not	come.SUBJ.2.S		
		'Dont come!'				

(43)	c.	*Na*	*tu*	*to*	*stilis!*		(Greek)
		NA(SUBJ.PRT)	him	it	send.SUBJ.2S		
		'You should send it to him!'					
	d.	*Na*	*min*	*tu*	*to*	*stilis!*	
		NA(SUBJ.PRT)	NEG.	him	it	send.SUBJ.2S	
		'You should not send it to him!'					

What is interesting is that some surrogate imperatives actually *must* be negated.

(44)	a.	**Călca*	*pe*	*iarbă!*		(Romanian)
		step.INF	on	the grass		
		'Step on the grass!'				
	b.	*Nu*	*călca*	*pe*	*iarbă!*	
		NEG	step.INF	on	grass	
		'Dont step on the grass!'				
	c.	**Grafis!*				(Greek)
		write.SUBJ.2.SG				
		'Write!'				
	d.	*Mi*(*n*)	*grafis!*			
		NEG	write.SUBJ.2.SG			
		'Dont write!'				

involved in the carrying out of the command by the addressee – the addressee causes something to come about. The causal feature in (39) is a feature of the Speech Event head, rather than of the event described by the verb. The agent of the causal speech event is the speaker, whereas the agent of the causal event described by the verb is the addressee.

In order to see why these examples are relevant, notice the crucial role played by negation. On the one hand, negation 'saves' the affirmative counterparts by making the sentences grammatical.

On the other hand, more importantly for the purpose of this section, the sentences in (44b,d) are interpreted as true of a second person singular subject, in spite of the fact that the verb itself contains no agreement morphology. It is the negative marker that brings in this person feature, which plays a crucial role in the syntax and semantics of all imperative clauses.

Given that the negative maker cannot be reasonably assumed to have a 2nd person feature, and given that this feature is not contributed by the verb either, we conclude that the 2nd person feature is hosted by an independent functional head, which we take to be the Speech Event head.

Before closing this section, let me briefly comment on how this view differs from Zanuttini 2008, who proposes that imperatives contain a Jussive Phrase which encodes the Addressee in the syntax. In her view, the Jussive Phrase has a 2nd person feature and its head enters a special relation with the Subject when T has no phi features – a relation that involves semantic binding and syntactic agreement.

(45) $[_{JussP}$ OP $[_{Juss'}$ Jussive^0 $[_{XP}$ Subject$_i$ $[_{X'}$ X^0 $[_{vP}$ t$_i$ $[_{v'}$ v^0 VP]]]]]]

Zanuttini's Jussive P is thus always Addressee based, as it always contains person features in the 2nd singular. In contrast, the Speech Event phrase that we propose can have 2nd person features (when causative), but it can also in principle have other person features as well (when not causative). The advantage is that this proposal can accommodate not only imperative clauses, but also other types of clauses, which are not anchored to the addressee. Moreover, as discussed above, a Speech Event phrase can account for tense anchoring as well.

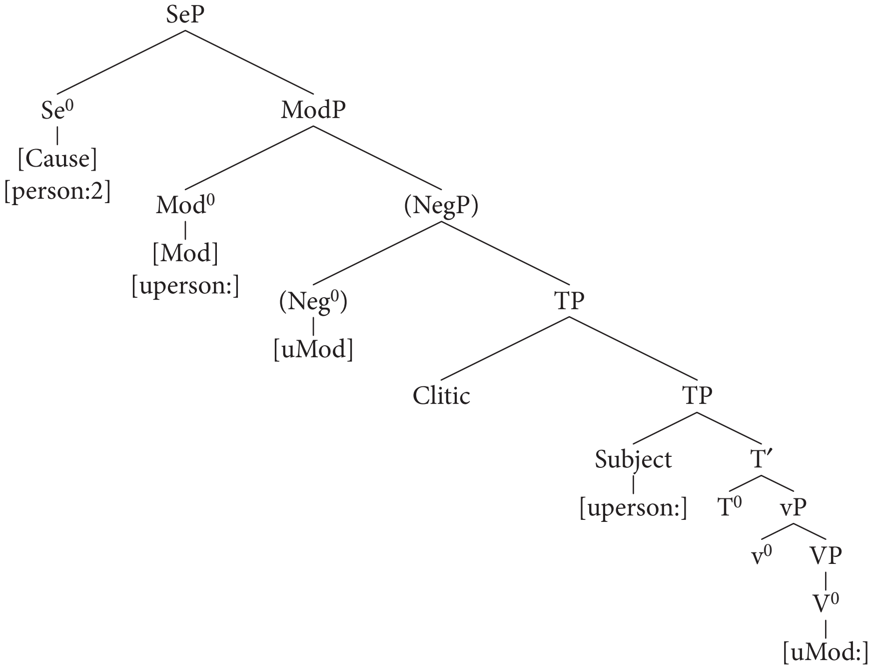
5. Modality and 2nd person features in imperatives: The analysis

In this section I will discuss how the two features introduced above – the modality feature of the high Mod head and the 2nd person feature of the Speech Event head – interact to account for the similarities and differences of various types of imperatives.

5.1 True imperatives

The syntactic structure of imperatives that I propose is given in (46), including the feature content that I assume for the relevant heads.

(46)



True imperative verbs raise to a high Mod head to check their uninterpretable modality feature against the interpretable Mod feature of the Mod head. Once they raise to the high Mod head, true imperatives come to precede clitics, which are related to the TP projection. The phonologically null subject of true imperatives gets its 2nd person features from Mod, which in turn checks its person features against the person feature of the Speech Event head. Crucially, I assume that the T of true imperatives is defective in the sense that it has no person feature.

The impossibility of negating true imperatives follows from the fact that negation also bears Modality features and the NegP is closer to the attracting Mod head than the imperative verb. If the negative marker is attracted to the Mod head, the uninterpretable Modality feature of the imperative verb will remain unchecked and unvalued and the derivation will crash.

5.2 Surrogate imperatives – Subjunctives

Recall that in the subjunctive imperatives described above in Sections 2 and 3 the verb does not raise to Mod, and instead an invariant particle is merged in Mod.

The uninterpretable person feature on Mod enters Agree with the interpretable person feature on the SpeechEvent head and is thus valued as 2nd person. The subject's person feature enters an Agree relation with the closest interpretable person feature. Unlike in the case of true imperatives, subjunctives have phi features in T and hence the interpretable person feature which is closest to the subject is the person feature on T, rather than the person feature on Mod. If the person feature on T happens to be 2nd person, the person feature on T and the person feature on Mod will coincide. But if the person feature on T is not 2nd person, we end up with two values of the person feature associated with subjunctive imperatives: a 2nd person value, obtained from an Agree relation with the Speech Event head, and an independent person feature, obtained from an Agree relation with T. The interpretation of such clauses is that of an event that is brought into existence by a 2nd person agent but whose subject is, say, 3rd person. In this case, the addressee is asked to see to it that someone else brings about a certain state of affairs (within the syntactic literature, cf. Potsdam 1998; Rupp 1999, 2003; Jensen 2003).

5.3 Surrogate imperatives: Infinitives

The derivation of surrogate imperatives in the infinitive form is similar to the derivation of subjunctives described above. In particular, an invariant infinitive particle is merged in Mod, and the verb follows the negative marker and the clitics. Unlike subjunctives, however, infinitives have no phi features in their T and moreover, the interpretation of their (null) subjects interacts with the properties of the negative marker in ways that are detailed below.

From the point of view of the availability of negative and affirmative infinitive imperative forms, two types of languages can be distinguished:

i. Languages in which both affirmative and negative forms are possible with suppletive imperatives in the infinitive form.

(47) a. *Nicht auf den Rasen treten!* (on a lawn) (German)
Not on the grass step.INF
'Do not step on grass!' (Sequeiros 2002, p. 109)

b. *Hier klingen!* (on a door bell) (German)
here ring.INF
'Ring here!' (Sequeiros 2002: 109)

ii. Languages in which only negative forms of short infinitives are possible as imperatives

(48) a. **Cãlca pe iarbã* (Romanian)
step.INF on grass
'Step on the grass!'

b. *Nu cãlca pe iarbã*
NEG step.INF on grass
'Don't step on the grass!'

However, if the infinitive is in the 'long' form (i.e. if the infinitive particle is overt), both affirmative and negative forms are possible as imperatives.

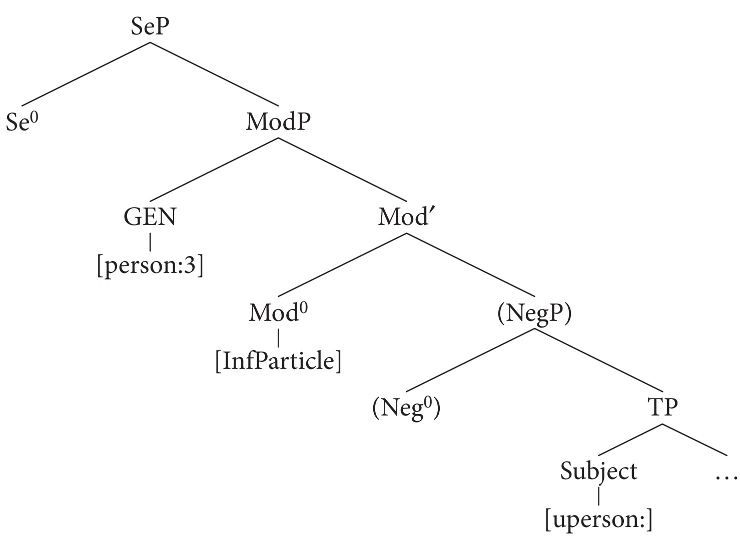
(49) a. *A se evita consumul de alcool.*
INF.PRT REFL.CL avoid.INF consumption of alcohol
'Avoid alcohol!' (Romanian)

b. *A nu se lăsa la îndemâna copiilor*
To.INF.PRT not REFL.CL leave at reach children.DAT
'Keep out of reach of children!'

Infinitives as surrogate imperatives exhibit different interpretations in the two types of languages. In the former type, the interpretation is generic, whether the infinitive is negated or not. Thus, suitable paraphrases for (47) would be 'One should not step on the grass!' or 'One should ring here!'. In contrast, in the second type of languages, a generic interpretation obtains only with long infinitives. With short infinitives, the negative infinitive (the only one possible) is interpreted as 2nd person singular. Thus, suitable paraphrases for (49) would be 'One should avoid alcohol!' or 'One should keep this out of reach of children!', while the only possible interpretation for the subject of (48) is 2nd person singular, and not generic.

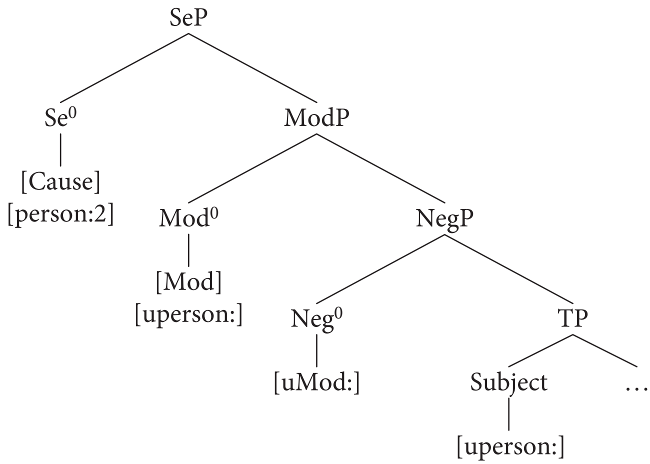
For type 2 languages I propose that the infinitive particle of long infinitives is merged in Mod, just like the subjunctive particle, but unlike subjunctive particles it licenses a Gen operator in SpecModP. The Gen operator has a default person feature which will value the person feature on the subject as a default 3rd person.

(50)



If no infinitive particle is present, as in the case of short infinitives, the negative marker raises to Mod to check its Mod feature, and in so doing, it incorporates the person feature of Mod, which is valued as 2nd person by Agree with the causative Speech Event head. Crucially, the negative head lacks Gen features.

(51)



The obligatory presence of negation in infinitive surrogate imperatives in these languages can be explained as follows: (i) the Mod head has an EPP feature in these languages. In other words, the Mod head in these languages must always be filled by lexical material: either an infinitive particle that is merged directly in Mod, or an item with a Mod feature, such as the verb, which is attracted and moves overtly to the Mod head; (ii) the infinitive verb itself does not bear a Mod feature; (iii) these languages have no null infinitive particles that could be merged in the Mod head. In the absence of negation, the EPP feature on the Mod head cannot be checked since nothing is merged in the Mod head and there is no item with a suitable matching Mod feature that could raise to the Mod head. If, on the other hand, the Neg head is present, the EPP feature on Mod can be checked against the Neg head, which can raise to Mod.

As to type 1 languages, in which both affirmative and negative forms are possible with suppletive imperatives in the infinitive form, I will propose that the infinitive verb stays low (the verb does not raise to the high Mod head) and that a null infinitive particle is merged in Mod. Infinitive imperatives in type 1 languages are thus very much like long infinitive imperatives in type 2 languages – the only difference is the overt vs covert nature of the infinitive particle. This would explain the consistent generic interpretation of infinitives used as surrogate imperatives in these languages.

6. Conclusions

In this paper I have identified two features that are arguably relevant for the syntax and semantics of imperative clauses: the modality feature and the 2nd person feature. The differences between true imperatives/surrogate imperatives can be captured in terms of whether these features are checked by the verb or not, as well as in terms of whether the subject checks its person feature against the 2nd person feature encoding the addressee or not.

True *imperatives* check both of these features on the verb: they raise to the high Mod head where they check the modality feature, as well as the person feature by Agree with the SpeechEvent head. The (phonologically null) subject of true imperatives gets its 2nd person features derivatively, by checking its person feature against the person feature of the Mod head. In contrast, with *surrogate imperatives*, the Modality feature or the 2nd person feature encoding the addressee are never overtly realized on the verb. The Modality feature is carried either by an invariant particle, or by the negative head, but not by the verb. There is thus a division of labour between the particles or negation on the one hand, and the verb, on the other hand, and the modality feature is carried by the former.

As to the person feature, some surrogate imperative forms of the verb (i.e. the subjunctive) can have person features, but these features are never checked against the 2nd person feature of the SpeechEvent head. The following surrogate forms were discussed:

Subjunctive imperatives check the Mod feature by Merge of a subjunctive particle in the high Mod head and the person feature by Agree with the phi features in T. The person feature of the subjunctive verb and thus of the subjunctive subject are 2nd person only by accident, i.e. if the person feature of T happens to be 2nd person. Crucially, subjects of subjunctive imperatives do not check their person feature against the person feature of the Speech Event head. *Infinitive imperatives* check their Modality feature either (i) by Merge of an infinitive particle (be it overt of covert) in the high Mod head, or (ii) by movement of the Negative head into the high Mod. Infinitive particles (be they overt or covert) license a Gen operator with default generic person features. The Gen operator is closer to the subject than the SpeechEvent head and thus the Subject enters Agree with Gen, and not with the SpeechEvent head. If no infinitive particle is present, and Negation raises to the high Mod head, the subject will get 2nd person features by Agree with the Mod head and implicitly with the SpeechEvent head. Even though negative infinitives come closer to true imperatives from the point of view of the person features of the subject, they still differ from the latter in that the person feature is not realized on the verb.

To the extent to which these features will prove to be instrumental for the characterization of other clause types as well, this will contribute to a better understanding of the similarities and differences between various types of clauses.

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Function without content

Evidence from Greek subjunctive *na*

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In this paper we provide new evidence for the assumption that the content of functional categories should be dissociated from its function (Ritter & Wiltschko 2009, 2011). In particular, we discuss evidence from lexicalization patterns. On standard assumptions, functional categories are intrinsically associated with content; consequently the exponents that spell out these functional categories would also be expected to be intrinsically associated with content. We argue that *na* spells out INFL before it is associated with any kind of content. This allows for a straightforward explanation of the seemingly erratic distribution of *na*. We further explore the consequences of this analysis and we provide evidence from the Down Syndrome grammar.

1. Introduction

In this essay we are concerned with the make up of functional categories. We argue that functional categories exist independent of their feature content. More specifically, we argue for the need to dissociate the function of functional categories from their content. We develop the argument as follows.

In Section 2, we review previous evidence for the dissociation of function and content. On the basis of language variation, Ritter and Wiltschko (2009), argue for a pre-Pollockian view of the functional category INFL. In particular, they argue that INFL universally serves as an *anchoring category* but that it is not universally associated with temporal content. Consequently, INFL cannot be equated with TENSE. Rather, TENSE is better understood as a language-specific instantiation of the universal category INFL.

In this paper, we introduce new evidence for this dissociation of function and content, namely evidence from *lexicalization patterns*. Our core proposal is that the subjunctive marker in Greek (*na*) spells out the function of INFL without its content. In Section 3, we review the distribution of *na*. On standard assumptions, functional categories are intrinsically associated with content; consequently the exponents that spell out these functional categories would also be expected to be intrinsically associated with content. We show that on this assumption, the distribution of *na* cannot be easily understood. We develop a novel analysis couched within the theoretical assumptions of Ritter and Wiltschko (2009, 2011). In particular, we argue that *na* spells out INFL before it is associated with any kind of content. We show that this allows for a straightforward explanation of the seemingly erratic distribution of *na*. We further explore the consequences of this analysis.

In Section 4, we discuss the implications of our analysis for the architecture of grammar. We argue that we need to recognize the possibility for early insertion of functional material (such as *na*).

In Section 5, we discuss the use of *na* by individuals diagnosed with Down Syndrome (henceforth DS). It is often claimed that DS is characterized by the impairment of tense and agreement. We show that the use of *na* is not affected. Given that *na* is associated with INFL it follows that the syntax of INFL is not impaired in DS. Rather what appears to be minimally affected is the association of INFL with content (such as tense).

Finally in Section 6, we conclude.

2. Dissociating function from content

The main goal of this essay is to establish that the function of a functional category exists independent of its feature content. If so, this would establish that functional categories have a life of their own and are not dependent on merging syntactic features during the process of structure building. To formally implement this insight we adopt the framework developed in Ritter and Wiltschko (2011; henceforth R&W). They propose that INFL is a universal functional category, which serves to anchor the event denoted by the VP to some other event.[1] The anchoring function comes about through an unvalued feature associated with INFL. Following Demirdache and Uribe-Etxebarria (1997 and subsequent work) R&W assume this feature to be [coin(cidence)]. Moreover, it is assumed that at least in indicative root clauses, the situation relative to which the event situation is ordered is the utterance situation (see Enç 1987). We take the abstract utterance situation argument to be associated with the specifier position of INFL

1. For the purpose of the discussion, we abstract away from the role of aspect.

(cf. Demirdache & Uribe-Etxebarria 1997).[2] The universal structure for indicative root clauses is thus as in (1).

(1) $_{\text{IP}}$[Utt-sit I$_{\textit{[ucoin]}}$ $_{\text{VP}}$[Ev-sit V]] UNIVERSAL GRAMMAR

On this view, the anchoring function in the sense of Enç 1987 decomposes into the *coincidence* feature inherent to INFL, and the abstract utterance argument in SpecIP. As we will see, it is possible for the *coincidence* feature to occur without the utterance argument. In this case anchoring is not deictic but is instead relative to some other abstract argument (see Section 2.2).

R&W further assume that unvalued features (such as [*u* coin]) have to be valued, or the derivation will not be legible for the interface, and thus crash. While the general idea behind this proposal is in line with much work within the minimalist program, the details of implementation differ considerably. Consider for example English indicative root clauses in the R&W framework. Here, the [*u* coin] feature associated with INFL is valued by tense morphology: past morphology values [*u* coin] as [–coin], while present morphology values [*u* coin] as [+coin]. This is illustrated in (2).

(2) a. $_{\text{IP}}$[Utt-sit I$_{\textit{[+coin]}}$ $_{\text{VP}}$[Ev-sit V$_{\text{\{present\}}}$]]
b. $_{\text{IP}}$[Utt-sit I$_{\textit{[–coin]}}$ $_{\text{VP}}$[Ev-sit V$_{\text{\{past\}}}$]] ENGLISH

The assumption that unvalued features must be valued for the derivation to converge is in accordance with standard minimalist assumptions. However, the nature of the features differs. In particular, on minimalist assumptions the probe goal relation triggering AGREE is initiated by an unvalued feature [uF], which requires in its c-command domain a valued feature of the same type [+F] or [–F], respectively. This contrasts with the claim in R&W according to which the unvalued *coincidence* feature is valued by the semantic content of the valuing element. Thus, the feature, which requires valuation, is not of the same type as the valuing element (which may but need not be tense marking, as we will see).[3]

With this formalism in place, we are now in a position to review previous evidence for the dissociation of function from content. The evidence presented thus far is twofold. First, Ritter and Wiltschko (2009) argue that the content associated with a given functional category is subject to language variation. If the content of

2. We assume the possibility for multiple specifiers to accommodate both the abstract situation argument, as well as the subject to be associated with INFL (see Chomsky 1995 for the assumption that a single head can be associated with multiple specifiers).

3. Whether this type of feature valuation should replace the standard minimalist Probe-Goal mechanism triggering AGREE, or whether it should be viewed as an additional mechanism, is an interesting question which we cannot pursue in the context of this paper.

a functional category can vary, we have evidence that the content of a functional category is independent of the category itself. We discuss this type of evidence in Section 2.1. Second, R&W argue that tenseless constructions such as infinitives and imperatives provide further evidence for the independence of content from function. We review this type of evidence in Section 2.2.

2.1 Evidence from tenseless languages

If the content of a functional category is independent of its function, it is predicted that one and the same functional category may be associated with different content. Ritter and Wiltschko (2009) argue that this is indeed what we observe. As mentioned above, in English indicative root clauses, the content associated with INFL is temporal. This is reflected by the fact that all such clauses must be inflected for tense: present (3a) or past (3b).[4] In the absence of tense inflection (3c), [*u* coin] cannot be valued, and the result is ungrammatical.

(3) a. He **is** kicking.
b. He **was** kicking.
c. *He **be** kicking.

According to this proposal, the inflectional character of tense morphology in English results from the fact that tense serves to value INFL. The obligatory binary opposition in tense is forced by the two possible values for [*u* coin]: past values [*u* coin] as [–coin], and thus asserts that the event time does not coincide with the utterance time; present values [*u* coin] as [+coin], and thus asserts that the event time coincides with the utterance time.

The essence of the Ritter and Wiltschko (2009) argument is that the anchoring function need not be substantiated by tense. Rather, other deictic categories, such as location and person may fulfill the same function. In particular, they argue that in Halkomelem Salish location serves to anchor the event situation to the utterance. As a consequence, the event situation is anchored via a spatial dimension: a distal marker values [*u* coin] as [–coin], and asserts that the event location does not coincide with the utterance location, as in (4a); a proximate marker values [*u* coin] as [+coin] and asserts that the event location coincides with the utterance location, as in (4b).

4. Following Enç (1996), Ritter and Wiltschko (2009) assume that future is a modal rather than tense. Thus, the use of future lies outside the scope of the present discussion. It should be noted however, that there may be languages where future functions as a tense. In this case, one could imagine that it would value INFL as [–coin]. A detailed investigation of future in the framework of R&W has to await further research.

(4) a. $_{\text{IP}}$[Utt-sit $\text{I}_{[-coin]}$ $_{\text{VP}}$[Ev-sit $\text{V}_{\{\text{distal}\}}$]]
b. $_{\text{IP}}$[Utt-sit $\text{I}_{[+coin]}$ $_{\text{VP}}$[Ev-sit $\text{V}_{\{\text{proximate}\}}$]] Halkomelem

As a result, Halkomelem is a language which lacks contrastive tense marking, but instead has contrastive location marking. That is, indicative root clauses are typically introduced by a locative auxiliary (Galloway 1993; Suttles 2004). This is illustrated in (5).

(5) a. ***lí*** *qw'eyílex tú-tl'ò*
dist dance he
'He is/was dancing [there].'

b. ***í*** *qw'eyílex tú-tl'ò*
prox dance he
'He is/was dancing [here].' Halkomelem

They further argue that in Blackfoot (Algonquian) person marking serves to anchor the event to the utterance. As a consequence, the event situation is anchored via participants: non-local (i.e. 3rd person) marking values [*u* coin] as [–coin], and asserts that the event participant does not coincide with the utterance participant as in (6a); in contrast, local (i.e. 1st or 2nd person) marking values [*u* coin] as [+coin], and asserts that the event participant coincides with the utterance participant, as in (6b).

(6) a. $_{\text{IP}}$[Utt-sit $\text{I}_{[-coin]}$ $_{\text{VP}}$[Ev-sit $\text{V}_{\{\text{other}\}}$]]
b. $_{\text{IP}}$[Utt-sit $\text{I}_{[+coin]}$ $_{\text{VP}}$[Ev-sit $\text{V}_{\{\text{local}\}}$]] Blackfoot

As a result, Blackfoot is a language that lacks contrastive tense marking but instead, has contrastive participant marking. That is, indicative root clauses are typically marked with a suffix marking local person, which contrasts with a zero non-local marker. This is illustrated in (7).

(7) a. *Kitsinóóhpoaawa* *Kitsinóókihpoaawa*
*kit-ino-o-**hp**-oaawa* *kit-ino-oki-**hp**-oaawa*
2-see-1:2-**local**-2pl 2-see-2:1-**local**-2pl
'I saw you (pl).' 'You (pl) saw me.'

b. *Ana póókaawa inoyííwa ani imitááyi.*
*an-(w)a pookaa-wa ino-yii-**Ø**-wa an-(y)i imitaa-yi*
dem-prox child-prox see-dir-**3**-prox dem-obv dog-obv
'The child saw the dog.' Blackfoot

In sum, we observe variation in the content of obligatory contrastive marking in indicative root clauses: its content is temporal in English, spatial in Halkomelem, and involves participants in Blackfoot. Furthermore, these three types of markers are in complementary distribution: Halkomelem and Blackfoot are tenseless;

Halkomelem and English don't have obligatory participant marking;[5] and finally Blackfoot and English do not have obligatory location marking. Assuming the classical structuralist criterion, according to which complementarity is the essence of identity, we may conclude that tense, location, and person marking are three different instances of the same category, namely INFL. This, in turn, supports the claim that the substantive content of a given functional category (tense, location, and person) is independent of its core function (i.e. deictic anchoring).

2.2 Evidence from tenseless constructions

The second type of evidence for the dissociation of function from content stems from constructions that are tenseless, even in languages that are otherwise tensed. In particular, R&W investigate the properties of tenseless constructions arguing that in these cases the core function of INFL (i.e. anchoring) is observable in the absence of substantive content.

Take for example infinitives in English, a construction that is often characterized as tenseless. On the surface, this is definitely the case: overt tense marking is prohibited in infinitives, as illustrated in (8).

(8) a. Yoshi wanted to play.
    b. *Yoshi wanted to play-**ed**.

R&W argue that despite the absence of temporal content in INFL, the embedded event is still anchored. But in this case, the event situation is not anchored via content in INFL, nor is it directly anchored to the utterance situation. Instead, the embedded event situation is anchored to the matrix predicate, which in turn is anchored to the utterance. More precisely, R&W argue that the semantic content of the embedding predicate serves to value [*u* coin] of the embedded INFL (see also Ogihara 1996; Abusch 2004; Katz 2001; 2004; Bittner 2005). A future oriented predicate such as *want* values INFL as [–coin] asserting that the embedded event does not coincide with the matrix event. This is illustrated in (9) where the white arrow indicates predicate valuation, while the black arrow indicates anchoring.

(9) $\ldots\ {}_{VP}[\ \text{Ev-sit} \quad \text{V}\ {}_{IP}[\ \text{I}_{[\text{-coin}]}\ {}_{VP}[\ \text{Ev-sit}\ \ \mathbf{V}\ ]]$

Crucially, on the assumption that the content of INFL is dissociated from its function, the existence of tenseless constructions is expected; though it is somewhat

5. For arguments that agreement of the type familiar from Indo-European languages differs from participant marking in Blackfoot see Ritter and Wiltschko (2009). Only the latter but not the former serves to value [*u* coin] associated with INFL.

unexpected on the prevalent view according to which INFL is equated with TENSE. The claim that, even in the absence of temporal content associated with INFL, its anchoring function (in the form of the [*u* coin] feature) is still present, predicts the existence of two types of infinitives: (i) infinitives where the embedded event does not coincide with the matrix event; these are the so called *future irrealis infinitives* embedded under future-oriented predicates like *want* illustrated in (8a) above; (ii) we also expect that an embedded INFL can be valued as [+coin] by the matrix predicate. This is indeed the case. The literature on infinitives recognizes a second type of infinitive, the so called *simultaneous infinitives*, which occur embedded under aspectual predicates such as *start*, as in (10a). These are analyzed as predicates that value the [*u* coin] feature of the embedded INFL as [+coin], as shown in (10b). Accordingly, it is asserted that the embedded event coincides with the matrix event.

(10) a. Mika started to dance.

b. … $_{\text{VP}}$[Ev-sit V $_{\text{IP}}$[I$_{\text{[+coin]}}$ $_{\text{VP}}$[Ev-sit **V**]]

In sum, in the absence of temporal content in INFL, we still observe the anchoring function via the abstract coincidence feature.[6] But in this case anchoring proceeds to the next available situation argument, which is the event situation associated with the matrix predicate. As a consequence, INFL no longer serves as a deictic anchor (because the embedded clause is not associated with an utterance situation; cf. Enç 1987), but instead it serves to sequence the embedded event relative to the matrix event.

This establishes that there are at least two types of valuation strategies available for INFL: first, it can be valued via morphological marking, directly associated with INFL. R&W refer to this as *m-valuation*. Secondly, in the case of infinitives, which lack morphological tense marking and consequently must lack m-valuation, they argue that the predicate serves to value INFL; this strategy is referred to as *predicate-valuation*.[7]

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6. On some analyses, of these phenomena, INFL is still argued to be associated with tense features. In particular, a dependent INFL would be associated with a [−TENSE] feature, while an INFL with independent tense is associated with a [+TENSE] feature (see for example Landau 2000, 2004; Wurmbrand 2001; Ambar 1992, 2010). See R&W 2011 for a detailed discussion of such proposals.

7. This is another aspect in which the mechanics of valuation in the R&W framework differs from the more standard minimalist Probe-Goal relation. In particular, while the unvalued feature requires a valuing feature in its c-command domain (scanning downwards), the R&W

Finally, R&W discuss a third strategy for valuation, which is found in the context of another tenseless construction, namely imperatives. Like infinitives, imperatives are characterized by the obligatory absence of tense morphology, as shown in (11).[8] In the absence of tense morphology, the utterance is obligatorily interpreted as a command (11a), while in the presence of tense morphology, the utterance is obligatorily interpreted as an assertion, and cannot be interpreted as a command (11b) and (11c).

(11) a. Everyone play!
i. *assertion
ii. ✓command

b. Everyone play-**s**!
i. ✓assertion
ii. *command

c. Everyone play-**ed**!
i. ✓assertion
ii. *command

R&W argue that in this case, INFL is valued by the higher functional category C(omp) – hence, they refer to this strategy as *C-valuation*. C in imperatives encodes directive force, which they argue values [*u* coin] associated with INFL as [+coin]. Moreover, they propose that in imperatives, the event situation associated with VP is not anchored relative to the utterance situation, but instead, relative to another type of abstract argument. In particular, they adopt Han's 2001 claim, according to which imperatives encode as part of their meaning a so-called *plan set*. According to Han (2001: 306):

> … by performing a directive action, the speaker instructs the hearer to update a […] plan set. A hearer's plan set is a set of propositions that specifies his/her intentions which represents the state of affairs the hearer intends to bring about. Thus, an imperative is an instruction to the hearer to add p to his/her plan set.

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approach allows for valuation from a lower head (tense-marked verb), or from a higher head (embedding predicate or higher functional head). The possibility for upward probing is however also explored in more standard minimalist analyses (see for example, Baker 2008; Rezac 2004; Putnam & van Koppen 2011; Henderson 2006; Bejar & Rezac 2009).

8. An anonymous reviewer points out that in Hebrew, a language with dedicated future tense morphology, imperatives are not tenseless but are instead future marked. To understand this pattern within the R&W framework, we would have to investigate the properties of future marking in Hebrew more carefully. This has to await another occasion.

Translating Han's insight into their framework, R&W suggest that the plan set is represented as an abstract argument in Spec CP, as illustrated in (12). Accordingly, the directive force in COMP values INFL as [+coin], and as such turns the clause-type into an instruction, rather than an assertion.

(12) $_{\text{CP}}[\text{Plan-set} \quad \text{C}_{[\text{dir}]}\ _{\text{IP}}[\ \text{I}_{[+\text{coin}]}\ _{\text{VP}}[\ \text{Ev-sit}\ \ \mathbf{V}\ ]]$

In sum, an imperative is interpreted as an instruction to the hearer, to make the event situation coincide with the plan set.

This proposal further predicts that we should also find instances where C-valuation values INFL as [−coin]. R&W argue that this is instantiated by counterfactual conditionals. In particular, they argue that counterfactual force in C values INFL as [−coin]. In this case the event situation is anchored relative to an evaluation world, associated with SpecCP.

(13) a. If I had a car, I would drive to the store.
b. $[\ \ \text{C}_{[\text{cf}]}\ _{\text{IP}}[\mathbf{I}_{[-\textbf{coin}]}\ _{\text{VP}}[\ \text{Ev-sit V}\ ]]]$

What is interesting in the present context is that counterfactual conditionals appear to be morphologically marked for tense (e.g. *if I **had** a car …*), nevertheless, the tense morphology does not seem to fulfill its usual function: it does not even seem to have temporal force. This is obvious from the fact that in this context, past morphology is compatible with a present time adverbial as shown in (14).

(14) a. If I had a car now, I would drive.
b. *I had a car now.

On the R&W analysis, the fact that tense morphology in counterfactual conditional lacks temporal force (i.e. it is a *fake past*; Iatridou 2000), follows from the claim that it does not serve to value [*u* coin] associated with INFL. Instead of m-valuation, we get C-valuation.

2.3 Summary

This concludes the review of previous evidence for the claim that the content of functional categories is independent of their function: INFL serves as an anchoring category even in the absence of tense. It is the [*u* coin] feature requiring valuation, which is responsible for the anchoring function. Crucially, however, tense features are only one option to value [*u* coin] and therefore, INFL cannot be equated with TENSE. On the one hand, evidence from language variation shows that other types of morphological contrasts may serve to m-value INFL: location and participant marking. Moreover, m-valuation is only one possible strategy to value [*u* coin]: it may also be valued via predicate valuation or C-valuation. The latter two strategies are responsible for the existence of tenseless constructions, even in languages that are otherwise tensed. It is precisely the existence of such tenseless constructions, which provides crucial support for the claim that the content of a functional category does not define it.

The valuation strategies associated with INFL are summarized in Table 1.[9]

Table 1. Valuation strategies for INFL (adapted from R&W)

Valuation strategy	**INFL value**	**Valuation content**		
		English	**Halkomelem**	**Blackfoot**
M-valuation	[+coin]	[present]	[proximate]	[local part]
	[–coin]	[past]	[distal]	[other]
Predicate valuation	[+coin]	aspectual verbs		
	[–coin]	futurate verbs		
C-valuation	[+coin]	[directive]		
	[–coin]	[counterfactual]		

In sum, the core of R&W's analysis is the claim that the functional category TENSE is decomposable. It has a universal core function, namely anchoring. This anchoring function may be substantiated by temporal content, which gives rise to the category we typically refer to as TENSE.

(15) TENSE = anchoring (INFL) + tense marking: {present, past}

The reason that – at least in Indo-European languages – INFL is often equated with TENSE, is that it is tense marking which is spelled out in the form of tense morphology on the verb. At least in English, there are no immediately obvious candidates for forms that would spell out the anchoring function of INFL itself: in tenseless constructions, INFL does not seem to be spelled out at all. Everything else being equal, we would however predict this to be the case: we should find instances where the anchoring function itself is spelled out. In the remainder of this paper, we show that this prediction is indeed borne out. In particular, we provide an analysis of the Greek subjunctive marker *na*, according to which *na* spells out the unvalued [*u* coin] feature associated with INFL.

9. For reasons of space we do not discuss the predicate- and C-valuation strategies found in Halkomelem and Blackfoot. See R&W for detailed discussion.

3. Greek subjunctive *na* spells out the anchoring function of INFL

In this section, we argue that the so-called subjunctive marker in Greek (*na*) can be analyzed as the spell out of the anchoring function of INFL. We proceed as follows. In Section 3.1, we explore the distribution of *na*. We show that it can be captured straightforwardly under the R&W analysis introduced above. In particular, we show that *na* is used in contexts of predicate valuation and C-valuation. In Section 3.2 we argue that the simplest analysis for the distribution of *na* is to analyze it as the spell out of the unvalued coincidence feature [*u* coin]. In Greek, m-valuation works in exactly the same way as presented above for English. Hence, in the interest of space we won't be discussing m-valuation here.

3.1 The distribution of *na*

For the purpose of this discussion we assume that *na* is associated with INFL (see Kyriakaki 2006; Malagardi 1994; Philippaki-Warburton 1987; Philippaki-Warburton & Veloudis 1984; Rivero 1994).[10] If so, the distribution of *na* can be characterized as in (16).

(16) *Na* spells out INFL in the absence of m-valuation

This captures the fact that *na* is used when INFL is either valued via predicate valuation, or via C-valuation. This is summarized in Table 2, where the shaded cells indicate that *na* is used in this context.

Table 2. Distribution of *na*

Valuation strategy	INFL value	Valuation content
M-valuation	[+coin]	[present]
	[–coin]	[past]
Predicate valuation	[+coin]	aspectual verbs
	[–coin]	futurate verbs
C-valuation	[+coin]	[directive]
	[–coin]	[counterfactual]

10. The assumption that *na* is associated with INFL is not uncontroversial. In particular, Agouraki (1991), Dobrovie-Sorin (1994) and Tsoulas (1995) argue that it occupies C. For the purpose of this paper, we simply assume that *na* is associated with INFL. We note that empirical evidence, which suggests that it is associated with C, may be reconciled with our view on the assumption that I moves to C (see Pesetsky & Torrego 2004).

We start by illustrating the use of *na* in the context of predicate valuation. Aspectual verbs, such as *arxis-* ('start') and *katafer-* ('manage') embed complement clauses introduced by *na*.

(17) a. *O Kostas arxis-e …*
DET Costas start.PRF-PAST.3.SG
*… **na** pez-i kithara.*
SUBJ play.IMPF-PRES.3.SG guitar
'Costa has started playing the guitar.'

b. *Katafer-a **na** telio-s-o …*
manage.PRF-PST.1.SG SUBJ finish.PRF-DEP.1.SG
… to vivlio mu.
DET book 1SG.GEN
'I managed to finish first.'

The *na* clause is interpreted like a simultaneous infinitive in English: the embedded event is interpreted as occurring simultaneously to the matrix event. This is consistent with the analysis according to which the matrix predicate serves to value INFL as [+coin], asserting that the embedded event coincides with the matrix event.

Similarly, future-oriented verbs like *thel-* also embed complement clauses introduced by *na*.

(18) a. *thel-is **na** par-ume merika fruta*?
want.IMPF-PRES.2.SG SUBJ take.PRF-DEP.1.PL some fruit
'Would you like us to get some fruit?'

b. *i-thel-a **na** pernus-ame…*
PAST-want.IMPF-PAST.1.SG SUBJ pass.IMPF-PAST.1.PL
…ap' ti vivliothiki.
from DET library
'I wanted us to pass by the library.'

In the examples in (18), the *na* clause is interpreted like a future irrealis infinitive in English. This is consistent with the analysis according to which, the matrix predicate serves to value INFL as [–coin], asserting that the embedded event does not coincide with the matrix event.

This establishes that *na* is used in the context of predicate valuation, irrespective of whether INFL is valued as [+coin] or [–coin].

We now illustrate the use of *na* in the context of C-valuation. First, consider imperatives.

(19) ***na** mas grap-s-ete.*
SUBJ 1.PL.GEN write-PRF-DEP.2.PL
'(do) write to us!'

On the R&W analysis, imperatives are analyzed as instantiating the valuation of [*u* coin] via C. If so, the use of *na* in imperatives is covered under the generalization that it spells out INFL in the absence of m-valuation.

As with predicate valuation, C-valuation comes in two guises. While in imperatives INFL is valued as [+coin], R&W argue that in counterfactuals INFL is valued by C as [–coin]. Given the generalization in (16), we would therefore expect that *na* is used in counterfactuals. This is indeed the case, as shown in (20).

(20) *An o Manos den itan arrostos …*
if DET Manos NEG be.IMPF-PAST.3.SG ill
… ***na*** *pigen-e sto parko.*
SUBJ go.IMPF-PAST.3.SG to.DET park
'If Manos wasn't ill, he could have gone to the park.'

Note in passing, that just like in English, we find past morphology in the counterfactual. Again, this is an instance of *fake past* (James 1982; Iatridou 2000), as evidenced by the fact that it is compatible with a present time adverbial, as shown in (21). In the context of a counterfactual clause (introduced by *na*), past marking is compatible with a present time adverbial (21a); in the context of an indicative clause, past morphology is incompatible with a present time adverbial (21b).

(21) a. *Na 'x-ame ena pagoto tora.*
SUBJ have.IMPF-PAST.1.PL one ice.cream now
'If only we had an ice-cream now.'

b. **Ix-ame ena pagoto tora.*
have.IMPF-PAST.1.PL one ice.cream now
*'We had an ice-cream now.'

The fact that past morphology is not associated with temporal force indicates that past does not serve to value INFL. Consequently, the use of *na* in counterfactuals also falls under the generalization in (16): *na* is used in the absence of m-valuation. And just as with predicate valuation, *na* can be used when C values INFL as [+coin], as in imperatives, and when C values INFL as [–coin], as in counterfactuals.

Finally, if INFL is valued via m-valuation (i.e. by means of tense morphology), then *na* cannot be used. This is shown in (22)–(24).

(22) a. *O Petr-os kolimb-ai kaθe proi.*
DET Peter-NOM swim.IMPF-PRES.3.SG every morning
'Peter swims every morning.'

b. *O Petros kolimb-ai tora.*
DET Peter-NOM swim.IMPF-PRES.3.SG now
'Peter is swimming right now.'

(23) a. *O Petr-os kolimb-use kaθe proi.*
DET Peter-NOM swim.IMPF-PAST.3.SG every morning
'Peter was swimming/used to swim every morning.'

b. *O Petr-os kolimb-is-e xθes to proi.*
DET Peter-NOM swim-PRF-PRES.3.SG yesterday DET morning
'Peter swam yesterday morning.'

(24) a. **O Petr-os na kolimb-ai tora.*
DET Petros-NOM SUBJ swim.IMPF-PRES.3.SG now
'Peter to swim now'.

b. **/??O Petr-os na kolimb-is-i tora.*[11]
DET Petros-NOM SUBJ swim-PRF-DEP.3.SG now
'Peter should swim right now.'

We have now established that *na* is used in four different contexts: embedded under aspectual verbs and under future-oriented verbs. These are the contexts where the interpretation of the embedded predicate depends on the semantics of the matrix predicate. They are known as intensional subjunctives, and are characterized as being selected by the matrix predicate (Stowell 1993). In addition, *na* is also used in the context of imperatives and counterfactuals. These fall under the classification of subjunctives that are licensed by an operator (i.e. polarity subjunctive, Stowell 1993). This is summarized in Table 3.

Table 3. The distribution of *na* and valuation

Valuation strategy	INFL value	Valuation content	Result
M-valuation	[+coin]	[present]	present tense
	[−coin]	[past]	past tense
Predicate valuation	[+coin]	aspectual verbs	simultaneous
	[−coin]	futurate verbs	future irrealis
C-valuation	[+coin]	[directive]	command
	[−coin]	[irrealis]	counterfactual

From a semantic point of view, it is not clear that these contexts constitute a natural class. From a syntactic point of view, however, they do. They are precisely

11. The example in (24b) is grammatical for some speakers when the main focus of the utterance falls on the subject *o Petr-os*. However, in this case the sentence receives a modal interpretation, such that "Petros should (be the one to) swim now", or an Imperative reading where Petros is indirectly instructed to swim. Therefore, we suggest that in such cases it is the modal force which values the [*u*coin] feature of INFL.

those contexts where INFL is not associated with temporal content. In terms of the R&W analysis these are the contexts that are not characterized by m-valuation.[12]

3.2 *na* spells out [*u* coin]

While the generalization regarding the distribution of *na* is fairly easy to state in terms of absence of m-valuation, there is still a non-trivial question remaining. What would a lexical entry for *na* look like? That is, what would the feature specification associated with it look like, so that it occurs only in contexts of predicate- and C-valuation? We cannot simply say that *na* spells out [+coin] or [–coin], because that would include m-valuation. So the exclusion of m-valued INFL is not a straightforward task. In this section, we propose that *na* spells out the function of INFL without its content. To formalize this insight we propose (25).

(25) *na* spells out [*u* coin] in INFL

What does it mean to spell out an unvalued feature? It simply means that in these cases INFL (which is intrinsically associated with [*u* coin]) is spelled out **before** it is valued. The only context in which this is possible is when the valuating head is higher than INFL (as it is in predicate- and C-valuation). Crucially, however, *na* does not serve to value INFL. Note that the claim that an unvalued feature can be spelled out runs counter standard assumptions about the architecture of language. We briefly address this issue in Section 4. In the remainder of this section, we wish to point out a number of advantages of the analysis in (25).

Accounting for the distribution of *na* with a unified lexical entry has proven difficult, precisely because of the fact that the semantics of the contexts where it is used is so different. What several researchers have pointed out however, is that *na* (and the subjunctive more generally) signals a *dependency*, as opposed to the indicative which is said to be independent; see Giannakidou (2009) for a recent discussion of this point. On our analysis, this is in fact all it does, but in a roundabout way. In particular, according to our analysis, *na* is not inherently anaphoric, nor does it directly stipulate a dependency anywhere in its lexical entry. Rather, it signals a dependency as a byproduct of spelling out an unvalued feature. Since, per UG, unvalued features must be valued, the presence of *na* signals that INFL still needs to be valued. Thus, it signals that INFL is dependent on a higher head that

12. An anonymous reviewer asks whether the infinitival marker *to* in English would be amenable to a similar analysis. We don't believe this to be the case: English *to* is only used in a subset of the environments where Greek *na* is used. At this point, we don't have anything to say about the proper analysis of *to* within the R&W framework.

can serve to value INFL: either the embedding predicate, or a higher functional head (namely, C).

According to R&W, in the context of predicate- and C-valuation there is no utterance situation associated with SpecIP, and henceforth, the event situation is ordered relative to some other argument. As a consequence, these events are not deictically anchored. Since *na* is used precisely in those contexts of predicate- and C-valuation, it is expected that *na* clauses lack an utterance situation and therefore, that there is no deictic anchoring. This is reminiscent of Giorgi's (2009) analysis, according to which subjunctive clauses lack a speaker coordinate.

Finally, our analysis captures the fact that in *na* clauses morphological tense marking is either absent or fake. That is, if *na* occupies INFL, it indicates the absence of m-valuation. Therefore, even if there are tense markers, we expect that they do not play their usual role. This captures the generalization that subjunctive is associated with *defective* tense (cf. Picallo 1985).

If our analysis of *na* is on the right track, we have further support for the dissociation of the function of a functional category from its content. If function and content were intrinsically related, we would not expect there to be exponents of functional categories that lack content.

4. The timing of spell out

The assumption that *na* spells out an unvalued feature (i.e. [u coin]) captures its distribution. However, it does not conform to standard assumptions regarding the architecture of the grammar. Consider for example, the quote below from Epstein and Seely (2002: 70).

> … spell out before valuation is problematic. As DBP (Derivation by Phase) notes, this is "too early" since unvalued features are in fact PF-uninterpretable (as well as LF-uninterpretable) and thus spelling out an expression containing such unvalued features will fail to converge.

There is, however, a simple solution to this problem, as we now show. To consider in more detail how the problem arises, let us look at the architecture of grammar commonly assumed within the generative framework. It is assumed that syntax manipulates abstract features only. Their exponents (sound-meaning correspondences) are added after syntactic computation. As indicated in Figure 1, the syntactic computation branches off to PF and LF respectively. This is known as *spell out*.

The existence of a morpheme that spells out an unvalued feature is not expected on these assumptions. If *na* is inserted after spell out, then its spelling

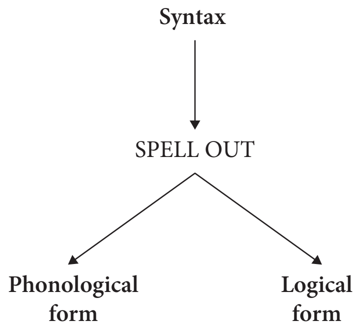

Figure 1. The architecture of the grammar

out an unvalued feature would mean that there is an unvalued feature which made it past *spell out*. If so, this unvalued feature would also reach LF where we would expect it to be illegible, and consequently result in ungrammaticality. Thus, if *na* does indeed spell out an unvalued feature [*u* coin], then it cannot be inserted after spell out. Instead, it must be the case that it is inserted prior to spell out. In particular, if *na* is inserted before spell out, then *na* may simply be inserted prior to valuation. Consider the derivation in (26). At the point in the derivation where INFL is merged, INFL is unvalued (26a). We propose that it is precisely at this point that *na* is inserted (26b).

(26) a. $\ldots\ {}_{\text{IP}}[\ [\text{I: } u \text{ coin}]_{\text{I}}\ {}_{\text{VP}}[\ \text{Ev-sit}\ \ \mathbf{V}\ ]]$
b. $\ldots\ {}_{\text{IP}}[\ \ [\textit{na}]_{\text{I: } u \text{ coin}}\ {}_{\text{VP}}[\ \text{Ev-sit}\ \ \mathbf{V}\ ]]$

At the point in the derivation when C is merged, it can value INFL. Assuming that CP but not IP acts as a phase (Chomsky 2000), INFL is still valued before spell out. As a consequence of being inserted before valuation, *na* appears to be associated with an INFL that is valued as [+coin] (27a) or as [–coin] (27b).

(27)
a. $\ldots\ {}_{\text{CP}}[\ \ \text{Plan-set C}\ {}_{\text{IP}}[\ [\ [\textit{na}]_{\text{I: [+coin]}}\ {}_{\text{VP}}[\ \text{Ev-sit}\ \ \mathbf{V}\ ]]$

b. $\ldots\ {}_{\text{CP}}[\ \ \text{Ev-sit}\ \ \ \text{C}\ {}_{\text{IP}}[\ [\ [\textit{na}]_{\text{I: [–coin]}}\ {}_{\text{VP}}[\ \text{Ev-sit}\ \ \mathbf{V}\ ]]$

The same holds for predicate valuation. Assuming that embedded complements introduced by *na* lack a CP layer, it would follow that there is no phase boundary between the valuing matrix predicate and INFL. Consequently, when the matrix V is merged, it values INFL before *Spell out*. Again, *na* appears to be associated with an INFL that is valued as [+coin] (28a) or as [–coin] (28b).

(28) a. … $_{VP}$[Ev-sit V $_{IP}$[[[*na*]$_{I: [coin]}$ $_{VP}$[Ev-sit **V**]]

b. … $_{VP}$[Ev-sit V $_{IP}$[[[*na*]$_{I: [-coin]}$ $_{VP}$[Ev-sit **V**]]

In sum, the generalization that *na* is used in contexts where INFL is not associated with temporal content (i.e. in the absence of m-valuation) straightforwardly captures its distribution. In this section, we have shown that the most economic way to capture this is to say that *na* spells out the unvalued coincidence feature associated with INFL. If this is the case however, it must be the case that *na* is inserted prior to spell out. As such, our analysis has significant implications for the architecture of grammar. We must recognize the possibility for inserting functional elements prior to spell out: there are at least some functors that appear to undergo *early insertion* (see also Wiltschko 2009 for this conclusion, based on patterns of alliterative agreement).

5. Evidence from the use of *na* by individuals diagnosed with Down Syndrome

In this section, we turn to the use of *na* by individuals diagnosed with Down Syndrome (henceforth DS). This is relevant in the present context because the language of DS is often described as being characterized by an impairment that affects TENSE (Ring & Clahsen 2005). If TENSE does indeed decompose into an abstract functional category responsible for anchoring (i.e. INFL), and temporal content that serves to substantiate INFL, then the question arises as to the exact nature of the TENSE impairment. On the present view, there are at least two cases to consider: either INFL is impaired, or else the association of temporal content with INFL is impaired. In what follows, we show that there is evidence for the latter. In particular, we show that the use of *na* is not affected in DS.

We start by considering in more detail, previous claims about the use of tense in DS. Research on English DS has argued that there is a significant problem with TENSE. This was evidenced by a poor performance in the use of past tense marking, present 3rd person singular, -*s*, as well as modals and auxiliaries (Eadie et al.

2002; Laws & Bishop 2003). The same was also observed with Dutch individuals diagnosed with Down Syndrome, where problems with past tense and auxiliary omission are reported (Bol & Kuiken 1990).

According to Ring and Clahsen (2005), the observed pattern can be accounted for by the Extended Optional Infinitive hypothesis (Rice, Wexler & Redmond 1999). In particular, according to Wexler (1994), during a certain stage of language acquisition (the so called Optional Infinitive Stage), typically developing children use tense marking only optionally. Instead of inflecting the verb for tense, they sometimes use an infinitive form. The same was also observed for children diagnosed with Specific Language Impairment, though at an older age (Rice & Wexler 1996, and subsequent work). Since a similar pattern is observed in DS, it is sometimes claimed that DS can be characterized as using a language that is not fully developed.

That this cannot quite be the right story is indicated by the fact that individuals diagnosed with DS which speak other languages, do not support this pattern. In particular, for German and Greek individuals diagnosed with DS tense is not found to be impaired. Specifically, Schaner-Wolles (2004) reports that German DS shows correct use of finite verbs in the context of verb second (98.4%). While there are cases where a bare stem or infinitive is used in the context of verb second, this is not restricted to DS. Instead, we find this with typically developing controls as well (Poeppel & Wexler 1993; Schaner-Wolles 2004). As for Greek DS, Tsakiridou (2006) reports only one tense error with her participants. Similarly, Christodoulou (2011) shows that the accuracy of tense use in DS reaches above 95% in Cypriot Greek DS. However, Christodoulou also observes that there *is* a large number of auxiliary and copula omissions.

What is interesting in the present context, however, is the use of *na* in DS. Based on a large corpus of data, Christodoulou (2011) observes that *na* is generally used correctly by Cypriot Greek individuals diagnosed with DS. As shown below, they are able to use *na* accurately with matrix clauses, (29), aspectual verbs (30), modal verbs (31), and directives (32), in both elicited and spontaneous productions in nine experimental tasks.[13]

(29) *k'* *istera* ∅ ***na*** ***skola -s-ume***.[14]
and later SUBJ get.off-PRF-DEP.1.PL
'And then we'll get off school/work.'

13. A number of issues arising from the DS phonetic and phonological restrictions, which may appear to have an effect on the surfacing inflectional features, are not discussed here. For an extensive discussion see Christodoulou (2011).

14. “ indicates absence of a sound. [] brackets indicate the production of a different sound from what is expected to be produced by a typically developed adult speaker of Cypriot Greek”.

(30) *o* *Nik -os* *vlep-i* *ti* *Dora...*
DET Nick-NOM see.IMPF-PRES.3.SG DET Dora
…***na*** ***krat-a*** *vivli-∅.*
SUBJ hold.IMPF-PRES.3.SG book
'Nick is seeing Dora holding a book.'

(31) *E-prep-e* *na* *e-vlep-e∅* *tis* *ikon-e∅.*
PAST-must-PAST.1.SG SUBJ PAST-see.IMPF-PAST.2.SG DET picture
'You should have seen the pictures.'

(32) *To[l]a* *na* *to* *kli-s-i∅* *to* *panathir -i.*
now SUBJ 3.NEU.SG close-PRF-DEP.2.SG DET window
'Now close the window.'

Examples (29) through (32) show that both the INFL system and the anchoring function are intact. Specifically, example (29) is a case of C-valuation, while (30) is an instance of predicate valuation, where INFL is valued by the matrix verb *vlep-i* 's/he is seeing'. Similarly, in (31) the [*u*coin] feature is valued by the modal verb *e-prep-e* 'should/must' of the matrix clause and in (32) the directive force in C values the unvalued coincidence feature under INFL. The construction in (32) serves as an alternative to the imperative, which expresses a less forceful command. Hence, individuals diagnosed with DS use *na* in exactly those contexts where we expect *na* to also appear in typically developed language. The data suggests that DS have no problem with INFL, since they use *na* in a number of diverse structural environments to encode a dependency.

This is further supported by the fact that DS sometimes even correctly add *na* in contexts where it is optional, and therefore sometimes absent in the input. Consider the following examples. (33) shows the target stimulus in the experiment while (34) shows the DS production. Crucially, *na* is added in the embedded clause in the DS production while it is missing in the target.

(33) **Production Imitation Stimulus**
e ***na*** *sas* *šereti-s-o …*
AUX SUBJ 2.PL.ACC say.goodbye-PRF -DEP.1.SG
… pri *fi-o.*
before leave.PRF-DEP.1.SG

(34) **DS Production**
∅ ***na*** *∅ šereti-s-o …*
SUBJ say.goodbye-PRF-DEP.1.SG
… pri ***na*** *fi-o.*
before SUBJ leave.PRF-DEP.1.SG
'I am going to say goodbye before I leave.'

This pattern was found in 13 out of 16 DS participants.[15] That is, while a subjunctive marker **is** possible, and frequently used in such environments in typically developed speech, it was not present in this particular stimulus, and yet it was added by Cypriot Greek DS participants. Note that the use of *na* in this context is fully consistent with the fact that dependent tense marking is found on the verb. In conclusion, examples (29) through (34) cast doubt on the claim that the DS INFL system is impaired. What our data indicates is that it is not INFL, which is impaired (i.e. the function), but rather, on occasion, the association of INFL with its content. This may result in either the omission of the morphological marking of tense (omission of an inflectional affix, copula or auxiliary), or the use of the default tense value (i.e. infinitive for English or German, and present for Greek). In all instances, subject-verb agreement and the assingment of nominative case on the subject were not affected. For a more detailed analysis see Christodoulou (2011).

Thus, the use of *na* in CGDS provides further evidence for our main claim according to which the function of a functional category is dissociated from its content. If the analysis of *na* developed in this paper is on the right track, this suggests that INFL (and thus the anchoring system) is not affected at all by DS. What seems to be slightly different than with typically developed grammar, on occasion, is the association of INFL with substantive content.

6. Conclusion

The purpose of this essay was to argue that the function of functional categories is independent of their content. We have reviewed evidence to this effect put forth in Ritter and Wiltschko (2009, 2011). Moreover, we have argued that the distribution of Greek *na* is best analyzed as lexicalizing the function of INFL without its content. If this analysis is on the right track, it provides further evidence for the proposed dissociation of function and content. In addition, we have argued that the simplest analysis of *na* requires the assumption that functional elements can be inserted prior to spell out, contrary to standard assumptions.

If we take the analysis at face value, then we can draw two conclusions about the nature of universal grammar. First, it appears that functional categories exist independently of the features that associate with them. The functional category we have investigated here (INFL) is associated with an anchoring function, which can

15. This was also observed with a small number of the typically developing participants.

manifest itself in two different ways: it may be responsible for deictic anchoring via tense marking in indicative root clauses, or else it may be responsible for encoding a dependency. It is the latter function that *na* spells out. Secondly, it appears that a given sound-meaning correspondence (*na*) may associate with syntactic structure before *Spell Out*.

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The association of sound with meaning

The case of telicity

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I show a correspondence between vowel quality and verbal telicity in native Japanese verbs that has not previously been recognized. A verb containing the vowel /e/ or /u/ denotes a telic event while a verb containing the vowel /i/ or /o/ denotes an atelic event. This correspondence holds not only in existing verbs but also in nonce verbs, which indicates that the correspondence is part of the synchronic grammar. On the basis of the findings, I discuss implications for phonology and explore the timing of associating vowel quality and verbal telicity within the current grammar model.

1. Introduction

In this paper I am concerned with how meaning is encoded in language. In particular I focus on an endpoint of an event denoted by the verb, i.e. verbal telicity. In Japanese, monosyllabic verbs containing the vowel /e/ or /u/ denotes an event with an endpoint. For example, in (1), the verb *ket-* 'kick' denotes an event where the action of kicking comes to end when the object *kan* 'can' comes to be kicked. Such verbs are telic.

(1) *Meari-ga kan-o ket-ta*
M.-NOM can-ACC kick-PST
'Mary kicked the can.'

(2) *Takasi-ga sakana-o tut-ta*
T.-NOM fish-ACC pull.up-PST
'Takashi pulled up the fish.'

By contrast, a monosyllabic verb containing the vowel /i/ or /o/ denotes an event with no endpoint. For example, in (3), the verb *ki-* 'wear' denotes an event such that the action of wearing the object *kimono* 'kimono' continues. Such verbs are atelic.

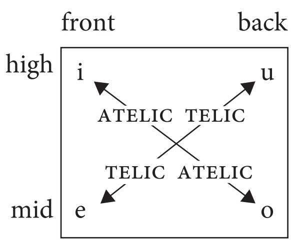
(3) *Hanako-ga kimono-o* ***ki****-ta*
H.-NOM kimono-ACC wear-PST
'Hanako wore the kimono.'

(4) *Taro-ga usagi-o* ***o****t-ta*
T.-NOM rabbit-ACC chase-PST
'Taro chased the rabbit.'

The main goal of this paper is to establish the correspondence between vowel quality and verbal telicity in Japanese. I also show that the correspondence is part of the synchronic grammar.

This paper is organized as follows. In Section 2, I show that the non-low vowels strictly correspond to verbal telicity in existing verbs. This correspondence is identified by controlling for structural contexts and by restricting the empirical domain. In Section 3, I show that even in nonce verbs fluent speakers of Japanese are sensitive to the vowel-telicity correspondence. In Section 4, I develop phonological analyses for the pattern of the correspondence shown in (5). In Section 5, I conclude this paper by exploring within the framework of generative grammar the point at which vowel quality corresponds to verbal telicity.

(5)



2. The correspondence in existing verbs

In this section I show the correspondence between vowel quality and verbal telicity in existing verbs. To identify the correspondence, I first (i) control for the structural context of verbal telicity and (ii) restrict the empirical domain of verbs.

2.1 How to find verbal telicity

The notion of telicity itself is compositional. That is, verbal telicity interacts with other components in the predicate such as the direct object and adverbs, as often discussed in English (Verkuyl 1972, 1993; Dowty 1979; Lasersohn 1995; among others). This also applies to Japanese and often conceals the telicity inherent to the verb itself. Thus, I control for two potential confounds: (i) the contribution of the direct object, and (ii) the possibility of repeating the event (*repetitiveness*).

In Japanese, accusative case on the direct object is marked by the suffix -*o*. Such direct objects reveal the telicity of the verb, as in (6a). If, on the other hand, the object is not *o*-marked, as in (6b), the verb phrase is not interpreted as telic (cf. Tenny 1994).

(6) a. *John-ga* (*gohunde*) *ittoo-no* *kuma-***o** *ut-ta*
J.-NOM in.five.minute one.CL-GEN bear-ACC shoot-PST
'John shot one bear in five minutes.'

b. *John-ga* (**gohunde*) *ittoo-no* *kuma-**ni*** *ut-ta*
J.-NOM in.five.minute one.CL-GEN bear-DAT shoot-PST
*'John shot at one bear in five minutes.'

The contribution of the verb towards the telicity of the entire verb phrase becomes apparent by keeping the direct object quantized, as in (7).

(7) a. *John-ga* (*gohunde*) ***ittoo-no*** ***kuma-o*** *ut-ta*
J.-NOM five.minute-at one.CL-GEN bear-ACC shoot-PST
'John shot one bear in five minutes.'

b. *John-ga* (**gohunde*) ***ittoo-no*** ***kuma-o*** *osi-ta*
J.-NOM five.minute-at one.CL-GEN bear-ACC push-PST
*'John pushed one bear in five minutes.'

The quantity of the direct object is optionally realized with overt classifiers and an object without an overt classifier (i.e. a bare noun) gives rise to ambiguity: the noun denotes either a quantized entity or a non-quantized entity. Therefore, even with a telic verb, the non-quantized reading of the bare noun can give rise to an atelic interpretation, as in (8).

(8) *John-ga* (*gohunde*) *kuma-o* *ut-ta*
J.-NOM in.five.minute bear-ACC hit-PST
i. 'John shot a bear in five minutes.'
ii. *'John shot bears (one after another) in five minutes.'

The second potential confound in determining the telicity of the predicate is the potential for *repetitiveness* (cf. Dowty 1979; Lasersohn 1995; van Geenhoven 2004). If the number of occurrences of the eventuality is not overtly specified by an adverb, the verb phrase may have a single occurrence reading or a repetitive reading, as in (9).

(9) *John-ga* (*gohunde*) *ittoo-no* *kuma-o* *ut-ta*
J.-NOM in.five.minute one.CL-GEN bear-ACC shoot-PST
i. 'John shot one bear once in five minutes.'
ii. *'John shot one bear repeatedly in five minutes.'

To rule out the repetitive reading I therefore use the frequentative adverb *itido* 'once/one time', which unambiguously yields the single occurrence reading, as in (10).

(10) *John-ga* (*gohunde*) ***itido*** *ittoo-no* *kuma-o* *ut-ta*
J.-NOM in.five.minute once one.CL-GEN bear-ACC shoot-PST
'John shot one bear once in five minutes.'

2.2 Yamato-Japanese verb stems

To identify the correspondence between vowel quality and verbal telicity, we also need to restrict the empirical domain. The correspondence holds only across one of the lexical strata found in Japanese, namely, the native lexical stratum called Yamato-Japanese. This is because Yamato-Japanese verb stems are inherently verbal, as in (11).

(11) $[_{\text{stem}}$ [...(C)V(C)]]- (Yamato-Japanese)

In contrast, all loanword verb stems are derived from nouns by suffixing the light verb *-su* (Grimshaw & Mester 1988) or by suffixing the verbalizer *-r* (Sato 1975), as in (12).

(12) a. $[_{\text{stem}}$ $[_{\text{N}}$ ...(C)V] *-su*]- (Loanword)
b. $[_{\text{stem}}$ $[_{\text{N}}$ ...(C)V(C)V] *-r*]-

I show that the derivational difference of verb stems between Yamato-Japanese and loanwords has consequences for their morphology and for their phonology.

Yamato-Japanese verb stems and loanword verb stems differ in the patterns of nominalizations. Loanword verb stems are derived by suffixing the verbalizer *-su* or *-r*. Thus, the root itself (without the verbalizing suffix) functions as noun, as in (13).

(13) Verb stem: *sutaba-r-* 'go to Starbucks' (Loanword)
watasi-wa ***<u>sutaba</u>****-ga* *suki*
1SG-TOP Starbucks-NOM like.NONPAST
'I like Starbucks.'

In contrast, the Yamato-Japanese verb stems are inherently verbal and they cannot be nominalized by subtracting the last consonant. Well-formed nouns are derived from the Yamato-Japanese verb stems by suffixing the nominalizing vowel /i/, as in (14).

(14) Verb stem: *idom-* 'challenge' (Yamato-Japanese)
ido**(**m**-i)-ga* *hituyou-da*
challenge-N-NOM necessary-COP
'A challenge is necessary.'

Yamato-Japanese verb stems and loan word verb stems also differ in prosody. Yamato-Japanese verb stems can be monosyllabic, bisyllabic, trisyllabic, or quadrisyllabic (cf. Kubozono 1995). Thus, as (15) shows, there is no restriction on the number of syllables for a well-formed Yamato-Japanese verb stem.

(15) Yamato-Japanese verb stems

Monosyllabic	Bisyllabic	Trisyllabic	Quadrisyllabic
tor-	*musub-*	*nagamer-*	*sakanobor-*
'take'	'knot'	'view'	'track back'

This contrasts with loanword verb stems. Since all loanword verb stems are derived, they cannot be monosyllabic. They minimally consist of a monosyllabic noun and the light verb *-su*, as in (16).

(16) $[_{\text{stem}}\ [_{\text{N}}$ ...CV]-***su***]

Monosyllabic	Bisyllabic	Trisyllabic	Quadrisyllabic
n/a	*ka-su-*	*kakin-su-*	*zyogingu-su-*
	charge-do-	charge.money-do-	jogging-do-
	'charge'	'charge money'	'jog'

Loanword verb stems with the verbalizer *-r* do not allow for monosyllabic forms, either. The verb stems with *-r* often take a truncated noun, as shown in (17). However, the noun contained in the verb stem cannot be monosyllabic (Ito 1990).

(17)

Original form	Truncated form	Verb form	Gloss
sabotaazyu	*sabo*	*sabo-r-*	'play hooky'
sutaabakkusu	*sutaba*	*sutaba-r-*	'go to Starbucks'
makudonarudo	*makku*	*maku-r-*	'go to MacDonald'

In this study, I investigate monosyllabic and bisyllabic Yamato-Japanese verb stems. I assume that the template of monosyllabic verb stems is (C)V(C) while the template of bisyllabic verb stems is (C)V(C)V(C). The onset and the coda of each syllable are optional. I use these verb stems in the past tense form (V-*ta*). This is because the inherent endpoint of telic events is clearly interpreted in the past tense, but not in the present. We have listed all the existing verbs which fall into this empirical domain. To make sure that we cover all the existing verbs in this domain, I have checked all the logically possible words for their existence in two Japanese dictionaries, *Daijirin (3rd)* (Sanseido) and *Shin Meikyo Jiten* (Taishukan). We can therefore be sure that we have an exhaustive list of existing transitive verb stems in the past tense. To make sure that accent-pitch does not play a role in determining verbal telicity, I have also checked the accent-pitch of these words in *Shin Meikai Nihongo Akusento Jiten* (Sanseido).[1]

1. The superscript "ˊ" on a vowel represents a high pitch while a vowel without the superscript represents a low pitch throughout the data in appendices.

2.3 The non-low vowels correspond to verbal telicity in existing verbs

I now demonstrate that the non-low vowels of the rightmost vowel correspond to verbal telicity. In monosyllabic verb stems, the quality of the single vowel corresponds to verbal telicity. In bisyllabic verb stems, the second vowel (Vowel 2), but not the first vowel (Vowel 1), corresponds to verbal telicity. In the rightmost vowel position, /e/ and /u/ are associated with a telic interpretation while /i/ and /o/ are associated with an atelic interpretation, as schematized in (18a) and in (18b), respectively.

(18) a. $[_{\text{stem}}$ … (C) {/e/,/u/} (C)]-*ta*
                         |
                       telic

b. $[_{\text{stem}}$ … (C) {/i/,/o/} (C)]-*ta*
                         |
                       atelic

The verbal telicity is diagnosed with two Japanese-specific (a) telicity tests (Ando 1982; Ueno & Kageyama 2001; among many). With the use of time-span adverbs (~*de* 'in x time') we can uniquely identify telic verbs. Telic verbs, but not atelic verbs, are felicitous with a time-span adverb. With the use of durative adverbs (~*noaida* 'for x time') we can identify atelic verbs. Atelic verbs, but not telic verbs, are felicitous with a durative adverb.

The above vowel-telicity correspondence was checked with 10 adult fluent speakers of Japanese. Out of these consultants, 5 were in their 20's and 5 in their 30's. Seven consultants spoke Eastern dialects including Tokyo dialect, while 3 spoke Western dialects.

2.3.1 *Monosyllabic transitive verb stems*

We begin with monosyllabic transitive verb stems. All of the verb stems containing either /e/ or /u/ are telic. There are 5 verb stems containing /e/ (see Appendix A for the verb list). For example, the verb stem ***é***- 'get' which consists of only a single vowel is felicitous with a time-span adverb 'in x time', as in (19a). In contrast, the verb stem is infelicitous with a durative adverb 'for x time', as in (19b).

(19) a. *Meari-wa (gohunde) itido issatu-no hon-o **é**-ta*
M.-TOP in.5.min once one.CL-GEN book-ACC get-PST
'Mary got one book once (in five minutes).'

b. *Meari-wa (*gohunnoaida) itido issatu-no hon-o **é**-ta*
M.-TOP for.5.min once one.CL-GEN book-ACC get-PST
'Mary got one book once (*for five minutes).'

There are also 16 verb stems containing /u/ (Appendix B). An example of such verb stems is ***ú**t-* 'hit'. This verb stem is felicitous with a time-span adverb, as in (20a), while the stem is not felicitous with a durative adverb, as in (20b).

(20) a. *Takashi-ga* (*gohunde*) *itido* *hitotu-no* *booru-o* ***ú**t-ta*
T.-NOM in.5.minute once one.CL-GEN ball-ACC hit-PST
'Takashi hit one ball once (in five minutes).'

b. *Takashi-ga* (**gohunnoaida*) *itido* *hitotu-no* *booru-o* ***ú**t-ta*
T.-NOM for.5.minute once one.CL-GEN ball-ACC hit-PST
'Takashi hit one ball once (*for five minutes).'

By contrast, all of the verb stems containing either /i/ or /o/ are atelic. There are 8 verb stems containing /i/ (Appendix C). An example of such atelic verb stems is ***í**t-* 'fry'. This verb stem is infelicitous with a time-span adverb, as in (21a). In contrast, the stem is felicitous with a durative adverb, as in (21b).

(21) a. *Meari-wa* (**gohunde*) *itido* *hitotu-no* *mame-o* ***í**t-ta*
M.-TOP in.5.minute once one.CL-GEN bean-ACC fry-PST
'Mary fried one bean once (*in five minutes).'

b. *Meari-wa* (*gohunnoaida*) *itido* *hitotu-no* *mame-o* ***í**t-ta*
M.-TOP for.5.minute once one.CL-GEN bean-ACC fry-PST
'Mary fried one bean once (for five minutes).'

There are also 12 verb stems containing /o/ (Appendix D). An example of such atelic verb stems is ***o**t-* 'chase'. This verb stem is infelicitous with a time-span adverb, as in (22a). In contrast, the stem is felicitous with a durative adverb, as in (22b).

(22) a. *Taro-wa* (**gohunde*) *itido* *ippiki-no* *usagi-o* ***o**t-ta*
T.-TOP in.5.minute once one.CL-GEN rabbit-ACC chase-PST
'Taro chased one rabbit once (*in five minutes).'

b. *Taro-wa* (*gohunnoaida*) *itido* *ippiki-no* *usagi-o* ***o**t-ta*
T.-TOP for.5.minute once one.CL-GEN rabbit-ACC chase-PST
'Taro chased one rabbit once (for five minutes).'

2.3.2 *Bisyllabic transitive verb stems*

We next consider bisyllabic transitive verb stems. I show that there is again a strict correspondence between the quality of the non-low vowels and verbal telicity. In particular, it is the rightmost vowel which functions as a predictor of verbal telicity in this case. The quality of the first vowel, on the other hand, has no effect on the telicity. The correspondence is identified across all possible syllable structures (VV, CVV, VCV, VVC, CVCV, CVVC, VCVC, and CVCVC).

All of the verb stems containing either /e/ or /u/ as the second vowel are telic. There are 4 verb stems containing /e/ as the second vowel (Appendix E).

An example of such telic verb stems is *tun**é**t-* 'pinch'. This verb stem is felicitous with a time-span adverb, as in (23a), while the stem is infelicitous with a durative adverb, as in (23b).

(23) a. *Taro-wa (gohunde) itido Meari-no ude-o tun**é**t-ta*
T.-TOP in.5.minute once M.-GEN arm-ACC pinch-PST
'Taro pinched Mary's arm once (in five minutes).'

b. *Taro-wa (*gohunnoaida) itido Meari-no ude-o tun**é**t-ta*
T.-TOP for.5.minute once M.-GEN arm-ACC pinch-PST
'Taro pinched Mary's arm once (*for five minutes).'

There are also 31 verb stems containing /u/ as the second vowel (Appendix F). An example of such telic verb stems is *ok**u**t-* 'send'. This verb stem is felicitous with a time-span adverb, as in (24a), while the stem is infelicitous with a durative adverb, as in (24b).

(24) a. *Taro-wa (gohunde) itido Meari-ni ittuu-no*
T.-TOP in.5.minute once M.-DAT one.CL-GEN
*iimeiru-o ok**u**t-ta*
email-ACC send-PST
'Taro sent one email to Mary once (in five minutes).'

b. *Taro-wa (*gohunnoaida) itido Meari-ni ittuu-no*
T.-TOP for.5.minute once M.-DAT one.CL-GEN
*iimeiru-o ok**u**t-ta*
email-ACC send-PST
'Taro sent one email to Mary once (*for five minutes).'

By contrast, all of the verb stems containing either /i/ or /o/ as the second vowel are atelic. There are 52 verb stems containing /i/ as the second vowel (Appendix G). An example of such atelic verb stems is *mús**i**-* 'steam'. This verb stem is infelicitous with a time-span adverb, as in (25a), while the stem is felicitous with a durative adverb, as in (25b).

(25) a. *Taro-wa (*gohunde) itido hitotu-no manzyu-o mús**i**-ta*
T.-TOP in.5.minute once one.CL-GEN bun-ACC steam-PST
'Taro steamed one bun once (*in five minutes).'

b. *Taro-wa (gohunnoaida) itido hitotu-no manzyu-o mús**i**-ta*
T.-TOP for.5.minute once one.CL-GEN bun-ACC steam-PST
'Taro steamed one bun once (for five minutes).'

There are also 30 verb stems containing /o/ as the second vowel (Appendix H). An example of such atelic verb stems is *mam**ó**t-* 'guard'. This verb stem is infelicitous with a time-span adverb, as in (26a), while the stem is felicitous with a durative adverb, as in (26b).

(26) a. *Taro-wa* (**gohunde*) *itido* *hitori-no* *kodomo-o* *mamót-ta*
T.-TOP in.5.minute once one.CL-GEN child-ACC guard-PST
'Taro guarded one child once (*in five minutes).'

b. *Taro-wa* (*gohunnoaida*) *itido* *hitori-no* *kodomo-o* *mamót-ta*
T.-TOP for.5.minute once one.CL-GEN child-ACC guard-PST
'Taro guarded one child once (for five minutes).'

In this section, I have shown that in Yamato-Japanese transitive verbs, the quality of the non-low vowels strictly corresponds to verbal telicity. This correspondence is sensitive to the vowel position, namely, at the rightmost vowel. In monosyllabic verb stems, the quality of the vowel corresponds to verbal telicity. In bisyllabic verb stems, Vowel 2 corresponds to verbal telicity. Thus, verb stems containing /e, u/ as the rightmost vowel are telic while verb stems containing /i, o/ as the rightmost vowel are atelic.[2]

3. The correspondence in nonce verbs

Based on the correspondence between the non-low vowels and verbal telicity in existing verbs, in this section I provide experimental support for the claim that the correspondence is part of the synchronic grammar. I first explain the general experimental design for the two experiments I have conducted. Then, I discuss the results of each experiment. I conclude that fluent speakers of Japanese are sensitive to the correspondence both in monosyllabic and in bisyllabic nonce verbs.

3.1 General experimental design

3.1.1 *Subjects*

The purpose of the experiments was to examine whether the correspondence between vowel quality and telicity value is active in the grammar. Thus, the grammar of speakers had to be developed and stable. Consequently, the subjects were all adult fluent speakers of Japanese. No subject participated in more than one experiment.

3.1.2 *The task*

In the experiments, I used a perception task, in particular, a forced-choice task. The forced-choice task was designed to match vowel quality with telicity. In a

2. The verb stems containing /a/ in the second vowel are either telic or atelic and the low vowel /a/ does not specify the telicity value of the verb stem (see Fujimori 2011 for details).

trial, a nonce verb was first presented as an auditory stimulus. After a 0.5 second silence, a pair of animated video clips appeared on a high-quality laptop screen. The video clips depicted two types of events: one telic and one atelic. A 0.5 second pause was inserted in between. Crucially, the depicted events did not correspond to any event associated with an existing verb that would name that event. The subjects were then asked to choose a movie clip which they thought matched the nonce verb. The forced-choice task was programmed with PsyScope X Build 51 and implemented on an Apple laptop.

3.1.3 *Stimuli*

3.1.3.1 *Sound tokens.* The nonce verbs were presented in auditory form, but not in written form. This was essential because the experiments were to examine whether the vowel quality is associated with telicity. The nonce verbs were modeled on existing monosyllabic or bisyllabic verbs (see Section 2.3). Each nonce verb was presented in a transitive sentence frame. Thus, the sentence contained a subject and an object, as in (27). The verb was repeated once again at the end, so that the subjects would not miss the unfamiliar nonce verb. The nonce verbs were recorded by a female speaker of Japanese.

(27)	*Pepe-ga*	*pengin-o*	***mút**-ta*, ***mút**-ta*
	P.-NOM	penguin-ACC	token-PST

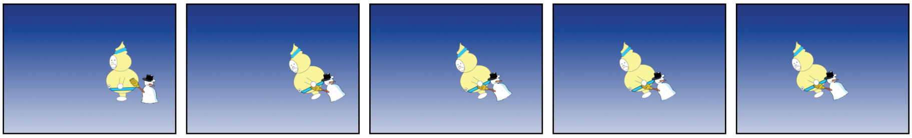
3.1.3.2 *Video clips.* Animated video clips were used to visually and unambiguously depict an endpoint of the event (cf. Wagner & Carey 2003). The video clips were created by using a graphic program, Motion Artist 4 (Smith Micro Software, Watsonville). The depicted event contained two event participants: one who initiated the event and the other who underwent it. Each video clip was 2 seconds long; at 0.4 seconds after the start of the movie clip, the event in question was initiated by the initiator. All telic events reached their natural endpoint at 1.6 seconds of the clip, as in (28), while the atelic events continued till the end, as in (29). The event occurred once with no repetition.

(28) Snapshots from a movie clip of telic motion

0 sec.	0.4 sec. (initial point)	1.0 sec.	1.6 sec. (endpoint)	2.0 sec.

(29) Snapshots from a movie clip of atelic motion

0 sec. | 0.4 sec. (initial point) | 1.0 sec. | 1.6 sec. | 2.0 sec.



To avoid the influence of existing verbs, all the video clips depicted an unfamiliar event. The main participants in the event were two alien creatures who were able to perform tasks which humans cannot. The unfamiliarity was independently checked with two adult speakers of Japanese. None of these speakers could come up with an attested Japanese verb denoting the depicted event.[3]

3.2 Monosyllabic nonce verbs

The purpose of Experiment 1 was to examine whether the subjects are sensitive to the correspondence of the non-low vowels with verbal telicity in monosyllabic nonce verbs. The subjects of Experiment 1 were 49 adult fluent speakers of Japanese. Out of these subjects, 32 spoke the Eastern dialect and 17 spoke the Western dialect. Their ages ranged from 20 to 50: 30 in the 20s, 14 in the 30s, and 5 over 40. None of them reported a history of seeing or hearing disabilities.

In Experiment 1, 40 nonce verbs were used. The nonce verbs included 20 monosyllabic tested tokens and 20 filler tokens. Thus, for all of the 49 subjects, the four vowels /e, u, i, o/ were examined in all possible syllable structures (V, VC, CV and CVC), as in (30).

(30) Tested nonce verbs in Experiment 1

Quality of vowel	**V-**	**VC-**	**CV-**	**CVC-**
/e/-telic	*é-(da)*	*éd-(da)*	*sé-(ta)*	*bet-(ta), nen- (da)*
/u/-telic	*ú-(da)*	*úd-(da)*	*sú- (ta)*	*but-(ta), nun-(da)*
/o/-atelic	*ó-(da)*	*ód-(da)*	*só-(ta)*	*bot-(ta), non-(da)*
/i/-atelic	*í-(da)*	*íd-(da)*	*sí-(ta)*	*bit-(ta), nin-(da)*

Throughout the experiments, two vowels were compared at a time. We first set up the null hypothesis which claimed that the subjects had a bias towards the choice

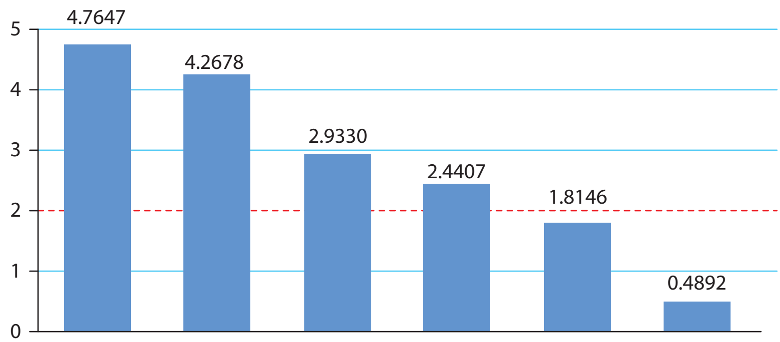
3. All the video clips used in the experiments are available in Quick Time format at ⟨http://cid-8e817abac54f7bb2.skydrive.live.com/browse.aspx/video⟩

of telic video clips across the compared vowels, whether the compared vowels correspond to a telic or an atelic value in existing verbs. To statistically test the null hypothesis, I used a non-parametric *d*-prime (d') test. The d'-value was the difference between *z*-transforms of the number of telic video clips chosen for the compared vowels. The value $d' = 0$ indicated that the subjects chose telic video clips for both of the compared vowels (i.e. a bias towards the choice of telic video clips across the compared vowels). The greater the d' value was, the more different in the choice of telicity the compared vowels were. The null hypothesis $d' = 0$ was tested by "measuring the deviation (z) between the observed and the hypothesized values (d'_0) in units of standard error [(se)]" (Wickens 2001: 208), as in (31).

(31) $$z = \frac{\widehat{d'} - d'0}{\widehat{se}(\widehat{d'})}$$

If the *z*-value was greater than the critical value 1.96 at the 5% significance level in a two-tailed test, there was less than 5% probability that the subjects had a response bias. Thus, we could reject the null hypothesis and take the alternative, which claimed that the difference between the compared two vowels in the choice of telicity was significant.

The overall results show that subjects were sensitive to the correspondence between the non-low vowels and telicity in nonce verbs. First we compared nonce verbs containing vowels that differ in telicity in existing verbs (e.g. /u/-telic and /o/-atelic). In these cases there was a significant difference in the choice of events. Figure 1 shows that the deviation (z) between the observed and the hypothesized d' values was greater than the critical value 1.96 (the dotted line in Figure 1) (u/o: $z = 4.7647$, $p < .01$; e/o: $z = 4.2678$, $p < .01$; u/i: $z = 2.933$, $p < .01$; e/i: $z = 2.4407$, $p = .01$). These results indicate that an event with an inherent endpoint was chosen for the nonce verb containing the vowels /e/ and /u/, which are the ones that correspond to telic events in existing verbs. In contrast, events that lack inherent endpoints were chosen for nonce verbs containing the vowels /i/ and /o/, which are the ones that correspond to atelic events in existing verbs. The next comparison was between nonce verbs containing vowels that do not differ in telicity in existing verbs (e.g. /u/-telic and /e/-telic). In this case there was <u>no</u> significant difference in the choice of events. Figure 1 shows that the deviation (z) was smaller than 1.96 (o/i: $z = 1.8146$, $p = 0.07$; e/u: $z = 0.4892$, $p = 0.62$). These results indicate that if the paired vowels are associated with the same telicity value in existing verbs, the telicity value of the video clip chosen in the task was also the same.



Pair	u/o	e/o	u/i	e/i	o/i	e/u
Telicity	telic/atelic	telic/atelic	telic/atelic	telic/atelic	telic/atelic	telic/atelic
p (z)	< 0.01	< 0.01	< 0.01	0.01	0.07	0.62

Figure 1. The non-low vowels in monosyllabic verbs. Deviation (z) between observed and hypothesized values (d')

3.3 Bisyllabic nonce verbs

Experiment 2 was to examine whether the subjects are sensitive to the vowel-telicity correspondence at a particular vowel position, namely, at the rightmost vowel. This position sensitivity was examined with bisyllabic nonce verbs. The subjects of Experiment 2 were 15 adult fluent speakers of Japanese. Six subjects spoke the Eastern dialect and 9 subjects spoke the Western dialect. Their ages ranged from 20 to 40: 11 in the 20s, 4 in the 30s.

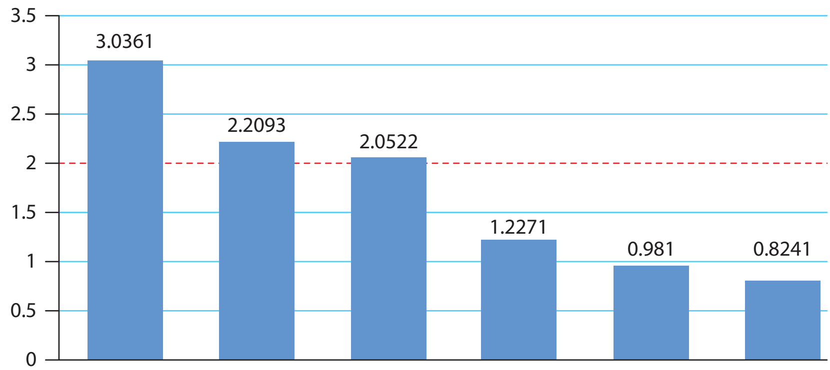
For all of the 15 subjects, 20 tokens were examined. These tokens took one of the non-low vowels as the second vowel of bisyllabic nonce verbs (e.g. *huret-* and *hurit-*): 4 sets of tokens for the type of consonants, as in (32), and the five vowels /e, u, i, o, a/ for the first vowel.

(32) Tested tokens in Experiment 2
{*VbVt-ta, VgVt-ta, VrVt-ta, hVrVt-ta*}

The overall results show that the speakers are sensitive to the correspondence between the quality of Vowel 2 and the telicity in bisyllabic nonce verbs. First we compared nonce verbs whose Vowel 2 differs in telicity in existing verbs (e.g. /u/-telic and /o/-atelic). As Figure 2 shows, in most of the cases there was a significant difference in the choice of events (e/i: $z = 3.0361$, $p < .01$; u/i: $z = 2.2093$, $p = .03$; e/o: $z = 2.0522$, $p = .04$).[4] The results indicate that an event with an

4. Note that there was no significant difference between /u/ and /o/ in the choice of events.

endpoint was chosen for the nonce verbs containing the vowel corresponding to a telic interpretation. In contrast, an event that lacks an endpoint was chosen for the nonce verbs containing the vowel corresponding to an atelic interpretation. The next comparison was between nonce verbs containing vowels that do not differ in telicity in existing verbs (e.g. /u/-telic and /e/-telic). In this case there was no significant difference in the choice of events (o/i: $z = 0.981$, $p = .33$; e/u: $z = 0.8241$, $p = .81$). These results indicate that if the paired vowels are associated with the same telicity value in existing verbs, the telicity value of the video clip chosen in the task was also the same.

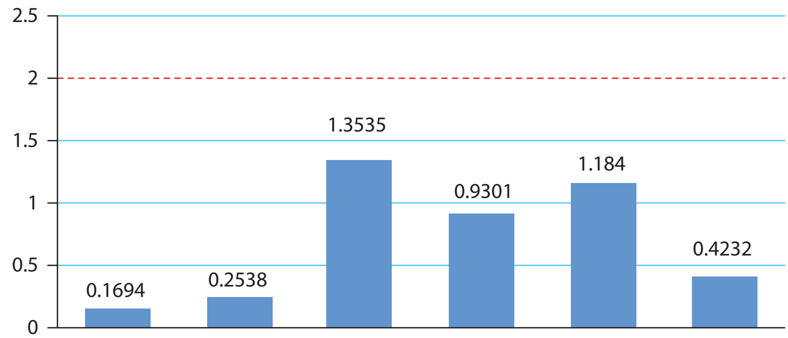


Pair	e/i	u/i	e/o	u/o	o/i	e/u
Telicity	telic/atelic	telic/atelic	telic/atelic	telic/atelic	telic/atelic	atelic/atelic
p (z)	< 0.01	0.03	0.04	0.22	0.33	0.81

Figure 2. The non-low vowels in vowel 2. Deviation (z) between observed and hypothesized values (d')

The sensitivity to the correspondence between the quality of Vowel 2 and telicity was contrasted with the results for Vowel 1. With Vowel 1, regardless of whether the pair of vowels differ in telicity in existing verbs, there was no significant difference between pairs of vowels in the choice of events (e/i: $z = 0.1694$, $p < .87$; u/i: $z = 0.2538$, $p = .80$; e/o: $z = 1.3535$, $p = .18$; u/o: $z = 0.9301$, $p = .35$; o/i: $z = 1.184$, $p = .12$; e/u: $z = 0.4232$, $p = .67$). This is shown in Figure 3. The clear difference between the results for Vowel 1 and Vowel 2 indicates that the quality of the rightmost vowel indeed associates with telicity.

To summarize, in Section 2 I have shown that the correspondence between the non-low vowels and verbal telicity in the existing monosyllabic verbs. In Experiment 1, the results showed that the subjects were sensitive to the correspondence between the quality of the rightmost vowel in the nonce verbs and the telicity depicted by the video clips. That is, the subjects had a significantly strong



Pair	e/i	u/i	e/o	u/o	o/i	e/u
Telicity	telic/atelic	telic/atelic	telic/atelic	telic/atelic	telic/atelic	atelic/atelic
p (z)	0.87	0.8	0.18	0.35	0.12	0.67

Figure 3. The non-low vowels in Vowel 1. Deviation (*z*) between observed and hypothesized values (*d*′)

tendency to associate telic movie clips with the telic vowels /e, u/, compared with the vowels /i, o/. These facts indicate that the correspondence between the non-low vowels and verbal telicity is synchronically *part of the grammar*. This is summarized in (33).

(33) Monosyllabic verb forms

Vowel quality	**Verbal telicity in**	
	Existing verbs	**Nonce verbs**
/e, u/	telic	telic
/i, o/	atelic	atelic

In bisyllabic existing verbs, the vowel position plays a crucial role; non-low vowels correspond to verbal telicity only in the second vowel position. The sensitivity to the vowel position also holds in bisyllabic nonce verbs; subjects were sensitive to the correspondence only in the second vowel position, as summarized in (34).[5]

5. It seems that the speakers are less sensitive to the vowel-telicity correspondence in bisyllabic nonce verbs, compared with monosyllabic nonce verbs. This might be due to that bisyllabic forms are found both in Yamato-Japanese verb stems and in loanword verb stems, while monosyllabic forms are unique to Yamato-Japanese ones (see also Section 2.2).

The facts of bisyllabic verbs and monosyllabic verbs indicate that the rightmost non-low vowels play a crucial role in determining verbal telicity.[6]

(34) Bisyllabic verb forms

Vowel 1	Verbal telicity in		Vowel 2	Verbal telicity in	
	Existing verbs	Nonce verbs		Existing verbs	Nonce verbs
/e, u/	telic or atelic	telic or atelic	/e, u/	telic	telic
/i, o/	telic or atelic	telic or atelic	/i, o/	atelic	atelic

4. Implications for phonology

The hitherto unrecognized correspondence between the non-low vowels and verbal telicity raises the phonological question: what property of the vowels constitutes a natural class for verbal telicity. In conventional distinctive features, the problem is that the vowels /e, u/ which correspond to [+telic] do not have features in common, other than [−low] and [−round], as in (35). /e/ has [−back] and [−high] while /u/ has [+back] and [+high]. The vowels /i, o/ which correspond to [−telic] do not have features in common, either. /i/ has [−back] and [+high] while /o/ has [+back] and [−high].

(35) The non-low vowels in conventional distinctive features

Telicity	vowel	[low]	[back]	[high]	[round]
[+telic]	/e/	−	−	−	−
	/u/	−	+	+	−
[−telic]	/i/	−	−	+	−
	/o/	−	+	−	−

I suggest that the correspondence between the non-low vowels and verbal telicity is accounted for by how far the tongue is dislocated from the tongue rest position, in the course of articulation. In this analysis, /e, u/ are close to the tongue rest

6. The fact that verbal telicity has a form in Japanese is not surprising, given that there are other languages where verbal telicity has a form such as Arabic (Er-Rayyan 1986; Fassi Fehri 1993) and Malagasy (Phillips 1996; Travis 2000). Verbal telicity is also overtly marked in sign languages such as American Sign Language (ASL) (Wilbur 2003; Maria & Wilbur in this volume). In ASL, in hand movement, a *rapid deceleration to a stop* denotes a telic event, while hand movement *continues relatively constantly* in atelic signs.

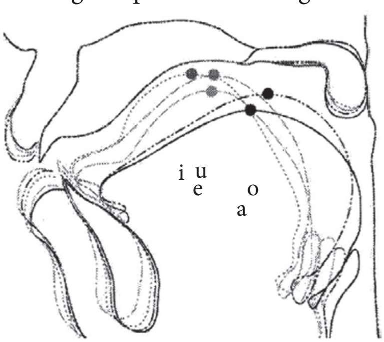
position ([central]) while /i, o/ are far from the tongue rest position and at the edges of the vocal tract ([peripheral]). Thus, [central] corresponds to the telicity feature [+telic] while [peripheral] corresponds to [−telic], as in (36).[7]

(36) The non-low vowels in [central]/[peripheral]

Telicity	**vowel**	**[low]**	**[central/peripheral]**
[+telic]	/e/	-	central
	/u/	-	
[−telic]	/i/	-	peripheral
	/o/	-	

This central/peripheral distinction is promising. Zhu and Hatano (2010) independently show with MRI pictures that the highest point of the tongue (large dots on the figure in (37)) is central in /e, u/ while the highest point is peripheral in /i, o/ (see also Uemura 1997). The tongue shape shows similar patterns. In /e, u/, the entire tongue is centralized, while the tongue is peripheral in /i, o/.

(37) The highest point of the tongue in articulating Japanese vowels



(Zhu & Hatano 2010: 49 Figure 6 with modification)

If this analysis is correct, it is predicted that the central/peripheral distinction will be statistically significant. Harshman et al. (1977) set up 13 points of the tongue surface on X-ray pictures and measure the distance between the tongue rest position and the moved tongue at each measuring point in English vowels. They show

7. Note that the analysis of central/peripheral distinction is provided for verbal telicity and that this analysis does not exclude the other conventional distinctive features such as [back] and [high]. The latter features are necessary for other morpho-phonological phenomena (Shibatani 1990).

that the central/peripheral distinction is significant. We can measure the non-low vowels in Japanese and examine whether the central and the peripheral vowels will show a similar pattern to what Harshman et al. find. I leave this measurement for future research.

5. Concluding remarks

In this paper, I have conducted a case study revealing a correspondence between vowel quality and verbal telicity in Yamato Japanese. In particular, verbal telicity is encoded by the quality of the rightmost vowel of the verb stem. /e/ or /u/ corresponds to [+telic] while /i/ or /o/ corresponds to [−telic]. This vowel-telicity correspondence holds not only in existing verbs but also in nonce verbs. That is, the correspondence is part of the synchronic grammar. I conclude this paper by exploring the point of the grammar at which the quality of the rightmost vowel corresponds to verbal telicity.

As seen in Section 2, telicity is composed in phrasal syntax (Verkuyl 1972, 1993). In this context, the question arises as to what role the correspondence between the non-low vowels and verbal telicity plays in the calculation of phrasal telicity. In what follows, I develop a morpho-syntactic analysis within the Principles and Parameters framework in its minimalist incarnations (Chomsky 1995 and subsequent work). In particular, I adopt Travis' (1991, 2000) assumption according to which verbal telicity is encoded in a functional projection dedicated for inner Aspect. I propose that in Yamato-Japanese verb stems, the rightmost vowel is associated with inner Asp. In particular, /e, u/ specify inner Asp as [+telic] while /i, o/ specify inner aspect as [−telic], as represented in (38).

(38) a. $\ldots[_{\text{outer Asp}}\ [_{v\text{P}}\ [_{v'}\ [_{\text{inner AspP}}\ \textsc{obj}\ [_{\text{inner Asp}}\ \langle\{/\text{e}/, /\text{u}/\}, [+\text{telic}]\rangle]]]]]$
b. $\ldots[_{\text{outer Asp}}\ [_{v\text{P}}\ [_{v'}\ [_{\text{inner AspP}}\ \textsc{obj}\ [_{\text{inner Asp}}\ \langle\{/\text{i}/, /\text{o}/\}, [-\text{telic}]\rangle]]]]]$

This representation has implications for how the rightmost vowel is associated with inner Asp and its semantic value. The rightmost vowel ⟨π⟩ is associated with its corresponding telicity value ⟨Σ⟩ before associated with inner Asp ⟨κ⟩ in phrasal syntax. This is schematized in (39).

(39) Early association of ⟨π⟩ with ⟨Σ⟩

Lexicon		Syntax	Spell-out
⟨π, Σ⟩	→	⟨κ⟩	

This early association of ⟨π⟩ with ⟨Σ⟩ has advantage in that it accounts for the proper assignment of the vowel quality to verbal telicity. The verbal telicity is apparent only if the direct object is quantized ([+q]), as in (40a) and (40b). If the direct object is non-quantized ([−q]), the verbal telicity is opaque to the phrase-level telicity as in (40c). This compositionality does not affect the association of vowel quality with inner Asp, given that the sound category association takes place before the telicity composition.

(40) The transparency/opacity of verbal telicity to phrase-level telicity

	OBJ	*verb*	*verb phrase*	
a.	[+ q]	[+ telic]	[+ telic]	(transparent)
b.	[+ q]	[− telic]	[− telic]	(transparent)
c.	[− q]	[+ telic]	[− telic]	(opaque)
d.	[− q]	[− telic]	[− telic]	(transparent)

This type of sound-category association is rather new to the current syntactic theory. In Distributed Morphology (Halle & Marantz 1993; Harley & Noyer 1999; among many), ⟨π⟩ of categorial heads ('morphemes') is inserted late after spelling out syntactically processed linguistic objects towards Phonological Form and Logical Form (⟨⟨κ, Σ⟩, π⟩), as schematized in (41).

(41) Late association of ⟨π⟩ with ⟨Σ⟩

<u>Lexicon</u>		<u>Syntax</u>		<u>Spell-out</u>
⟨Σ⟩	→	⟨κ⟩	→	⟨π⟩

However, this late association of ⟨π⟩ with ⟨Σ⟩ is problematic in Japanese because of the compositional property of telicity. If inner Asp is assigned its form after spell-out, the form is determined based on the telicity value of the verb phrase. Thus, in (52c) where the verbal telicity is opaque to phrasal telicity, inner Asp is assigned a wrong form on the basis of the telicity value of inner AspP at spell-out.

If the vowel-telicity correspondence is an instance of early association of ⟨π⟩ with ⟨Σ⟩, as (39) shows, it is further expected that the association of ⟨π⟩ with ⟨Σ⟩ is independent from syntactic category ⟨κ⟩. That is, there are category neutral sound-meaning correspondences which may apply across syntactic categories in Japanese. However, this line of research is beyond our present scope and I leave the issue on the timing of sound-meaning association for future research.

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Appendices

Appendix A. Monosyllabic transitive verb stems containing /e/ (n = 5)

Syllable	Past	Gloss	Diagnostics for (a)telicity	
			in	for
e	é-ta	get	Yes	No
Ce	hé-ta	pass	Yes	No
CeC	két-ta	kick	Yes	No
	nét-ta	knead	Yes	No
	sét-ta	bid	Yes	No

Appendix B. Monosyllabic transitive verb stems containing /u/ (n = 16)

Syllable	Past	Gloss	Diagnostics for (a)telicity	
			in	for
uC	út-ta	hit	Yes	No
	ut-ta	sell	Yes	No
	un-da	bear	Yes	No
CuC	tut-ta	pull up	Yes	No
	sút-ta	strike	Yes	No
	sut-ta	suck	Yes	No
	zút-ta	drag	Yes	No
	nút-ta	sew	Yes	No
	nut-ta	rub	Yes	No
	yút-ta	do up one's hair	Yes	No
	yut-ta	utter	Yes	No
	kút-ta	devour	Yes	No
	hut-ta	swing	Yes	No
	tun-da	stack	Yes	No
	kun-da	scoop	Yes	No
	hun-da	tread	Yes	No

Appendix C. Monosyllabic transitive verb stems containing /i/ (n = 8)

Syllable	Past	Gloss	Diagnostics for (a)telicity	
			in	for
Ci	ki-ta	wear	No	Yes
	mí-ta	see	No	Yes
	ni-ta	simmer	No	Yes
	si-ta	do	No	Yes
iC	ít-ta	fry	No	Yes
CiC	kít-ta	cut	No	Yes
	sit-ta	know	No	Yes
	hít-ta	fart	No	Yes

Appendix D. Monosyllabic transitive verb stems containing /o/ (n = 12)

Syllable	Past	Gloss	Diagnostics for (a)telicity	
			in	for
oC	ot-ta	chase	No	Yes
	ót-ta	bend	No	Yes
CoC	mót-ta	carry	No	Yes
	mot-ta	heap	No	Yes
	tót-ta	take	No	Yes
	hót-ta	dig	No	Yes
	mon-da	massage	No	Yes
	ton-da	fly	No	Yes
	sót-ta	shave	No	Yes
	nón-da	swallow	No	Yes
	yón-da	read	No	Yes
	yon-da	invite	No	Yes

Appendix E. Bisyllabic transitive verb stems containing /e/ in the second syllable (n = 4)

Syllable	Past	Gloss	Diagnostics for (a)telicity	
			in	for
CVCeC	tunét-ta	pinch	Yes	No
	hinét-ta	twist	Yes	No
	syabét-ta	chatter	Yes	No
	sesét-ta	fool/pick	Yes	No

Appendix F. Bisyllabic transitive verb stems containing /u/ in the second syllable (n = 31)

Syllable	Past	Gloss	Diagnostics for (a)telicity	
			in	for
VCuC	okut-ta	send	Yes	No
	egút-ta	gouge	Yes	No
	abút-ta	roast	Yes	No
CVCuC	tikút-ta	inform	Yes	No
	sikún-da	plan	Yes	No
	kosút-ta	scrub	Yes	No
	kezut-ta	whittle	Yes	No
	mekut-ta	leaf (a page)	Yes	No
	megut-ta	go round	Yes	No
	megun-da	give generously	Yes	No
	kukut-ta	tie together	Yes	No
	susut-ta	sip	Yes	No
	tukút-ta	make	Yes	No
	tudut-ta	spell	Yes	No
	yusut-ta	swing	Yes	No
	sukut-ta	scoop	Yes	No
	nugut-ta	wipe	Yes	No
	tutún-da	wrap	Yes	No
	nusún-da	rob	Yes	No
	kurún-da	roll	Yes	No
	musun-da	knot	Yes	No
	kasút-ta	graze	Yes	No
	sasut-ta	rub	Yes	No
	nagút-ta	punch	Yes	No
	nasút-ta	rub on	Yes	No
	nabút-ta	mock at	Yes	No
	makut-ta	roll up	Yes	No
	matut-ta	offer (honorific)	Yes	No
	tagút-ta	haul	Yes	No
	hazun-da	bound	Yes	No

Appendix G. Bisyllabic transitive verb stems containing /i/ in the second syllable (n = 52)

Syllable	Past	Gloss	Diagnostics for (a)telicity	
			in	**for**
Vi	oi-ta	put	No	Yes
CVi	kii-ta	listen to	No	Yes
	sii-ta	lay	No	Yes
	hii-ta	pull	No	Yes
	síi-ta	force	No	Yes
	kói-ta	excrete	No	Yes
	tói-ta	dissolve	No	Yes
	doi-ta	pull back	No	Yes
	noi-ta	pull back	No	Yes
	sui-ta	plow	No	Yes
	sui-ta	like	No	Yes
	nui-ta	unplug	No	Yes
	húi-ta	blow	No	Yes
	hui-ta	sweep	No	Yes
	mui-ta	face	No	Yes
	mui-ta	show one's fangs	No	Yes
	kúi-ta	regret	No	Yes
	kái-ta	write	No	Yes
	sai-ta	bloom	No	Yes
	sái-ta	tear	No	Yes
	tai-ta	make a fire	No	Yes

Syllable	Past	Gloss	Diagnostics for (a)telicity	
			in	**for**
CVi	nai-ta	cry	No	Yes
	hái-ta	sweep	No	Yes
	mai-ta	roll	No	Yes
	mái-ta	seed	No	Yes
	yai-ta	burn	No	Yes
VCi	óbi-ta	take on	No	Yes
	abi-ta	bathe	No	Yes

(Continued)

Appendix G. (Continued)

Syllable	Past	Gloss	Diagnostics for (a)telicity	
			in	for
CVCi	músi-ta	steam	No	Yes
	kasi-ta	lend	No	Yes
	sási-ta	stub	No	Yes
CVCi	tasi-ta	add	No	Yes
	dási-ta	put out	No	Yes
	nási-ta	perform	No	Yes
	házi-ta	be ashamed of	No	Yes
	wabi-ta	apologize	No	Yes
	kari-ta	borrow	No	Yes
VCiC	izít-ta	finger	No	Yes
CVCiC	tigít-ta	cut into pieces	No	Yes
	sikít-ta	compart	No	Yes
	mikít-ta	forsake	No	Yes
	misít-ta	acquaint	No	Yes
	kogít-ta	cut into small pieces	No	Yes
	kozít-ta	wrench	No	Yes
	segít-ta	dam	No	Yes
	negít-ta	beat down	No	Yes
	nezít-ta	twist	No	Yes
	musit-ta	pluck	No	Yes
	kagít-ta	limit	No	Yes
	kazít-ta	gnaw	No	Yes
	nazít-ta	rebuke	No	Yes
	hasít-ta	run on	No	Yes

Appendix H. Bisyllabic transitive verb stems containing /o/ in the second syllable (n = 30)

Syllable	Past	Gloss	Diagnostics for (a)telicity	
			in	for
VoC	oot-ta	cover	No	Yes
	aót-ta	agitate	No	Yes
CVoC	seót-ta	shoulder	No	Yes
	haót-ta	put on	No	Yes
VCoC	inót-ta	wish	No	Yes
	idón-da	challenge	No	Yes

Appendix H. (Continued)

Syllable	Past	Gloss	Diagnostics for (a)telicity	
			in	for
VCoC	ogot-ta	be proud	No	Yes
	osot-ta	strike	No	Yes
	odot-ta	dance	No	Yes
	omót-ta	think	No	Yes
CVCoC	kikón-da	wear (extra clothes)	No	Yes
	sikón-da	train	No	Yes
	nikón-da	stew	No	Yes
	mikon-da	estimate	No	Yes
	metót-ta	marry	No	Yes
	tunót-ta	collect	No	Yes
	nanót-ta	give one's name	No	Yes
	mamót-ta	guard	No	Yes
	tamót-ta	hold	No	Yes
	kamót-ta	pull a fast one on	No	Yes
	tadót-ta	track back	No	Yes
	satot-ta	realize	No	Yes
	tayót-ta	rely on	No	Yes
	nazót-ta	trace	No	Yes
	kakot-ta	enclose	No	Yes
	sasot-ta	entice	No	Yes
	matót-ta	robe	No	Yes
	yatót-ta	hire	No	Yes
	kakon-da	enclose	No	Yes
	nagón-da	relax	No	Yes

PART III

Phonology, syntax

Towards a bottom-up approach to phonological typology*

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The set of combinatoric possibilities of even simple formal systems explodes quickly. Adopting (perhaps overly) simple assumptions about phonological representation and computation, we show that, with just a handful of featural primitives, the number of possible segments, the number of possible inventories and the number of possible rule targets quickly reaches shockingly high levels. Not only is this result inevitable for pretty much any feature system, but it is also desirable. The crucial point is to define sets (of segments, inventories, or rule targets) intensionally, and see that we can account for a vast range of phenomena using a minimal toolkit, in parallel to recent *evo-devo* work in biology. Understanding the combinatorics is a step towards a biolinguistic approach to phonology.

The "evo-devo revolution" (e.g. Carroll 2005) refers to the synthesis of evolutionary biology and developmental biology now possible with the recent explosion in the understanding of genetic mechanisms. The discussion of evo-devo, for example by Chomsky (2007), is based on various parallels between evo-devo thinking and ideas driving recent work in linguistic metatheory. For the purposes of this paper, the most important shared theme is the idea that a vast range of phenomena can be explained using what seems to be a fairly minimal toolkit.

In earlier work, Chomsky (2000, p. 122) says that the goal of linguistic theory is "to abstract from the welter of descriptive complexity certain general principles governing computation that would allow the rules of a particular language to be given in very simple forms". This is an example of what Chomsky calls in more recent work (2007) a "top-down" approach (from language data to principles). Citing the parallels with evo-devo, Chomsky suggests that we need to also focus

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on a converging "bottom-up" approach that asks "How little can be attributed to UG while still accounting for the variety of I-languages attained... ?" In this paper, I suggest that the simple combinatorics of feature systems and rule systems are encouraging – the combinatorics of formal systems explodes so quickly that making a model rich enough to capture a vast typology (the range of possible linguistic variation) should not be a worry. A corollary to this idea is the conclusion that concerns that a model of UG may be too rich, in the sense of allowing the description of languages that will never be attested, are unfounded. This is not because we are assured to find "restrictive" models that do not allow for such languages, but because even the simplest systems give rise to combinatoric possibilities that quickly exceed astronomical levels. A more sophisticated notion of restrictiveness is needed.

I offer a tack to the problem of UG that is in the spirit of the bottom-up approach. If we can show that well-accepted, basic linguistic concepts actually provide for a greater richness of descriptive power (a richer typology) than previously suspected, we can take heart that the welter of descriptive complexity is in fact tractable within a relatively simple theory. To rephrase: I suggest that some basic tools are more powerful than we have realized for capturing a wide range of phenomena.

I'll make several arguments that the typology covered by current models is potentially much richer than intuitions suggest, and that this richness has already been exploited by some scholars. The first argument brings together a simple idea from feature logic with elementary combinatorics to revisit the basic issue of how many possible segments can be defined with a given feature system, and how allowing underspecification affects the set of possibilities. The second argument builds on the first by looking at how many possible segment inventories result from the sets of segments we derive under different assumptions. The third argument shows how the results of the first argument can lead to an explosion of descriptive power in a model of phonological computation. The third argument, building on the discussion from the first, literally shows that the representation of *nothing* in standard underspecification theory can increase the size of the typological space of a computational system by trillions.

To reiterate, in the following sections we explore, respectively, the number of segments, the number of inventories and the number of grammars (rule systems) that can be defined under simple assumptions about phonological representation. In each section, we compare the value arrived at under a basic assumption of binary features with a value based on a binary system that also allows underspecification.

If one wants to explore the combinatorics of a formal system, one must define what that system is. Some of the phonological literature does not use binary features, instead using privative ones or gradient ones, say. I am not exploring the combinatorics of such systems. In addition to *assuming* binarity (that +*F* and –*F* are the only possibilities for how a feature F can appear in a representation) I am *assuming* that one or more features can be missing from the representation of a segment, that is, I am *assuming* underspecification, and not providing empirical arguments for allowing it. The paper explores some implications of this assumption that underspecification is allowed by UG.[1]

1. How many segments can be defined?

A staple of linguistic (and general scientific) argumentation is the demonstration that variety and complexity can emerge from combinations of simple elements. For example, one appeal of the Principle and Parameters (Chomsky & Lasnik 1993) model of syntax is that language variation can be attributed to differences in the parameter settings in different grammars – or more precisely, a grammar *is* a particular combination of parameter settings. With relatively few parameters set in various combinations, we can model many languages. Similarly, combinations of a small set of phonological features give rise to the possibility for a number of potential segments (viewed as sets of valued features) of a much higher magnitude.

1.1 The standard claim: 2^n

In both cases, that of using a small set of universal parameters to account for syntactic typological variation and that of using a small set of features to account for the possibility of large and varied segment inventories, it is common in the literature to assume that both parameters and features are binary – they come in two varieties, they combine with one of two coefficients, say "+" or "–". In order to demonstrate the combinatorial power of such a binary system, we often refer to the massive possibility space that grows exponentially as the number of

1. For some reason, reviewers of this work have consistently interpreted it as claiming to provide new arguments for underspecification. There are no empirical arguments offered, only claims that accepting underspecification and recognizing the combinatoric implications of doing so has potentially interesting implications for the study of phonological typology, along with a conceptual argument that parallels one used in syntax. As I have suggested, pretty much any system will yield a richer typology that is often recognized. I focus on underspecification since it is often adopted without the effects of such an assumption being recognized. In a fuller treatment in progress, I offer more support for adopting underspecification.

parameters or features grows. For example, McGilvray (1999, p. 114), in a discussion of the Principles and Parameters model points out that with fourteen independent binary parameters we get 2^{14} = 16,384 possible languages, and he calls this a "comfortable margin" over the 6,000 or so languages assumed to exist. We should of course note that the number 6,000 refers, not to I-languages, mental grammars, but to the sociopolitical entities that are described in, say, the *Ethnologue* (http://www.ethnologue.com/). We expect that the total number of I-languages extant in the world is actually much higher. Should we worry that the margin is not so comfortable? Sakas and Fodor (2001, p. 196) discuss the approximately one billion grammars describable with thirty parameters – 2^{30} is a little over a billion, so one way to make the margin between attested languages and potential languages more "comfortable" is to increase the number of parameters.

Newmeyer (2004, p. 541–2) addresses the issue of microvariation discussed by Kayne (2000):

> However, once one starts comparing syntactic differences between individuals speaking the 'same' language/dialect, the number of grammars increases exponentially, indeed perhaps it might be "some number substantially greater than 5 billion" (p. 8)!
>
> Kayne is not troubled by this result, since, as he points out, "the number of independent binary-valued syntactic parameters needed to allow for 5 billion syntactically distinct grammars is only 33 (2 raised to the 33rd power is about 8.5 billion) [...] it seems plausible that the child is capable of setting at least that many syntactic parameters" (p. 8).
>
> Kayne's math may be right, but from that fact it does not follow that only 33 parameters would be needed to capture all of the microvariation that one finds in the world's languages and dialects. In principle, the goal of a parametric approach is to capture the set of possible human languages, not the set (however large) of actually existing ones. One can only speculate that the number of such languages is in the trillions or quadrillions. In any event, Kayne's own work suggests that the number of parameters is vastly higher than 33.

My point here is just that 2^n is the standard value assumed in discussions of parametric systems.

The same value is used in discussing phoneme inventories. Kornai (2008) mentions the possibility of thirty-six binary valued features yielding 2^{36}, or about 69 billion possible segments. In a limited domain, it is not unusual to find discussion of the eight vowels of Turkish instantiating the 2^3 = 8 possibilities defined by the combinations of the binary features [±high], [±back] and [±round]. Giegerich (1992, p. 114) mentions that "generally, *n* features can occur in 2^n different combinations". Surprisingly, both Kornai and Giegerich appear to disapprove of the massive combinatory possibilities provided by *n* features (since attested phoneme inventories tend to be limited to safely under 100 members[2]), whereas, in the case of binary syntactic parameters, authors seem to approve of the potential such a system holds. But again, the point here is just that 2^n is assumed to be the relevant number, whether or not one approves or disapproves of the resulting richness.

I will argue that, in fact, Kayne's math is not quite right, or at least not for phoneme inventories – although it is the math that pretty much everyone invokes. I will show that, given a single assumption, the number that we should be discussing is actually *much* greater, and thus the combinatorial systems based on binary features and binary parameters are even richer that typically recognized. What this means is that we can do more with what we already have in our models – we can model over 10 billion languages with just 21 parameters, or over 50 thousand underlying segments with just 10 binary features. From this point on, I restrict discussion to phonological features and segments.[3]

1.2 How many segments?

The value 2^n for segment inventories is based on a model of full specification that assumes a set of features $\mathcal{F}$ of cardinality *n*, and treats a segment as a set of

2. Their implicit reasoning seems a bit flawed here, since, under their own assumptions, the typological richness of feature combinations should not be matching the inventories of individual languages, but rather the intersection of the inventories of all possible languages, the set of possible segments. This distinction is clarified below.

3. A full consideration of syntactic issues will have to deal with questions like the following: What is the correct feature model for syntax? – see Adger and Svenonius (2011) for recent discussion. What, if anything, is the correlate of an underspecified segment in the domain of parametric variation? Under Minimalism, parametric variation is reformulated as variation on the features associated with functional heads. If these syntactic features are capable of taking on multiple values, we get the same kind of basic combinatorics as with phonological features. If we do not assume the strongest version of the Cartographic Approach (e.g. Cinque (1999)) that every sentence in every language contains the same hierarchy of functional projections, but instead allow that some projections can be lacking in some languages, we allow for languages to have a subset of the universal set of functional heads present in syntax. For example, it could be the case that a given language lacks a functional head for evidentiality, and thus this category is not projected, but in every other respect, the language could match another language. I have left the mention of syntactic typology in the paper on account of the obvious parallel in the structure of typological discussion in the two domains, and also in the hope of piquing the interest of syntacticians.

attribute-value pairs, or coefficient-feature pairs, also of cardinality n. For example, if $\mathcal{F}$ is $\{F_1, F_2, F_3\}$, then the set of possible segments Σ contains these 8 members:

(1) Σ with three features and underspecfication: $|\Sigma| = 8$
$\{\{+F_1, +F_2, +F_3\}, \{+F_1, +F_2, -F_3\}, \{+F_1, -F_2, +F_3\}, \{+F_1, -F_2, -F_3\}$
$\{-F_1, +F_2, +F_3\}, \{-F_1, +F_2, -F_3\}, \{-F_1, -F_2, +F_3\}, \{-F_1, -F_2, -F_3\}\}$

Each set of valued features inside a pair of brackets corresponds to a segment. Here, each feature occurs with either a "+" or a "–", so there are $2^3 = 8$ possible segments. There are three features and the cardinality of each segment/set is 3.

For more than 20 years, phonologists have argued that there is another way to conceive of segments,[4] although we are often not explicit in doing so. In particular, there are several arguments that segments can be lacking any mention of some features.[5] In other words, if $\mathcal{F}$ has cardinality n then a segment has cardinality less than or equal to n.

To give a brief example,[6] one might analyse the vowel of the Turkish plural suffix which alternates between a non-high, non-round back vowel, and a non-high, non-round, front vowel as lexically specified as non-high and non-round, but not specified for the back/front distinction.

Note that the surface variant of the plural marker *-lar* occurs after back vowels and the variant *-ler* occurs after front vowels in (2):

---

4. I am completely ignoring the vast literature that treats segments as more structured than sets, for example, McCarthy (1988), in part because I have argued against such feature geometry models (Reiss (2003b)), and they have also been widely ignored in recent literature, especially the Optimality Theoretic literature, which often puts aside issues of representation. This is a study of one particular model of segments and features, not an attempt to justify that model. However, the combinatoric effects of underspecification discussed here will generalize to such models to some extent.

5. The arguments for underspecification originated as being restricted to underlying (lexically stored) segments, but have been extended to surface segments as well; see the target interpolation literature, with copious instrumental phonetic justification of Keating (1988), Cohn (1993), Choi (1992), as well as discussion and implications presented by Mark Hale (Hale (2007) and Hale & Reiss (2008)). Steriade (1995) gives a useful survey of arguments for underspecification, but concludes with a rejection of the idea and adoption of a mix of privative and binary features. It is beyond the scope of this paper to evaluate her non-uniform view of features. It is worth noting that in practice, underspecification is still widely used, for example, the existence of Dep constraints in OT is predicated on the possibility of candidates containing features that are not present in input forms.

6. The analysis I sketch here is fairly standard, but by no means the only one available to phonologists.

(2) Turkish singular/plural pairs

singular	plural	meaning
ip	ipler	rope
kıl	kıllar	body hair
sap	saplar	stalk
uç	uçlar	edge
son	sonlar	end
öç	öçler	vengeance
gül	güller	rose
ek	ekler	junction

Since the choice of underlying /a/ or /e/ would have to be made arbitrarily by the linguist and by the child, a common solution is to assume that the lexical form has neither of these vowels, but instead has an underspecified vowel, denoted here as /A/, that can surface as either, depending on the context.

(3) The underlying [–high] and [–round] vowel /A/ has no specification for [back], and surfaces as *e* or *a* depending on context

A

lexical $\begin{bmatrix} -\text{round} \\ -\text{high} \end{bmatrix}$

after a [–back] vowel → e   after a [+back] vowel → a

surface e $\begin{bmatrix} -\text{round} \\ -\text{high} \\ -\text{back} \end{bmatrix}$ a $\begin{bmatrix} -\text{round} \\ -\text{high} \\ +\text{back} \end{bmatrix}$

The value for ±back is filled in by the phonological computational system – underspecified /A/ surfaces as either [e] or [a] – see Isac and Reiss (2008) for more data and discussion at a basic level. Once again, in this paper, I will be *assuming* that there are underspecified segments, for example in the lexical form of the Turkish plural. The paper does not pretend to argue for underspecification aside from making a conceptual argument in Section 1.3. The paper is mainly concerned with the implications for typology of the decision to accept the existence of underspecification.

So, with the assumption of underspecification, we can therefore think of a segment as a set of coefficient-feature pairs in which set each feature occurs *at most* once. For each feature F in $\mathcal{F}$, a given segment will either *not* contain a coefficient-feature pair that contains F, or contain +F, or contain –F.[7]

One can make this more formal, but the basic idea should be clear. With full specification, and say three features, the set of possible segments was shown in (1). With the assumption of underspecification the set of segments, E, is shown in (4).

(4) Σ with three features and underspecfication: $|\Sigma| = 3^3 = 27$

$\{\emptyset,$
$\{+F_1\}, \{-F_1\}, \{+F_2\}, \{-F_2\}, \{+F_3\}, \{-F_3\},$
$\{+F_1, +F_2\}, \{+F_1, -F_2\}, \{+F_1, +F_3\}, \{+F_1, -F_3\},$
$\{-F_1, +F_2\}, \{-F_1, -F_2\}, \{-F_1, +F_3\}, \{-F_1, -F_3\},$
$\{+F_2, +F_3\}, \{+F_2, -F_3\}$
$\{-F_2, +F_3\}, \{-F_2, -F_3\}$
$\{+F_1, +F_2, +F_3\}, \{+F_1, +F_2, -F_3\}, \{+F_1, -F_2, +F_3\}, \{+F_1, -F_2, -F_3\}$
$\{-F_1, +F_2, +F_3\}, \{-F_1, +F_2, -F_3\}, \{-F_1, -F_2, +F_3\}, \{-F_1, -F_2, -F_3\}\}$

What is the cardinality of this set, Σ? You can count, but for the general case, there are now three possibilities for a feature in a segment: occuring with +, occurring with – or, not occurring. So if the cardinality of $\mathcal{F}$ is n, then the cardinality of Σ is 3^n. That's how underspecification gets us to 3^n.

I reiterate that the simple fact that 3^n is greater than 2^n for positive values of n is not being offered here as an argument for underspecification. I am *assuming* a model with binary-valued features and underspecification and just pointing out the implications of doing so. If we want to explore the typological power of a formal system, we need to specify its properties. I could have made other assumptions, consistent with other feature systems in the literature, and I would probably have reached different conclusions.

1.3 Less is more – "stripped-down" UG

It is obvious that the universal segment inventory with 27 segments based on 3 features in (4) will correspond to *at least* as many phonetic realizations as the

7. It is possible to make a four-way distinction of +F, –F, absence of F, and 'unvalued' F (denoted ∅F). In this paper, following Reiss (2003a, p. 210), I do not consider the possibility of ∅F because accepting it leads us to expect that ∅F could serve to identify natural classes, and I don't think there is evidence that such classes play a role in phonology. Unvalued features are used widely in syntax (see Adger & Svenonius (2011)), but the issue turns out to be orthogonal to our central claim that a binary system allows more than just a two-way distinction. For our purposes, I will treat "absence of F" and "∅F" as equivalent, or more precisely, the latter will be used as a way to refer to the latter in a phonologist's metalanguage. There are an infinite number of assumptions one could make – this paper explores the implications of one set of assumptions that has some currency in the literature.

inventory with 8 segments in (1), since every member of the latter is a member of the former – the set in (1) is a subset of the set in (4). In fact, if underspecification can persist to the surface, the output of the grammar, then we expect the underspecification system to be able to model more phonetic distinctions than the system that requires full specification. This possibility is exploited by the target-interpolation studies cited in Footnote 5: to capture a phonological category that lacks the steady-state components of, say, [+nasal] segments and [−nasal] segments, the target interpolationists posit absence of [nasal] as a third possibility, with varying amounts of nasality filled in during the articulation of the segment due to non-featural coarticulatory effects of neighboring segments.

One might be concerned that the massive increase in combinatorial power entailed by underspecification presents a problem for the learner since it appears to increase the size of the hypothesis space for learning lexical items. I think that it is not clear that this is so, and in fact, the 3^n view has at least two arguments to commend it. First, let's assume that each feature must be learned separately for each segment in each stored lexical item. Then the search space actually increases by only 3/2 under my suggestion – instead of just, say, "+" or "−" the learner must figure out whether the feature is present at all in a given segment.[8] In terms of the complexity of a problem, this is a small linear increase in the size of the search space, an increase which has no bearing on the learning problem.

But there is another factor at play in comparing the two combinatoric positions. The question is not just a comparison of 2^n versus 3^n for a fixed n. A model that makes use of underspecification may be able to make do with far fewer features, so the right comparison may be 2^m versus 3^n with m much bigger than n – recall Chomsky's statement that "the less attributed to genetic information (in our case, the topic of UG) for determining the development of an organism, the more feasible the study of its evolution". It is a mistake to see the growth from powers of 2 to powers of 3 as an increase of richness – we need to appreciate the decrease from m to n, which reflects the biolinguistic issue of the *actual content of the Human Language Faculty*.

Suppose the number of possible segments[9] is actually around one billion, just to choose an arbitrary number for illustration, as in the discussions cited above.

8. This is not to suggest that figuring this out is trivial. See Chapter 6 of Hale and Reiss (2008) for an case where a phonetically underspecified segment and a fully-specified one can be pronounced identically.

9. Or languages, if we want to keep the possible relevance to parameters/syntactic features in mind.

Without underspecification, we need the cardinality of $\mathcal{F}$ to be around 30, since 2^{30} is just over a billion. However, if we allow the underspecification approach, we get to a billion with n equal to just nineteen – 3^{19} is over a billion, as shown in Figure 1 below. In this example alone, the reduction from 30 to 19 is relatively greater than the increase from 2 to 3 values, so we could just as well argue that the problem is simplified for a learner when there are fewer features to consider.

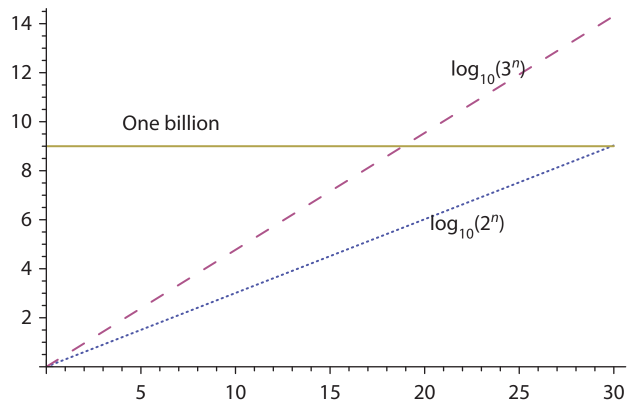

Figure 1. Comparison of $y = log_{10}2^n$ and $y = log_{10}3^n$

Just to stress this idea and to show that the differences are great even for smaller numbers of features/parameters, consider that with eight vowel features, 2^8 gives 256 possible underlying segments, but we get into the same range with just five features using powers of three: $3^5 = 243$.

Now, one should *not* conclude from all this that every time we have trouble modeling a phonetic distinction we will find a solution by allowing underspecification of features that already are well established in the literature. All of our proposals about the content of UG are tentative. The correct conclusion has been accepted implicitly in the work on phonetic underspecification and target interpolation cited above. These scholars discuss the case of Marshallese vowels that begin, say, with the phonetic correlates of [+back] and [+round] and end with the correlates of [–back] and [–round] when preceded by a back round consonant and followed by a front unround consonant. Rather than positing a whole new set of features for these transitional vowels, these scholars analyze them as lacking specification for [back] and [round] with the phonetic realization reflecting the coarticulatory effects of surrounding consonants. My point is that such explanation is only available if underspecification is available (both underlyingly and on the surface). So, part of my justification for assuming underspecification is the empirical support provided by the target interpolation literature.

Now, I will argue that allowing underspecification is also a *conceptually* elegant move, although it might *appear* to make the model more complicated. To put it differently, here is an argument that the move from 2^n to 3^n is actually a simplification. I first invoke some analogies from syntax.

In *Syntactic Structures*, Chomsky (1957, p. 23–4) points out that attempting to define a longest possible sentence for English would make the theory more complex – the model which says nothing about length, despite the fact that every observable sentence has a finite, and actually fairly small length, is better than a model that stipulates an arbitrary (albeit empirically valid for all corpora) upper limit like say "1000 words".[10] More recently, Chomsky has suggested that the collapsing of Merge and Move is a natural result of giving up arbitrary stipulations of a similar type. Move, referred to here as IM (Internal Merge) was initially banned:

> It also follows that it was a mistake – mine in particular – to suppose that displacement is an "imperfection" of language that has to be assigned to UG or somehow explained in terms of its special functions. On the contrary, its absence would have to be accounted for by a UG stipulation barring IM. It therefore follows that some form of transformational grammar – by now a radically stripped-down version of early proposals – essentially "comes free." [Chomsky (2007)]

I suggest that the full-specification model of segments, the one that restricts the cardinality of the segment set to 2^n is essentially like the ban against Internal Merge. The underspecification model that yields 3^n segments is "stripped-down" – it does without the requirement that all features be listed for each segment. It is theoretically more elegant to allow segment to lack any specification for one or more features, and the vast literature on underspecification makes it appear to be empirically justified.[11]

---

10. Chomsky's point occurs in the discussion of finite state grammars, a model he is rejecting, but this point carries over to subsequent models he develops – a grammar that limits sentence length or the number of possible sentences "will be so complex that it will be of little use or interest". Amazingly, ten years later, Olmsted (1967) published, in *Language* no less, an article arguing that "the assumption of infinite sentence length is not only not factual but, what may seem more important to some, it is counter-intuitive. Probably the assumption can be abandoned without any great damage to Chomsky's system" [305]. Sadly, Olmstedian 'reasoning' appears to be once again on the rise, at least in phonology.

11. As noted above, Steriade (1995) concludes with a rejection of underspecification and a need for a non-uniform view of features. It is clear, however, that in general, subsequent literature did not accept Steriade's conclusions, given the widespread use Dep constraints in the OT literature, constraints that penalize candidates with feature values that are 'filled in' *vis-a-vis* what is in the input form. If a binary value is "filled in" in the output candidate, then it must have been absent, that is, the segment was underspecified, in the input.

We are now in a position to re-evaluate the notion of restrictiveness. A model of UG with some overt restrictions may define a subset of the typological space (a smaller set of possible languages) defined by the same model without those restrictions, but the former is, by definition, a richer, less elegant model. I claim that allowing underspecification, or rather ceasing to prohibit it, is an empirically justified increase in the correct kind of restrictiveness – the kind that restricts ontological commitments of a model to the minimum necessary. The reasoning parallels, in the domain of phonological *representation*, Chomsky's unification of Merge and Move in the domain of syntactic *computation*.[12]

2. How many inventories?

The preceding section computed the number of possible segments given a UG that provides n binary features. We found that if underspecification is allowed, then the number of possible segments is 3^n, and if underspecification is not allowed, the number of possible segments is 2^n. We then illustrated in Figure 1 how much faster the set of possible segments grows if underspecification is allowed. This is obviously a simple mathematical fact, but one which seems to be underappreciated in the literature, as illustrated above. Finally, I argued that allowing underspecification simplifies the model by removing the stipulation that a segment must have specification for all features, and thus there is a conceptual argument in favor of underspecification that parallels Chomsky's argument for unifying Merge and Move.

However, there is more to this story of combinatoric explosion. Our goal here is typological, a characterization of the set of possible languages. Each language has an inventory of segments[13] which are chosen from the set of possible segments.

12. It is thus incumbent upon a critic of the argument I have given to either reject my claim that the phonological situation parallels the syntactic one in relevant ways, or else to critique the common core of the two arguments, derived from Chomsky.

13. We can choose to characterize underlying segments, those that are present in the lexicon, or surface segments. We won't worry about this distinction here – in principle, the typological space of the two kinds of segments is identical. Note that I am not claiming that the inventory is relevant to phonological computation, although this claim is often made in the literature. Instead, I view the inventory as a generalization about the contents of lexical items (or surface forms).

Given a set Σ of possible segments, an inventory, ι, is a subset of Σ – a given ι is the set of segments that a given language has.[14] So, the set of possible inventories, $\mathcal{I}$, is just the set of all possible subsets of Σ, the so-called Power Set of Σ, Pow(Σ). Bear in mind that for a set X with cardinality c, the cardinality of Pow(X) is just 2^c.[15] So, how does the number of features provided by UG translate into the number of possible inventories? Well, without underspecification, the number of segments is 2^n, and so the number of inventories is 2^{2^n}. With underspecification, the number of segments is 3^n and so the number of inventories is 2^{3^n}. Let's see the difference for several values of n:

(5) Number of inventories for n features without and with underspecification

Number of features	Number of inventories	
n	w/o underspec: 2^{2^n}	w/underspec: 2^{3^n}
1	4	8
2	16	512
3	256	1.34×10^8
4	65,536	2.42×10^{24}

For the sake of concreteness, let's illustrate the first case shown in (5) to demonstrate that a UG *with a single feature* yields 4 possible inventories if underspecification is not assumed and 8 inventories if underspecification is assumed. For expository convenience we will denote a segment as ς and show the features of a segment thus: ς_i:{+F}. This means that segment ς_i has the feature specification {+F}.[16] In understanding the distinction between the inventories in (6) and (7) it is crucial to keep clear the difference between a *segment* with no features, which is only allowed in the underspecification case in (7), as opposed to an *inventory* with no segments, which is allowed under either model.

In a UG with just one feature, but with full specification, without underspecification, in (6), there are two possible segments ($2^1 = 2$) in the universal segment inventory Σ_{full}. The set of language specific inventories, $\mathcal{I}_{full}$, includes the empty

14. Obviously, various languages can have the same inventory and differ in other ways – by having different rules, for example.

15. Since for each subset of Σ you have to make the binary choice of whether a particular member of Σ is present or absent.

16. Previously we have said that the segment *is* the set of feature specifications. Here, we are slightly amending this definition – we'll use a ς with no features to denote, for example, a mora or timing slot that has no featural content. Thus we can refer to a segment that has the empty set of featural specification.

set, the two inventories of one segment each, and the inventory with both segments, so there are four members of this set, $\iota_0 \cdots \iota_3$, assuming one feature and *full* specification. (The Power Set of a set of two elements has cardinality $2^2 = 4$, and so there are four inventories.)

(6) $\mathcal{I}_{full}$: Inventories definable with a single binary feature ±F and full specification (*without* underspecification)

- Set of features: $\mathcal{F} = \{F_1\}$ (just one feature)
- Set of segments: $\Sigma_{full} = |\varsigma_1 \colon \{+F_1\}, \varsigma_2 \colon \{-F_1\}$ (two segments)
- Set of inventories: $\mathcal{I}_{full} = Pow(\Sigma_{full})$ (four inventories)
  - $\iota_0 = \emptyset$ (no segments)
  - $\iota_1 = \{\varsigma_1\}$
  - $\iota_2 = \{\varsigma_2\}$
  - $\iota_3 = \{\varsigma_1, \varsigma_2\}$ (all possible segments)

Allowing underspecification, but still restricting UG to one feature, we get a different set of segments, Σ_{under}, and a different set of inventories, $\mathcal{I}_{under}$. As we see in (7), there are *three* possible segments ($3^1 = 3$) in Σ_{under}, since it is now possible to define a segment with no feature values, the ς_0 in (7), below. This additional segment (*vis-à-vis* the model in (6), above) can be added or not to each of the inventories defined in (6), yielding twice as many inventories, $\iota_0 \cdots \iota_7$, in $\mathcal{I}_{under}$, all listed here:

(7) $\mathcal{I}_{under}$: Inventories definable with a single binary feature ±F with underspecification
Set of features: $\mathcal{F} = \{F_1\}$ (just one feature)
Set of segments: $\Sigma_{under} = \{\varsigma_0 : \{\ \}, \varsigma_1 : \{+F_1\}, \varsigma_2 : \{-F_1\}\}$ (three segments)
Set of inventories: $\mathcal{I}_{under} = Pow(\Sigma)$ (eight inventories)
– $\iota_0 = \emptyset$ (no segments)
– $\iota_1 = \{\varsigma_1\}$
– $\iota_2 = \{\varsigma_2\}$
– $\iota_3 = \{\varsigma_1, \varsigma_2\}$
– $\iota_4 = \{\varsigma_0\}$
– $\iota_5 = \{\varsigma_0, \varsigma_1\}$
– $\iota_6 = \{\varsigma_0, \varsigma_2\}$
– $\iota_7 = \{\varsigma_0, \varsigma_1, \varsigma_2\}$ (all possible segments)

Of course, as the number of features grows above one, the size of the two definable sets of inventories diverges quickly, since the general formulas are 2^{2^n} *vs*. 2^{3^n}.

Looking back at (5), the numbers speak for themselves. Even if we do not allow underspecification, having just four features gives the possibility of 65 thousand different inventories. However, with underspecification, four features yields $3^4 = 81$ segments, which in turn yields 2^{81}, or over 2 *septillion* (million billion billion) possible inventories. Figure 2 plots the log_{10} of the number of inventories for *n* features, with and without underspecification, just to give an indication of how underspecification leads to a typological explosion in the number of possible inventories. Of course this is not surprising given the explosion in the number of possible segments, discussed in the previous section.

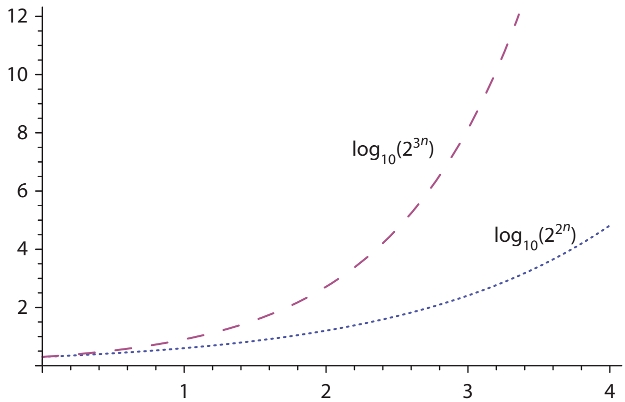

Figure 2. Comparison of $log_{10}(2^{2^n})$ and $log_{10}\ (2^{3^n})$

This is all simple math, but it is perhaps worth reiterating that a feature inventory of merely 4 features yields the possibility of 2 *septillion* different segment inventories.

3. How many grammars?

We now turn to yet another aspect of phonology to get a feel for how simply accepting underspecification leads to combinatoric explosion. Let's reiterate and clarify a few things. First, we are assuming underspecification, not arguing for it here, although I have argued that assuming it is elegant. Second, I am making simple mathematical arguments that are hopefully correct. Finally, if we adopt the assumption of underspecification and the math is correct, we still need to worry if the implications are theoretically plausible and appealing. We'll briefly address this last point in the concluding section of the paper.

In this section, I illustrate the potential effects of underspecification on the combinatorics of computational systems (grammars). If we keep the number of features constant, and we make use of a single model for computation, what kind of effect on combinatorics do we get when we allow underspecification? Obviously, in doing an exercise like this I make no pretensions to knowing the correct number of features provided by UG, and I also do not know the correct computational system for phonology. However, the simple results given here are probably as dramatic whatever computational system is chosen.

For example, since Optimality Theory (Prince & Smolensky 2004) is merely a theory of constraint ranking, the feature combinatoric arguments given here are as relevant to OT in the abstract as they are to a rule-based model. To give a simple illustration, an OT model implemented with features that allow only full specification would have only feature-changing mappings for input to output, say $t \rightarrow d$ or $d \rightarrow t$. In each case, an underlying value (e.g. [+voice] for a devoicing result) does not appear on the surface (a MAX violation), and the surface contains a value (e.g. [–voice]) that is not in the input (a DEP violation). If feature filling processes are allowed, that is, if, as assumed in the literature, you can have a DEP violation without a MAX violation, then you have licensed underspecification in the model. This obviously impacts the set of possible languages. The following discussion chooses one toy model of phonology different from OT, a much simpler one, but the implications are general.

A common formalization for phonological rules is the following:

(8) $w \rightarrow x \,/\, y \_\_\_ z$

Each of the letters in (8) can be thought of as a variable whose domain is the set of segments or natural classes of segments (expressed as feature bundles) in the grammar. We typically assume that *w* and *x* are distinct, that there are no vacuous rules,[17] but we will ignore this detail. We also allow rules to *not* specify either the left or right environment (either *y* or *z*, but not both, can be left out of the schema in (8)), but again, we won't worry about this, either. The reasons for both of these simplifications are (i), that they don't affect the order of magnitude of our typologies, as will become clear; and (ii), that the simplifications allow us to parallel a simple discussion of a set of formal systems called Cellular Automata, on which the following discussion is based (Wolfram 2002).[18] Finally, we know that (8) can't handle certain types of rules, such as metathesis rules, which reverse the order of two segments, but again, we overlook this and proceed with our simple model of a rule system.

What if the set of segments Σ has only two members, say $\Sigma = \{a, b\}$? How many rules can be defined? Well, for each variable in (8), we can assign it the value *a* or *b*, so there are four binary choices, yielding $2^4 = 16$ distinct rules. However, for a given environment, we assume that a language can only have one of the two rules

17. This is unlike the Faithfulness constraints of Optimality Theory which explicitly encode identity mappings between inputs and outputs.

18. The Cellular Automata can also be stated in a way that ignores either the right or left side of a target, so our simplification is not a matter of substance.

that use that environment – the grammar deterministically determines an output for a given input. In other words, you can have $a \rightarrow b$ / a ___ a or you can have $a \rightarrow a$ / a ___ a, but not both. A rule like (9i) can be expressed as (9ii), which is another familiar notation for linguists, or as (9iii) which corresponds to a notation common in the Cellular Automaton (CA) literature:

(9) i. $a \rightarrow b$ / a ___ a
ii. *aaa* $\rightarrow$ *aba*
iii.

a	*a*	*a*
	b	

The interpretation of (9iii) in the CA literature is this: "If there is a neighborhood consisting of an *a* with an *a* to its left and an *a* to its right, rewrite that (first mentioned) *a* as a *b*". If we restrict environments to the immediate right and left, and if we have only two elements, {*a*, *b*} (or (Black, White} or {0,1}), then there are eight possible neighborhoods, as shown in (10).

(10) The eight neighborhoods definable with a two-way distinction

a a a	*a a b*	*a b a*	*a b b*
b a a	*b a b*	*b b a*	*b b b*

There is a binary choice of *a* or *b* for each slot in the neighborhood, so a three slot neighborhood has $2^3 = 8$ possible values.

Now, if we think of a language as the specification of what happens in every neighborhood, we have a binary choice for each neighborhood, as shown in (11).

(11) A language is a list of outcomes for each input neighborhood

a a a *a/b*	*a a b* *a/b*	*a b a* *a/b*	*a b b* *a/b*
b a a *a/b*	*b a b* *a/b*	*b b a* *a/b*	*b b b* *a/b*

So, one possible language would have these rules:

(12) One language

a a a *b*	*a a b* *b*	*a b a* *a*	*a b b* *a*
b a a *a*	*b a b* *a*	*b b a* *b*	*b b b* *a*

And another language would have these rules:

(13) Another language

a a a *a*	*a a b* *b*	*a b a* *b*	*a b b* *b*
b a a *a*	*b a b* *b*	*b b a* *b*	*b b b* *a*

Since there are eight input sequences and a binary choice (*a* or *b*) for rewriting the middle segment of each string, there are $2^8 = 256$ distinct sets of rules. In our terms, each set of 8 rules defines a language.[19] Wolfram calls this family of CAs, the ones that have three-cell input neighborhoods and two letters/colors, the Elementary Cellular Automata (ECA). So, we can think of the family of ECA as a Universal Grammar that defines a space of 256 possible languages.

What can we do with this analogy? Well, we have already seen in Section 1 that a binary feature system with underspecification allows for a three-way contrast, so even with one binary feature and the use of underspecification, we get three different representations, the ς_0, ς_1, and ς_2 of Section 2.[20] So, the cardinality of Σ is going to be at least 3 – we can use the symbols *a,b,c* to represent the segments ς_0, ς_1, and ς_2, respectively.[21] How does this affect our analogical model of UG? What happens to the ECA model if we maintain three-cell neighborhoods, but allow for *three* different representational elements, surely a conservative amount for language? The math is simple, but, the results are shocking for anyone who has never thought about CA, as we will see.

Before moving to the math, I just want to make it clear that I am not proposing that CA are good models of grammatical computation. They are used here for an analogy that in many ways is far too conservative, since languages

19. A point of terminology: in the CA literature, a "rule" is a full set of instructions for how to rewrite each neighborhood – what we call a "language" here corresponds to a "rule" in the CA literature.

20. Put aside the question of how we refer to the 'empty' representation – I have some suggestions in work in progress and Reiss (2003a).

21. If you have something against binary features and underspecification, you can still derive some pleasure from this section: replace the $\Sigma = \{a, \mathrm{b}\}$ of the preceding discussion with tones: let $\Sigma = \{\mathrm{H}, \mathrm{L}\}$. Some languages have at least three distinct tones, call them H, L and M. So, it is not difficult to convince ourselves that there are subsystems of phonology with at least three mutually exclusive representations – a vowel is H, L or M in such a language (ignoring contours).

actually have rich representational systems containing many features. On the other hand, if one is tempted to think that CAs, and ECAs in particular, are too simple to be interesting, I can point out that one of the ECA, Wolfram's ECA 110, has been shown by Cook (2004) to be equivalent to a Universal Turing Machine. A Universal Turing Machine (UTM) is an abstract program that can simulate the behavior of any other Turing Machine. Turing (1937) provides a definition of computation with his machines: if a function is computable, then there is a Turing Machine that can compute it. Turing discovered that there is also a machine, the UTM, that can simulate all other particular Turing machines and thus the UTM itself defines computation. The amazing discovery of Cook is that the humble ECA 110, whose description is identical to the language in (13), above, is equivalent in power to a UTM. With the right understanding of inputs and output, and some assumptions matching those used for Turing machines (unbounded length of the tape) anything that can be computed, can be computed with ECA 110 – which is literally (13)!

Therefore, we don't have to worry that ECAs are too simple to be interesting for our analogy – they are simple to describe but as computationally powerful as a class as any possible model of grammar.

So, here's the effect of using three representational entities, say $\Sigma = \{a, b, c\}$. For each of the three cells in the neighborhoods, we now have a three way choice: the first cell can be an *a*, a *b* or a *c*. Ditto for the second and third cells. This yields $3^3 = 27$ neighborhoods. Again, define a language to be a full set of rules, one for each neighborhood. We have three choices for the output of the center cell of each neighborhood, so the total number of languages derives from a three-way choice for each neighborhood: 3^{27} which is 7,625,597,484,987, over 7 *trillion*. Our new UG, defined by a CA with three segments/letters and three-cell neighborhoods, provides a typological space of astronomical size. The general formula for three-cell neighborhoods and *n* representational elements is n^{n^3} : $2^{2^3} = 256$; $3^{3^3} \sim 7$ trillion. With four elements, the typology grows to $4^{4^3} = 3.4 \times 10^{38}$. Our discussion of the literature on restricting the size of the universal segment inventory is again looking somewhat irrelevant.

Before leaving this section, let's be clear about what has and has not been said. I have not said that Cellular Automata are good models for phonological computation, and I have not said that phonology must be equivalent to a Universal Turing Machine. I have argued that the typological explosion we see with an increase from 2 to 3 elements (segments or feature specifications, say) in a really simple rule model is probably modest in comparison with what we would see in a more realistic phonological model with 20 or 30 different features and all kinds of rules or constraints with various modes of interaction.

4. Conclusions

I have taken a fairly well-established idea from phonology, the notion that segments do not necessarily consist of fully specified feature matrices, and shown that accepting such underspecification allows a massive increase in the number of segments we can describe in principle using a small set of features. There is no reason to think that we are anywhere near an understanding of the "correct" set of features for phonology, and I myself have advocated (Hale, Kissock, & Reiss 2007) consideration of a much larger set than is typically assumed. However, like most discussion on the topic, I had assumed that any increase in n, the cardinality of the set of features, leads to growth in the cardinality of the set of possible segments according to the function 2^n. This turns out to have been a mistake. The feature set may or may not be significantly larger than what is typically assumed, but we now see that the relevant measure is 3^n. Of course, this greater size suggests that certain distinctions in the phonological behavior of morphemes typically attributed to featural inconsistencies in the literature might be amenable to reanalysis as a specification/underspecification distinction. In fact, this has already been proposed in the literature on target interpolation. Denying this possibility leads to the bizarre view that there are massive numbers of phonologically differentiated segments that do not correspond to phonetic differences. In other words, our new understanding puts us on the path to reducing the feature set attributed to UG and benefitting from the point made by Chomsky (2007) that "the less attributed to genetic information (in our case, the topic of UG) for determining the development of an organism, the more feasible the study of its evolution" – it is simpler to study the evolution of a simple system than a complex one. We really can get more from less if we know what to count.

We also streamline the theory by defining segments as consistent sets of valued features, with no constraint that every member of $\mathcal{F}$ must be in the set that defines a segment. Again, by making a simpler theory, we get more. This argument was suggested as a parallel to the unification of Merge and Move in syntax.

Next, I pointed out that the set of possible segment inventories is the Power Set of the the set of possible segments, and so, identifying a language with a segment inventory (actually a conservative move, since languages can differ on many dimensions) yields 2 septillion languages if UG is assumed to have just 4 features.

Finally, I explored via an analogy the possibility that small changes (actually a simplification, a stripping-down) in the representational system has potentially explosive implications for the descriptive power of a theory of grammar. In the analogy, a well-defined class of CA, such as the 256 ECA, is treated as parallel to a model of Universal Grammar, which defines a particular set of languages.

However, if we want the three-way contrast of a theory with underspecification (+F, –F and absence of F) to be somewhat directly simulated in a CA model, we need to employ CA with a three-way contrast, and we showed that this increase raised the cardinality of the new model of UG from 256 to over 7 trillion. This demonstration involves a representational system that is clearly simpler than that adopted in any actual model of grammar, where there are multiple features. It also involved a class of computational systems that is much simpler to define than any serious model of grammar. I reiterate that *I am not claiming that CA will provide good models of I-languages*, but if anything, the analogy is conservative despite its extreme conclusions.

The tension between descriptive and explanatory adequacy has parallels in all domains of science – chemistry for example has led us to the once shocking conclusion that everything we see, touch, smell and taste is made from the same few basic particles. I suggest that the supposedly outlandish notion[22] that all human grammars can be reduced to variations of a Universal Grammar becomes much less susceptible to the scorn it often invokes from non-linguists by consideration of my simple analogy – our *intuitions* about combinatorics are just not useful guides for understanding the complexity we experience in everyday life.

Within linguistics, there is a tendency to worry about a model of grammar being "too powerful", in the sense of defining a too-large space of possibilities. As I have argued elsewhere (Hale & Reiss (2008), Chapter 1), when we abstract from superficial descriptive complexity, it is inevitable that we end up with a UG that, in principle, allows for more grammars than could ever be attested. The reasons that most possibilities are not attested fall outside of the theory of grammar in this view – grammars that are inconsistent with factors constraining human life on earth, for example, will never be attested. This realization, that even very simple formal systems can yield essentially limitless possibilities should liberate us from worrying that our models are too rich, in this naive sense. The more we "abstract from the welter", the more general the model becomes and the more "unattestable" languages we appear to allow. Superficially, we appear to have a less restrictive theory, since extensionally, the set of languages increases in cardinality as we remove restrictions. However, a theory with fewer *overt* restrictions, is more streamlined than an otherwise identical theory with restrictions. The former model, without *overt* restrictions is actually the more elegant, more restrictive theory.

22. It is trivially easy to find evidence that the notion is still considered outlandish by many scholars in other fields, including psychologists, neuroscientists, philosophers, education scholars, and anthropologists.

The key to understanding why the massive combinatoric explosion we have seen is not problematic is just to realize that sets of features (defining segments), sets of segments (defining inventories), and sets of rules (defining grammars) can all be characterized intensionally. Yes, a language faculty with four binary features and underspecification 'yields' 2 septillion possible inventories. However, the learner does not literally search through a space of this size to find the inventory of the target language. Instead the learner parses input in terms of a modest set of four features and their coefficients. For each segment encountered there are four three-way decisions to be made: "What is the value of F_1, '+', '–' or ABSENT?; What is the value of F_2 ...". The inventory is just a generalization (not necessarily ever formulated by the language acquisition device, since it plays no role in grammatical computation) over the contents of the lexicon (or the output of the grammar). This simple approach promises to lead us to a stripped down model of UG, in line with view that "the less attributed to genetic information ... the more feasible the study of its evolution". Understanding the combinatorics of phonological systems is thus a step towards a biolinguistics of phonology.

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The emergence of phonological forms*

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As it becomes increasingly clear that language emerged suddenly in our species over the space of less than 100,000 years, the pressure to understand how the externalization system could have been 'language-ready' prior to the emergence of syntax grows as well. Phonology, like other components of language, must then be understood to rely maximally on abilities that already found applications in other cognitive domains at the time externalized language emerged. In this chapter, I provide evidence from sign language and from animal cognition that the perception of a discrete phonological signal relies heavily on abilities humans share with our mammalian cousins. I build the case for this view with evidence from both humans and animals, discuss computational models of categorization that can build categories through feedback between perception and production, and provide a natural case study in phonological evolution provided by a young sign language. These arguments support the view that the building blocks of the phonological system – features and categories – were present prior to the emergence of externalized language as we know it.

1. Introduction: Phonology & evolution

As it becomes increasingly clear that language emerged suddenly in our species over the space of less than 100,000 years – the blink of an eye, in evolutionary terms – the pressure to understand how the externalization system could have been 'language-ready' prior to the emergence of syntax grows as well. This is particularly true if Chomsky (2008: 136) is correct in suggesting that phonology is an 'ancillary' module, and that phonological systems are "doing the best they can to satisfy the problem they face: to map to the [Sensory-Motor system] interface syntactic objects generated by computations that are 'well-designed' to

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satisfy [Conceptual-Intentional system] conditions" but unsuited to communicative purposes (see also discussion in Samuels 2011). Phonology must then be understood to rely maximally on abilities that already found applications in other cognitive domains at the time externalized language emerged.

This view of phonology's peripherality accords with the evolutionary scenario advocated by Hauser et al. (2002) and Fitch et al. (2005), who argue that language may have emerged suddenly as a result of minimal genetic changes with far-reaching consequences (cf. Pinker & Jackendoff 2005; Jackendoff & Pinker 2005, who see language as manifesting complex design). As Hornstein & Boeckx (2009: 82) explain,

> [I]n light of the extremely recent emergence of the language faculty, the most plausible approach is one that minimizes the role of the environment (read: the need for adaptation), by minimizing the structures that need to evolve, and by predefining the paths of adaptation, that is, by providing preadapted structures, ready to be recruited, or modified, or third factor [non-specific to language] design properties that emerge instantaneously, by the sheer force of physical laws.

Indeed, the discreteness of the phonological signal is an excellent candidate for explanation in terms of the third factor, since, as Jackendoff (2011: 604) notes,

> the only way to develop a large vocabulary and still keep vocal signals distinguishable is to digitize them. This is a matter of signal detection theory, not of biology.... So we might want to say that the digital property of phonology comes by virtue of 'natural law'.

Yet Jackendoff on the same page argues that processing such a discrete signal system is part of the human language faculty, narrowly construed (in the terminology of Hauser et al. 2002), meaning that it is unique to both humans and language. If this claim were correct, this property of phonology would pose a considerable difficulty for evolution, despite its apparent connection to principles that are independent of language.

In this chapter, I provide evidence from sign language and from animal cognition that the perception of a discrete phonological signal does not in fact pose such a grave evolutionary difficulty. Rather, the building blocks of the phonological system – features and categories – were present prior to the emergence of externalized language as we know it: our physiology and phonetic capabilities have shaped the structure of our speech (and sign), rather than vice versa (a point made previously by Piattelli-Palmarini 1989). There are many reasons to believe that this is the case for our perceptual systems, as will be discussed throughout the remainder of this chapter. It is also increasingly known to be true for both the vocal and manual systems of articulation employed by spoken and signed language. Fossil evidence shows that the flexed basicranium indicative of a lowered, language-ready larynx and the flattened face responsible for the modern supralaryngeal vocal tract were both present hundreds of thousands of years before the emergence of language (Nishimura et al. 2006; see Bower 1989 for an overview). The emergence of bipedal walking and the shortening of the toes (with reduced grasping ability) appears to have led to the hands taking over increased area in the sensory-motor cortex, leading to increased dexterity that was subsequently exploited by gestural and sign systems (Bowers 2006).

The biolinguistic arguments presented here sit alongside evidence I have presented elsewhere for evolutionary precursors of and analogs to phonological operations and representations, drawing heavily on research on many aspects of animal cognition (Samuels 2009b, 2011, Samuels et al. To appear). These studies focused predominantly on the abstract computational aspects of phonology, while here I examine the building blocks of phonetic/phonological categories. I will first discuss the status of features in phonological theory before turning to categorical perception, and then to how to relate features to categories. This will expand our discussion to signed languages and to linguistic production, keeping an eye on evolutionary concerns all the while.

2. Features in phonological theory

One of the most important advances in twentieth-century phonological theory was Roman Jakobson's proposal that segments can be decomposed into distinctive features to which phonological processes refer.[1] Numerous sign languages have been examined from a featural perspective as well (see for example Corina & Sagey 1989), and although I will set the manual modality aside for the time being, I will return to it later in the chapter.

Although not all modern phonological theories accept features as such,[2] distinctive feature theory provides a simple explanation for some basic facts of phonological patterning. One such set of facts concerns regular plural formation in

1. The idea of decomposing speech sounds into features really dates back to Alexander Melville Bell's *Visible Speech*, published in 1867, but this discovery gained little ground prior to the re-introduction of features into phonology by Jakobson in 1928. See Halle (2005) for an overview of the history of feature theory.

2. Some opt instead for an element-based system (in the Government Phonology tradition; see for example Kaye et al. 1985). Others use a gestural score (in the Articulatory Phonology tradition; see Browman & Goldstein 1986) or a wholly exemplar-based organization (Bybee 2001). See Vaux & Miller (2010) for some arguments in favor of distinctive features rather than these alternatives.

English. If learners simply listed the allomorphs of the plural and the sounds which they follow, they would arrive at a set of rules such as the following (Halle 1978):

(1) a. If a noun ends with /s z š ž č ǰ/, add /ɨz/;
b. Otherwise, if the noun ends with /p t k f θ/, add /s/;
c. Otherwise, add /z/.

Rather than listing each sound individually, one can instead look for acoustic and/or articulatory commonalities – features – that the sounds in (1a) and (1b) share. The sounds in (1a) are all strident (they have a 'hissing' quality due to turbulent airflow through a constricted oral cavity) and they are all coronal (they are made with the tongue blade or corona raised towards the hard palate). The sounds in (1b) also share a feature, namely a lack of voicing (vibration of the vocal cords). Taking these properties into account, a feature-based alternative to (1) is as follows (Halle 1978):

(2) a. If the noun ends with a sound that is [coronal, strident], add /ɨz/;
b. Otherwise, if the noun ends with a sound that is [nonvoiced], add /s/;
c. Otherwise, add /z/.

Although (1) and (2) are extensionally equivalent as far as English is concerned, nevertheless we know that speakers of English posit (2) and not (1) because of how they perform on a simple experiment. We can distinguish between the two rules by asking what happens when native English speakers are forced to pluralize a word which ends with a sound that does not exist in English, such as *Bach* (i.e. /bax/). If they choose the segment-based rule, since /x/ is not listed in (1a) or (1b), the plural of *Bach* ought to be /baxz/. But if they choose the feature-based rule (and assuming they also know that /x/ is unvoiced), they will form /baxs/. Since native English speakers' intuitions converge on /baxs/, they must choose (2) despite the attractive competing hypothesis for which there is in fact no counterevidence. This is to be expected if features rather than segments are really the building blocks of phonological representations all the way down to the neural level, which (as I will argue later) may be rooted in the basic properties of mammalian auditory processing.

In short, features capture the fact that various groups of sounds behave alike: they are all affected by or trigger a particular rule, or they are all subject to a particular distributional restriction. When one examines such groups of sounds, one finds that they typically have in common a property which is acoustic (for instance, all the sounds' first formants fall within a given frequency range) or articulatory (all the sounds are produced with vibration of the vocal folds). Phonologists call these groups of similar sounds "natural classes." The standard view, as expressed by Kenstowicz (1994: 19), is that "the natural phonological classes must arise from and be explained by the particular way in which UG organizes the information that determines how human language is articulated and perceived." This is typically taken to mean that natural classes are defined by features which reflect phonetic properties, and those features are part of UG. In other words, the phonological grammar operates over features and the sounds in question pattern together because there is a phonological process which refers to the feature which they share. Thus, an equation is made between *phonetically natural* classes, *featurally natural* classes, and *phonologically active* classes, definitions of which I provide here, from Mielke (2008: 12–13).

(3) a. *Phonetically natural class*
A group of sounds in an inventory which share one or more phonetic properties to the exclusion of all other sounds in the inventory.

b. *Featurally natural class*
A group of sounds in an inventory which share one or more distinctive features, to the exclusion of all other sounds in the inventory.

c. *Phonologically active class*
A group of sounds in an inventory which do at least one of the following, to the exclusion of all other sounds in the inventory:
– undergo a phonological process
– trigger a phonological process, or
– exemplify a static distributional restriction.

The main task of feature theory, then, is to find the phonetic features which accurately describe the attested phonologically active classes in the world's languages. This goal has been approached from both articulatory and acoustic perspectives, and since the two are confounded it is not obvious that either a perception-based or production-based system ought to be preferred *a priori*. Miele (2008) undertook a large-scale survey of 6,077 phonologically active classes from 648 language varieties representing 51 language families, seeking to quantify how well the major feature theories of the past fifty years capture phonologically active classes. The results of this survey show that about three-quarters of phonologically active classes comprise a natural class (i.e. they can be characterized by a conjunction of features) within each of the three theories he tested: the *Preliminaries to Speech Analysis* (Jakobson et al. 1952) system, based on acoustics; the *SPE* (Chomsky & Halle 1968) system, based on articulation; and the Unified Feature Theory (Clements & Hume 1995), also articulatory.

Mielke (2008: 77) notes that when phonetic cues are clear-cut, all three models do well, but "[i]n the phonetic gray areas[…] the phonological patterning of sounds is as varied as the phonetic cues are ambiguous." This is one reason why Mielke suspects that traditional, innatist feature theory has the story backwards: feature specifications emerge from phonetic properties, not the other way around. Instead of maintaining the expectation that phonological investigation will ultimately reveal a universal set of phonetic features, instead we should view phonological alternations as driving the construction of a feature system. This is sometimes called the "emergentist" view as opposed to the "innatist" one, but for reasons which will become clear throughout this chapter, I believe these labels create a false dichotomy.

I suggest that a hybrid of these two approaches may actually be the most plausible.[3] If sensitivity to the phonetic properties of human speech is innate but not specific to language, then we may say that such properties were simply co-opted for a linguistic purpose. Phonological feature systems might then each be organized a bit differently. In the remaining sections, I will build the case for this view with evidence from both humans and animals, discuss computational models of categorization that can build categories through feedback between perception and production, and provide a natural case study in phonological evolution provided by a young sign language.

3. Categorical perception

Let us begin by looking at the beginning of a language-learner's life. The human auditory system matures early, and many studies have shown that the youngest infants are capable of discriminating phonetic contrasts that are utilized in the various languages of the world (Werker & Tees 1984). But remarkably quickly, this power begins to wane; by six months of age, babies already exhibit a decline in their ability to discern vowel contrasts that are not present in their linguistic experience, and their performance degrades similarly with consonant contrasts not too long thereafter (Polka & Werker 1994). Learning a specific language with its particular subset of the possible contrasts seems to entail the loss of the ability to discriminate non-native contrasts (Eimas et al. 1971; Werker, Tees 1984, *inter alia*). This learning trajectory supports the view that children are born with a full set of phonological features, subsequently losing access to the ones which are not contrastive in their language.[4] Not only are the sets of contrasts used

3. This should be seen as a refinement of the view I advocated in Samuels (2009a), which took the emergentist position to be the null hypothesis.

4. It has been shown, however, that some sensitivity to non-native contrasts remains, both neurally and behaviorally; such contrasts are both detectable and learnable by adults under certain circumstances (such as if one becomes a phonologist). See Samuels (2011), §3.2 for discussion.

cross-linguistically available to human infants, it appears that many of them are also perceived by non-humans.

Take, for example, the distinction between the voiceless stops /p t k/ and their voiced counterparts /b d g/. English speakers perceive a category boundary at +15/+20 ms. of voice onset time (VOT), which is known as a short-lag/long-lag distinction (Hay 2005). The discrimination peak at this category boundary thus coincides with the positive auditory discontinuity – a bias in the auditory system, common to humans and most mammals, which produces a non-linear mapping between acoustic inputs and the percepts they produce. This +20 ms. VOT boundary, to which many mammals are sensitive, appears to be the strongest case of a speech category boundary matching with an auditory discontinuity.

Auditory discontinuities seem to provide natural boundaries for speech categories (Kuhl 1993, 2000), but importantly, these are psychoacoustic biases that exist independently of human speech. Hay (2005), confirming earlier work by Williams (1974) and Streeter (1976), shows that the areas of increased sensitivity corresponding to auditory discontinuities persist even in languages such as Spanish and Kikuyu, in which the discontinuities do not serve as speech category boundaries. Hay found that the same auditory discontinuities manifested in both English and Spanish speakers, but that the discrimination peaks centered on these discontinuities were of a different size and shape for the two groups of speakers when measured in both speech and nonspeech perception tasks. In other words, "the underlying perceptual mechanisms that facilitated discrimination in the first place remain intact, although sensitivities may be enhanced [by language acquisition]" (Hay 2005: 103).

Across several domains, we are beginning to discover that infants are born with generic biases which become more specific during the course of development. For instance, experiments undertaken on face perception by Pascalis et al. (2002) showed that six-month-old human infants are as good at discriminating non-human primate faces as they are at telling apart human faces. They suggest the following (references omitted):

> Our experiments support the hypothesis that the perceptual window narrows with age and that during the first year of life the face processing system is tuned to a human template. This early adjustment does not rule out the possibility that later in life individuals can learn how to discriminate a new class of stimuli on a perceptual basis. As is the case for speech perception, our evidence with face processing indicates the existence of an early tuning period that is likely dependent on experience. Although it is difficult to compare directly the tuning of speech perception with the tuning of face perception, there may be overlap between these systems. By 3 months of age infants are already relating these two types of information, as they are able to associate faces with voices. Systems for

> processing faces and for processing speech may thus develop in parallel, with a similar timing and a mutual influence. One possibility is that there is a general perceptuo-cognitive tuning apparatus that is not specific to a single modality and that can be described as an experience-expectant system.

This scenario is exactly what is to be expected if children engage in the same type of category building across multiple domains, including speech and face perception. It seems that infants are born especially sensitive to contrasts which straddle auditory discontinuities (virtually by definition), but as they grow and are exposed to language, their perception of (speech) sound is specifically tailored to the input they receive. It is not the auditory discontinuities which change – these are immutable and language-independent, being dictated purely by anatomy – but rather, the categorical perception boundaries. Category boundaries coinciding with sensory discontinuities are not only the most salient to infants but also the easiest for adults to learn, though other boundaries are also readily learnable (Hay 2005), even by language-impaired children (Wright 2006). Such a framework is also consistent with the idea that feature contrasts are supported by small articulatory differences producing amplified, 'quantal' acoustic/perceptual effects, as proposed by Stevens (1972, et seq.).

Neurally, the mechanism that supports this type of perceptual warping is cortical re-mapping, again a process known to occur across multiple sensory modalities and cognitive domains.[5] The human sensory cortex undergoes this type of change in a number of different circumstances: for instance, when a person becomes blind or deaf, the other senses can take over the brain areas which formerly served the now-absent sense, and a similar process occurs with amputees (Ramachandran & Blakeslee 1998). Learning a musical instrument which requires very fine motor control of the fingers can cause an increase in the amount of cortex associated with the digits (Elbert et al. 1995). And in oscine birds who exhibit 'closed-ended' song learning, we find that neurogenesis is associated with this process (see Anderson & Lightfoot 2002 §9.5.2). Birds also show the perceptual magnet effects characteristic of warping of the cortical map (Kluender et al. 1998). In short, the mechanism of cortical re-mapping is neither special to speech nor to our species – see Guenther & Gjaja (1996) for a wide variety of additional references supporting this point – but it creates a type of neural expertise which makes our processing of speech special.

5. Categorical perception has been demonstrated in humans for non-speech sounds, faces, and colors. It has also been shown that macaques, baboons, and mice perceive conspecific calls categorically (Cheney & Seyfarth 2007), and that crickets, frogs, blackbirds, sparrows, quail, finches, budgerigars, marmosets, and other animals also perform categorical labeling (see references in Hauser 1996 and Kluender et al. 2006).

4. Babbling: Production to perception

Coen (2006) develops a computational model of how warping of the cortical map leading to categorical perception of sounds could plausibly occur. His model is based on the idea that

> in a notion reminiscent of a Cartesian theater – an animal can 'watch' the activity in its own motor cortex, as if it were a privileged form of *internal* perception. Then for any motor act, there are two associated perceptions – the *internal* one describing the generation of the act and the *external* one describing the self-observation of the act. The perceptual grounding framework described above can then *cross-modally ground* these internal and external perceptions with respect to one another. The power of this mechanism is that it can learn mimicry … [It yields] an artificial system that learns to sing like a zebra finch by first listening to a real bird sing and then by learning from its own initially uninformed attempts to mimic it. (Coen 2006: 19)

In short, this approach takes seriously the idea that mimicking and babbling are crucial to the process of connecting auditory and articulatory representations in both songbirds and humans, which when completed serves a number of purposes.[6] "The motor system for speech and birdsong production must be appropriately controlled, vocal production must be compared to an auditory template, and, if sound production does not match the auditory template, the error must be detected and the vocal signals must be changed accordingly" (Bolhuis et al. 2010: 752). Songbirds and humans have converged on similar solutions to establishing this type of feedback loop. The interesting commonalities in the vocal learning processes of birds and humans have been recognized since Darwin, and in recent years, biolinguists have begun to understand that their core components share a deeply conserved neural and developmental foundation:

> Most aspects of neurophysiology and development – including regulatory and structural genes, as well as neuron types and neurotransmitters – are shared among vertebrates. That such close parallels have evolved suggests the existence of important constraints on how vertebrate brains can acquire large vocabularies of complex, learned sounds. Such constraints may essentially force natural selection to come up with the same solution repeatedly when confronted with similar problems. (Hauser et al. 2002: 1572)

6. It is often remarked that humans are the only primates with the capacity for vocal learning. However, see Masataka (2003: 98ff) for evidence of vocal learning in macaques and marmosets. Cheney & Seyfarth (2007) and Arbib (2005) discuss imitation more generally in monkeys and chimpanzees; see also Samuels (2009b).

Bolhuis et al. (2010) delve deeper into the behavioral, neural, and genetic underpinnings of babbling ('subsong') in different species of songbirds, ultimately relating these commonalities to human babbling as well. It is important to note here that vocal learning and the associated babbling have emerged independently in multiple clades of birds, and Bolhuis et al. (2010) emphasize that different brain regions and neural pathways are at work in these different lineages. Nevertheless, there are commonalities at every level as well, from the molecular to the neural to the behavioral, and it even appears that some of the cortical areas involved in auditory memory and processing are homologous with functionally similar areas in mammals despite 300 million years of evolutionary separation (Bolhuis et al. 2010: 751).

A number of studies on the expression of the gene *FOXP2* provide perhaps the strongest evidence for convergence at the molecular level. As is by now well known, a heterozygous mutation in *FOXP2* is associated with language impairment and facial dyspraxia in humans (Lai et al. 2001). *Foxp2* is highly conserved, differing in only three nucleotides between mice and humans, suggesting it has been under strong selectional pressure (Enard et al. 2002; Shu et al. 2005).[7] There are several reasons to believe that *Foxp2* plays some role in tuning synaptic connectivity while song is plastic in juvenile finches, as Bolhuis et al. (2010) report. The gene's mRNA is expressed at an increased level in brain areas associated with song learning in juvenile finches, during breeding season (when adults make changes to their song repertoires), and during actual singing. Moreover, finches with artificially reduced *Foxp2* expression show higher song variability and decreased accuracy in production. In sum, it appears that this gene is somehow involved in regulating the neural plasticity necessary for song learning, as well as the sensori-motor feedback loop required to connect perception to production.

Coen's (2006) model of how this type of internal feedback aids the vocal learning process succeeds at learning to categorize different components of birdsong; it also capably learns human vowel categories, which lends further support to the idea that the mechanisms at play in these two tasks are similar. In addition to internal feedback, the model also utilizes input from multiple modes of external perception (in the case at hand, sight and sound). Emphasizing the role of visual input in human speech perception (though it is certainly not necessary for the

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7. Homozygous *Foxp2* mice knockout mice die as pups, likely due to issues with lung development. Mice with two disrupted copies of the gene produce virtually no ultrasonic whistles and a dramatically reduced number of clicks compared to both wildtype and heterozygous knockout mice, while those with one damaged copy produce a normal number of clicks but a significantly reduced number of whistles compared to wildtype mice (Shu et al. 2005).

construction of a phonological system) explains three facts that have long been known (the first two of which are discussed in Coen 2006 §2.1): first, that watching the movement of a speaker's lips can greatly aid comprehension; second, that speech sounds which are acoustically ambiguous can usually be distinguished by unambiguous visual cues; third, that visual input can affect an auditory percept, as in the famous "McGurk Effect" auditory illusion (McGurk & MacDonald 1976), in which a subject presented with (for instance) a synchronized visual /ga/ and auditory /ba/ perceives /da/.[8] Recent neurological studies corroborate this behavioral evidence: it has been shown that both visual and somatosensory input reaches the auditory cortical regions in macaques, and that watching lip movements produces a response in the supratemporal auditory cortex in humans (see Brosch et al. 2005; Ghazanfar et al. 2005, 2008, and references in Budinger & Heil 2006). Also, Weikum et al. (2007) have shown that visual information alone is sufficient to allow four- to six-month-old infants to discriminate between languages.

Coen demonstrates that his cross-modally grounded category-building algorithms can learn bird songemes (the birdsong equivalent of phonemes), and he also successfully models the English vowel system in this way. Even without priors such as the ultimate number of categories to be established, his artificial learner achieves a high degree of accuracy. The results Coen obtained are also consistent with those of de Boer (2001) and Oudeyer (2006), who model the emergence of vowel systems. These three models differ both in their aims and in the parameters they assume, yet they all do a very good job of approximating attested vowel systems. There is much more work to be done in this area – one obvious shortcoming of current research is that consonants need to be studied in addition to vowels – and I leave a detailed comparison of the existing models up to future research.

5. Relating categories and features

The task that now remains is to bring all the pieces together: to relate the phonological features discussed in §2 to the picture of category learning sketched in §3–4. My conclusions here will be more tentative but I hope they will point towards areas where both linguists' and biologists' attention can be directed to help shed some light on this topic.

8. It is interesting to note that something similar to the McGurk Effect has been recently reported in female frogs' perception of male frogs' mating calls (Taylor et al. 2008).

As I see it, features are the properties that cross-cut categories, allowing them to be grouped in various ways. The question, then, is whether features are abstracted from categories or whether they pre-exist categories. I will suggest that both answers are actually correct. This is in spirit a reconciliation of the "innatist" and "emergentist" positions concerning the origin of phonological features (introduced in §2).

I have already mentioned in previous sections that many other animals can use acoustic parameters relevant to human speech, such as VOT, in categorical perception. This is particularly true of other mammals, since our auditory systems are so alike. Brown & Sinnott (2006), reviewing a large number of animal and human discrimination studies beginning with Kuhl & Miller's (1975) pioneering work on chinchillas, found that humans and non-humans perceive similar categorical boundaries for seventeen of the twenty-seven phonemic contrasts on which they have been tested to date. It is also known that birds and primates, among other animals, spontaneously attend to formants, the peaks in energy that are crucial to how human speech sounds are distinguished (Fitch 1994). This is in some sense unsurprising: surely the human auditory system did not evolve a whole new set of sensitivities solely for phonology without any basis in the inherited mammalian perceptual system.

Even more recently, with single-neuron recordings from the auditory cortex of ferrets (who have a range of hearing very similar to ours) listening to human speech, we are just beginning to understand how individual cells react to this kind of auditory stimulus (Mesgarani et al. 2008). Using this technique, it is possible to look at every instance in which a particular neuron fired while listening to the human speech and then determine what the properties of the acoustic stimulus are common to each of those instances. For instance, some neurons respond best to the vowels /i ɪ ɨ/; these neurons are tuned to a frequency band where this group of vowels has a formant (a strong energy peak). Other neurons are more broadly tuned in terms of frequency but respond best to a fast transition between silence and a burst of noise, as in the stop consonants. In short, it looks as though ferrets have neurons which detect acoustic properties that correlate with phonological features. Though this work is in its infancy, already it is becoming clear that ferret auditory cortex has the capacity to detect formant transitions, frication noise, and other basic properties of human speech. All of this suggests that human speech exploits basic perceptual abilities that were present prior to the emergence of full-fledged phonology (or language). Assuming the same capabilities in humans pre-linguistically (in either the ontogenetic or phylogenetic sense), the act of linking categories to features would then be reduced to coding these perceptual properties abstractly, as unary or binary features such as ±VOICE (in the case of VOT), and tagging categories with these features.

One possibility for how features might be abstracted from categories along these lines is suggested by Odden (2009). Odden argues that features can be learned on the basis of observing phonological alternations. For example, consider a process of vowel harmony in Kikerewe, stated in purely segmental terms (i.e. categories rather than features):

(4) {i, u} → {e, o} /{e, o} $\{$p t č k f s β z b d ǰ g w l y h m n n ŋ$\}_0$ _

The learner can posit features (written here as F_i) on the basis of sounds that behave similarly in the harmony process. That is: {i, u} have something in common, namely that they are undergoers. Call their common feature F_1. The segments {e, o} also have something in common. They are the products of the rule, and they also play a role in triggering it. Call their common feature F_2. Similarly, {p t č…} also behave equivalently in the environment of the rule, so they have a common feature, F_3. In this way, the learner figures out what in typical phonological parlance would be [+HIGH] (F_1), the class of mid vowels (F_2; perhaps with the help of other processes in the language, revised to [−HIGH, −LOW]), and [−SYLLABIC] (F_3). Looking at the inverses of these sets can yield binary features, if desired.

Although I have focused largely on features of acoustic perception here, I maintain that Mielke (2008) gives good reason to believe that the acoustic and articulatory approaches to featural organization are not mutually exclusive.[9] I already discussed one suggestive piece of data, namely that acoustic and articulatory feature systems achieve roughly the same success at characterizing phonological patterns. What's more, the idea that features can be of either type provides a ready account for the phonetic observations made by Anderson (1981), Lindau & Ladefoged (1986), Kingston & Diehl (1994), Pulleyblank (2006), and Brunelle (2008), among others: a particular feature/contrast can have multiple different articulatory or acoustic targets. To take an example from Pulleyblank (2006), the feature commonly known as [ATR] has the following correlates in various languages:

(5) Articulatory correlates of [ATR] contrast (Lindau & Ladefoged 1986)

a. Tongue root advancement/retraction and larynx lowering/raising (Akan, Igbo, Ijo)
b. Tongue height (Ateso)

9. That is to say, it is not necessary to adhere to either the strictly articulatory approach advocated by Morris Halle throughout the years or the strictly acoustic/auditory approach of Harris (1994).

c. Phonation difference and tongue root advancement/retraction (Shilluk, Dinka)
d. Tongue height or root movement and sometimes larynx height (Luo)

The picture that emerges from all these studies is that the dichotomy between acoustic and articulatory features is a false opposition. It is also interesting to note in addition that Coen's (2006) model can utilize input from multiple modalities to construct phonological categories, allowing categories to be constructed from a mix of acoustic and articulatory properties.

All of this is in keeping with a position for which I argue in Samuels (2011), following Hale & Reiss (2000a,b), namely that phonological computation is a system of abstract symbol manipulation. Features are the atomic abstract symbols manipulated by this system. Just as the semantic content of roots is inaccessible to morphosyntax, the phonetic content of features is inaccessible to phonology, so it is not necessary from the standpoint of phonological computation to restrict features arbitrarily to either acoustics or articulatory instructions. This is why Hall (2007: 17) argues that whether features refer to acoustic or articulatory properties is immaterial to both phonology and phonetics:

> The phonological component does not need to know whether the features it is manipulating refer to gestures or to sounds, just as the syntactic component does not need to know whether the words it is manipulating refer to dogs or to cats; it only needs to know that the features define segments and classes of segments. The phonetic component does not need to be told whether the features refer to gestures or to sounds, because it is itself the mechanism by which the features are converted into both gestures and sounds. So it does not matter whether a feature at the interface is called [peripheral], [grave], or [low F2], because the phonological component cannot differentiate among these alternatives, and the phonetic component will realize any one of them as all three.

A logical extension of this view is that, if phonology does not care whether it is dealing with acoustic or articulatory features, it certainly ought not care whether it is dealing with audition or vocal output at all. And indeed, since Stokoe (1960), it has been widely recognized that sign languages have phonology, and have phonological features. This underscores the modality independence of phonology, and therefore the necessity of divorcing phonological representations and operations from phonetic substance. But features are an important point of contact between form and substance: they are the currency of abstract phonological computation, but they are also the elements which are transduced and interpreted phonetically.

There is much evidence to support the view that "categories/features emerge as a result of contact with language data, and they naturally reflect the modality of the language being learned…. [T]he formal role of distinctive features and other primitives is the same for both modalities" (Mielke 2008: 18; see also Brentari 1998).[10] Interestingly, studies of sign language phonology have shown that sign language features do not pattern in the same way as spoken language features; there are no apparent correspondences between the two. The featural systems posited for sign are very different from the ones posited from spoken language in several ways. First, there seem to be far more features in signed language: for example, Stokoe (1960) makes use of twelve place distinctions, and even the very conservative feature set posited for sign by Sandler & Lillo-Martin (2005) has nearly twice as many features as the *SPE* system (recall §2). Secondly, the organization of these features appears to be quite distinct from geometries posited for spoken languages (see Corina & Sagey 1989; Brentari 1998; Mielke 2008, *inter alia*). Furthermore, the features utilized in signed language are grounded in properties of the articulators that are independent of language, which leads Corina & Sagey (1989) to claim that sign language feature systems are not specified by UG, but rather learned.

We should nevertheless expect, parallel to the case of spoken language features, that there is some neural basis for the features relevant to the manual and facial articulators (the latter being shared by both speech and sign). I suggest that the literature on mirror neurons and canonical premotor (F5) neurons in monkeys can provide a starting point for investigations in this direction. This can be true even if the "mirroring" aspect of mirror neurons – that there is a distinct population of neurons that fire both when an individual is performing a particular action and when another individual is observed performing that action – is overstated. Still, the notion that different neurons are sensitive to different handshapes and to different facial movements such as protrusion of the lips and tongue (see Rizzolatti & Craighero 2004 for an overview) is instructive, providing an interesting comparandum to the ferret auditory cortex data discussed earlier in this section. The articulatory configurations to which these neurons are sensitive could perhaps provide the building blocks of sign language, including hand shape, mouth shape, and hand movement.

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10. A reviewer asks why, if categories are this abstract, there are no languages that mix modalities for instance by having a stop inventory of /p t k/ plus a snap of the fingers. I do not have any particular speculations about this point, except to reiterate the point made in §4 that even 'auditory' speech is supported by visual cues.

6. Conclusions

Although everything I have said thus far implies that all languages across modalities are structured in terms of features that cross-cut phonological/phonetic categories, this is not necessarily the case. Hyman (2008: 87) wonders what a language would look like in the absence of phonology, concluding that "It is hard to imagine what a language without a phonology might look like," but it might, in the "extreme characterization," "lack.. . a fixed inventory of distinctive segments [and] any sequential constraints on segments."

There may in fact be an example of just such a language blossoming in the Negev Desert. This is Al-Sayyid Bedouin Sign Language (ABSL), which emerged during the past century among an isolated community with a high percentage of hereditary deafness: out of 3,500 individuals in the community, approximately 150 people across three generations are deaf (Aronoff et al. 2008); Sandler et al. (2011) argue that not only does ABSL lack a discernible segment inventory and phonotactic restrictions, thereby meeting Hyman's criteria, it also displays a much higher rate of lexical variation than in other sign languages. Where one would typically expect only a small amount of variation (think *tom[ej]to ~ tom[a]to*), instead in ABSL it is apparent that many signs, even common ones, have several variants. For example, Aronoff et al. (2008) note that the ABSL sign for BANANA can be made with the index finger touching the thumb, or with all four fingers extended; the sign for DOG can be made by the side of the face or in front of the chest. These handshape and location variations would be potentially contrastive in other sign languages, which use handshape, location, and movement path among their primary distinctive features. Overall, there is a notable and complete absence of minimal pairs in the language, strikingly unlike any other language previously observed:

> In ABSL, we have as yet not found clear-cut pairs distinguished by a meaningless formational element. We have found some signs with different meanings that are formationally similar to one another, but the difference between them is transparently attributable to iconicity rather than to substitution of meaningless contrastive formational elements. (Aronoff et al. 2008: 137)

This supports the conclusion that, particularly among older speakers of ABSL, there is no system of phonological features (or more to the point, no phonological system) in place, although speakers signal prosodic breaks with eyebrow and head/body position changes (Aronoff et al. 2008: 140).[11] This brings us back to the idea

11. This lack of lexical phonology correlates with a distinct lack of derivational and inflectional morphology. Indeed, only in the one type of complex words found in ABSL – compounds such as LONGBEARD+THERE 'Lebanon' and HEADSCARF+THERE 'Palestinian Authority' – do we

introduced at the outset of this chapter, that phonology is an afterthought; language is optimized to map syntactic objects to the Conceptual-Intentional interface, but not to externalize them. Although this may seem like a very radical Minimalist position, it was in fact advocated already by Charles Hockett (1960). Hockett believed that "duality of patterning" – the existence of two levels of combinatorics, one of morphemes into words and one of phonemes into morphemes – was a late development in the history of language. He claimed that "there is excellent reason to believe that duality of patterning was the last property to be developed, because one can find little if any reason why a communicative system should have this property unless it is highly complicated" (Hockett 1960: 95). In other words, there is some practical limit on the number of discriminable elements in language (or any other domain), and once one approaches that limit, the second level (phonological patterning) emerges. One way that this could occur, consistent with the discussion throughout this chapter, is for features to emerge, relating categories by means of pre-existing perceptual and articulatory sensitivities. Phonological features may not then be strictly necessary to language, but their emergence in a full-fledged linguistic system may be virtually inevitable. Already, the youngest generation of ABSL signers is putting linguists on the verge of being in a position to test this claim.

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see a phonological process, namely assimilation. Thus, ABSL appears to bear out the prediction made in Samuels (2011): no lexical phonology in the absence of morphology.

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PART IV

Language development

Non-native acquisition and language design

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Biolinguistics sees language as a cognitive organ and L1-acquisition as a process of language growth. A natural assumption within this approach is that of Lenneberg (1967), who assumes that language growth is subject to certain time restrictions. Some scholars hold Lenneberg's assumption to be correct; pointing out that L2-acquisition differs from L1-acquisition in not being uniform, automatic or convergent as the latter is; a difference that could follow from loss to access to the mental mechanisms responsible for L1-acquisition due to aging. Many researchers, however, refute Lenneberg's assumption, pointing out that foreign languages are natural languages and must therefore be constrained by UG; the very mechanism responsible for L1 acquisition. I argue that this debate has taken place without a working model of the design of language. I show that, without such a model, the questions of the debate are misleading. I further show that once a minimalist model is considered, a time restriction on language growth is consistent with the fact that foreign languages are UG constrained. Finally, I argue that time restrictions only constrain those areas of language that involve parameter-setting (e.g. lexical learning), and never those determined by language design.

1. Introduction

The literature on language acquisition identifies differences and similarities between native or L1 acquisition and the process of non-native acquisition (NNA). On the differences side, it has been observed that children's ability to acquire their native language is independent of intelligence, culture, learning style or any affective factor like interest or motivation. Regardless of the potential role of such language-external factors, the process of L1 acquisition is uniform across the species, taking place with relative ease, rapidity, and without the need of instruction. There is no such a thing as the wrong learning style for acquiring a native language or an unduly motivated child failing to reach a native level of attainment because of a lack of interest in the language of his/her speech community. It is safe to say that regardless of the attitude that the child might bring to the language acquisition scene, acquisition of his/her native language will just automatically happen to him/her.

The acquisition of a foreign language (LF), on the other hand, is neither automatic nor a uniform process: some people succeed more than others in their ultimate level of attainment, and even for the most successful foreign language learners, reaching a native-like level of proficiency in all areas of the target language seems to be a rare achievement. If one is asked to summarize the differences between L1 acquisition and NNA in three words, one could say that whereas L1 acquisition is *automatic*, *reliable* and *convergent* (Bley-Vroman 2009), NNA is characterized by none of these properties. L1 acquisition is reliable because it is uniform (all normal children acquire the language of their speech communities), and it is convergent because the language system children acquire is like that of the other members of their speech community.

There are however strong similarities between L1 and NNA (see White (2003) for a nice discussion of the issues). Perhaps the most striking one being the fact that foreign languages (like L1s) are natural languages. The role of a general theory of language acquisition is therefore to account for the similarities and differences between these two types of acquisition.

The uniform development of the process of first language acquisition across the species, as well as its automatic nature, makes the process seem more like organic development than learning. Undeniably, organic development requires the interplay of genetic factors that determine and channel the general course of development while requiring the interplay of some form of input for the genetic program to follow its course. In the case of anatomical organs, the input takes the form of nutrition, but it is the genetically specified program that determines whether the organ in question will develop to become the heart, the lungs, or the pancreas. In the case of "cognitive organs" like vision, the input takes the form of certain visual stimuli that seem necessary for the normal development of vision to follow its course, but it is the genetic endowment of the organism that determines that we are dealing with a case of vision development rather than one of hearing development. That visual stimuli play a role in the development of vision is shown by the finding that if the organism is not exposed to the appropriate visual stimuli within certain specific time frames or "critical periods", ulterior visual development with respect to the property of the stimuli might be difficult and, ultimately, less successful or even impossible (Robert 2006). Yet, despite the clear role of the relevant stimuli in the development of vision, the process is so automatic and beyond our control that we do not normally think of a human child "learning" to see binocularly or a kitten "learning" to see horizontal lines.

The acquisition of our native language is largely beyond our control and, if the child is exposed to the appropriate stimuli (in the form of linguistic input), development of our first language seems to be as inevitable and automatic as our visual development. Recognizing the similarities between language development and that of other cognitive systems, many researchers concerned with the biological foundations of language started, around the second half of the 20th century, to look at language development in terms of organ development, generally. This shift in perspective is described in the following quote from Chomsky (2008).

> The problem that has virtually defined the serious study of language since its ancient origins, if only implicitly, is to identify the specific nature of this distinctive human possession. Within the "biolinguistic perspective" that began to take shape fifty years ago, the concern is transmuted into the effort to determine the genetic endowment of the faculty of language FL, understood to be a "cognitive organ," in this case virtually shared among humans and in crucial respects unique to them, hence a kind of species property (p. 1).

In the biolinguistic conception of human language, in which language development is akin to organic development, language "growth" is expected to be subject to certain time constraints or sensitive periods in which the rate of growth is greater than any development occurring after closure of the given period: organs do not grow forever. And indeed, many researchers have argued that language development is subject to a sensitive period (Penfield & Roberts 1959; Lenneberg 1967; among many others), which might account for the differences between L1 and NNA alluded to above, concerning the properties of reliability and convergence. Chomsky (2005) synthesizes the expectation as follows.

> Like other kinds of growth, language acquisition happens easily at a certain age, but not later. There comes a time when the system doesn't work anymore. There are individual differences […] **but for most people**, after adolescence, it becomes very hard. The system is just not working for some reason, so, **you have to teach the language as something strange**. (p. 128, emphasis added)

Despite the fact that time constraints on language development seem to be the null hypothesis from a biolinguistic point of view in which language acquisition is viewed as language growth (a kind of organic growth), scholars are divided with respect to the existence of such time restrictions in the field of NNA. Some scholars in this field have followed Chomsky and Lenneberg in adopting the null hypothesis: that language growth, like any organ growth, goes through a sensitive period (e.g. Bley-Vroman 1989, 1990, 2009). On the other hand, on the basis of some success documented in the area of NNA, other scholars have denied the existence of time constraints in language development or any fundamental difference between L1 and NNA. Generally, scholars in the latter group have sought to demonstrate that adult L2 acquisition is constrained by principles of universal grammar just like the process of L1 acquisition is (See e.g. Flynn & Martohardjono 1995; White 2003a, 2003b). If so, the argument goes, universal grammar remains available through life, hence language development must not be subject to a critical period. Before such a conclusion can be established, however, the question of the language abilities that an L2 brings to the second language scene because of his/her native language must be elucidated, an issue foreseen by Lenneberg (1967), who develops the critical period hypothesis most prominently. He writes:

> A person can learn to communicate in a foreign language at the age of forty. This does not trouble our basic hypothesis of age limitations because we may assume that the cerebral organization necessary for language learning as such has taken place during childhood, and since natural languages tend to resemble one another in many fundamental aspects (see Appendix [A]), the matrix for language skills is present.

The presence of the native language alluded to by Lenneberg complicates the debate on the effect of time constraints in the process of NNA. Scholars agree that foreign languages are natural languages and as such must be constrained by universal principles of human language, but in light of the native language abilities of the foreign language learner, the fact that his interlanguage is constrained by universal principles of human language is not a proof against the effect of an age factor or time constraint in language acquisition, as one can always argue that the foreign language learner is actually deriving the relevant principle from his native language (see White 2003a for a discussion of the relevant issues). Since, traditionally, universal principles of language have been taken to be a part of universal grammar (UG), the debate of whether L1 and NNA are fundamentally different or whether NNA is subject to a time constraint or sensitive period has become the debate of whether it can be shown that NNA has direct access to UG, or whether access to UG has to be mediated through the L1 of the L2 learner.

The field of NNA has progressed considerably through the research agendas triggered by the debate. Most of this research, however has been carried out without a working idea of what the general architecture of the language faculty must look like. In the present article, I will show that many of the issues and arguments that have been advanced in the literature against the hypothesis that language growth proceeds with ease at certain time, but not later, looses steam once we evaluate the issues and arguments in light of an architecture of the FL that is consistent with the biolinguistic approach.

2. What is the architecture of the language faculty?

Generally, a natural language expression is a pairing of sound and meaning. Accordingly, any model of human language that recognizes such a fact must posit the existence of a sound interface and a meaning interface, given that sound and meaning have different properties. Beside that, linguistic expressions have an unbounded hierarchical structure, which implies among other things that they must be generated, rather than retrieved from a memory-based storage system. This means that besides the meaning and sound interfaces, there must be a structure building interface. Consequently, the minimal architecture that one can posit, given these facts of human language, is a tripartite architecture in which the structure-building interface interacts with the sound and meaning interfaces. It is this tripartite architecture that the biolinguistic approach to language adopts, where the structure building, sound, and meaning interfaces are respectively referred to as the computational system of human language (C_{HL}), the sensori-motor and the conceptual-intentional interfaces (see Chomsky 1995, 2001, 2004, 2005, 2008). Hauser, Chomsky and Fitch (2002), hereon HCF, call the C_{HL} the faculty of language in the narrow sense (FLN), and refer to the global architecture consisting of such a system together with the sensori-motor and conceptual intentional interfaces as the faculty of language in the broad sense (FLB). These authors leave open the possibility that the FLB might include other cognitive systems. Following their usage, the linguistically relevant architecture of the FLB can be schematically represented as in Figure 1, where the empty circle represents the other cognitive systems alluded to by HCF. I will not discuss such systems in what follows.

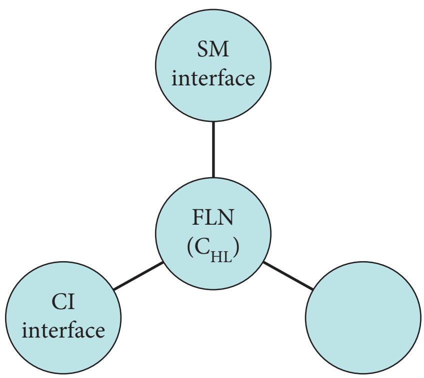


Figure 1. Components of the FLB

The positing of an architecture like the one in Figure 1 requires a rethinking of many fundamental concepts. As HCF point out, one question that emerges from a biological perspective is how much of the architecture, if anything, is uniquely human and how much of it we share with the chimpanzees and other animals. HCF hypothesize that only the FLN is uniquely human.

Another question that emerges in connection with the architecture in Figure 1 is the question of what exactly is UG. The concept of UG was motivated by the empirical fact that any normal child can acquire any human language. The uniformity and rapidity of the language acquisition process across the species, regardless of cultural settings, required positing a genetically determined "tool box" or UG that translated essentially into an inborn capacity to acquire any human language. There is substantial empirical evidence showing that this capacity for acquiring natural languages changes with time. Thus, whereas we can safely bet that a newborn orphan will learn Swahili, Japanese or Pirana depending of whether he is adopted by Swahili, Japanese or Pirana people, it would not be reasonable to assume that a 60 year old English speaker can learn any of these languages in a similar fashion.

Assuming that the new born orphan and the 60 year old of the previous scenario share the architecture in Figure 1, it follows that the initial ability to acquire any language (i.e. UG), which the new born do not share with the 60 year old, cannot be equated with the language faculty schematized in Figure 1: the former is a particular state; the latter, a cognitive structure. The distinction between UG and the language faculty has been blurred at times giving rise in my opinion to much misguided debate. Chomsky seems aware of the need of sharpening the distinction when he talks about "reinterpreting" UG as the initial state of the language faculty. He writes:

> Within the "biolinguistic perspective" that began to take shape fifty years ago, the concern is transmuted into the effort to determine the genetic endowment of the faculty of language FL, understood to be a "cognitive organ," in this case virtually shared among humans and in crucial respects unique to them, hence a kind of species property. So construed, language is I-language, a state of FL, **and universal grammar (UG) is reinterpreted as the theory of the initial state of FL** (p.1, emphasis added)

3. What is included in the initial state (UG)?

With the advent of the Principles and Paremeters approach (hereon P&P) in the early 80's, UG was thought to contain a set of principles and parameters that guided the process of language acquisition. At the time, principles constraining the possibility of *wh*-dependencies across islands (e.g. Ross' (1967) island constraints), the binding principles, the ECP, the head movement constraint, the constraint responsible for WCO effects, and the Overt Pronoun Constraint (OPC) were taken to be a part of UG, among many more. Besides such principles, such parameters as the null subject parameter, the *wh*-movement parameter and the head parameter, to name just a few, were also taken to be part of the initial state. As Chomsky has pointed out repeatedly in a number of lectures, however, such a rich UG is problematic from an evolutionary perspective: the greater complexity of the initial state, the less plausible it is to attribute its emergence to a single evolutionary event. The problem is that since it is not obvious that the emergence of language can be the result of natural selection, one might want to attribute its emergence to a sudden evolutionary event like a mutation. It is for such considerations that HCF find it advantageous to hypothesize that the FLN (i.e. the C_{HL}) only consists of a single binary operation *Merge* that takes two linguistic items and merge them into one syntactic object. The appearance of merge, which one in fact might hypothesize to be the result of a single evolutionary event, brings with it the property of recursion; the consequence of the fact that the operation can apply to its own output. Given evolutionary concerns, then, the best hypothesis of the initial state is that it is simply the first state of the architecture in Figure 1. If true the hypothesis would entail that there are no principles guiding the process of language growth other than those resulting from the nature of Merge, the nature of the mapping between FLN and the interfaces of FLB or from language independent general principles of the kind suggested by Chomsky (2005). If the hypothesis can be shown to work, the process of language growth might reduce to parameter settings as allowed by the type of principles just mentioned, especially those arising from the architectural design of the FLB. What about the parameters? In the current stages of the biolinguistic approach, parameter-setting is assumed to be restricted to a certain area of the lexicon. If so, language growth might reduce to lexical learning and we need not assume that there are principles other than those discussed above; a welcome result from an evolutionary perspective.

4. Principles of language growth and the architecture of the FLB

Chomsky (2005) observes that if we assume that the FLB has the properties of other biological systems, we should expect to find three factors involved in the process of language growth: genetic endowment, experience, and principles not specific to the language faculty. The genetic endowment factor is given by the fact that we Homo sapiens start out with the architecture in Figure 1 set at state 0 (S_0), the initial state. For the initial state of FLB to change, however, we need experience in the form of linguistic input so that parameter-setting can take place and lexical acquisition can proceed successfully. Among the principles not specific to the FLB, Chomsky mentions "principles of structural architecture and developmental constraints that enter into canalization," and "principles of efficient computation." Although the former type of principles is included under the rubric "principles not specific to the faculty of language" one might expect to find principles of structural architecture that might turned out to be specific to the FLB. Whatever the ultimate answer to such a possibility is, given the evolutionary concerns discussed above, we should seek to reinterpret any principle of language traditionally attributed to the genetic endowment in terms of principles of structural architecture or efficient computation. Below I will examine how this goal can be achieved.

4.1 Reinterpreting principles of UG

4.1.1 *Case study 1: Knowledge of constituent structure*

Consider the phenomenon of question formation in English as exemplified in the pairs in (1)–(2).

(1) a. You are eating something
b. What are you ___ eating?

(2) a. You have eaten cake.
b. *Have* you ___ eaten cake?

It is well known now that the fronting of the verbal element in such examples is not based on linear precedence, but is sensitive to the constituent structure of the sentence. For instance, although contrasts like (2) provide positive evidence that the leftmost element can be fronted, such evidence would lead the child to produce ungrammatical questions upon encountering examples like (3)

(3) The boy that **is** sitting on the floor **is** eating.

If one fronts the leftmost *is* in (3), the resulting question will be ungrammatical (i.e. *Is the boy that sitting is eating). The experimental evidence available on the phenomenon shows that knowledge of the principle responsible for the appropriate structure-sensitive fronting is innate, hence not learned (see e.g. Crain 1991, Crain & Nakayama 1986). The principle has therefore been attributed to UG. Can we show that the relevant principle reduces to properties of the architecture in Figure 1? In the current stages of the minimalist program the reduction is straightforward. As mentioned above, the appropriate fronting is sensitive to the structure of the sentence and involves identifying the subject of the sentence and fronting the first verbal element after the subject constituent. In contemporary minimalism, both the generation of structure and the fronting of syntactic items are the result of the single operation merge (i.e. external and internal merge, see Chomsky 2001, 2004, 2008). The question of why the leftmost *is* in (3) cannot be fronted reduces to the question of why the *is* inside the subject constituent cannot be internally merged at the level of the matrix C head. The answer to this question is available in the multiple spell out approach proposed recently in the minimalist program (MP). In such an approach, the construction of the independent (non-selected) parts of a sentence proceeds in parallel and incrementally until it reaches the level of the phase (i.e. the vP or CP level). The FLN or C_{HL} is the interface responsible for carrying out the incremental build up of the expression being derived. Every time a phase is reached, the C_{HL} sends the structure to the sensori-motor and conceptual intentional interfaces for spell out. In some versions of the multiple spell out approach, the spell-out domain of a phase is just the complement of the phase (see e.g. Chomsky 2001 & Nissenbaum 2000). Thus, when the C_{HL} transfers the structure to the interfaces, only the complement of the phase is spelled-out. Material in the Spec of the head of a phase gets spelled out at the next phase level. Once a particular domain is spelled out, the C_{HL} can access the spell out object as a whole, but nothing inside it. With this information in mind, let us revisit the question of why fronting the leftmost *is* in (3) leads to ungrammaticality, as shown in (4).

(4) *Is the boy that __ sitting on the floor is eating?

For *is* to appear at the beginning of the sentence, leaving a gap as in (4), it must have been merged (internally) from the gap position. But the gap position is contained inside a relative clause, an adjunct. Evidence of the kind presented by Freidin (1986) and Lebeaux (1988, 1990,1991, 2009) indicate that adjuncts can be merged late, so the question arises as to whether the adjunct is present in the derivation at the moment when the C head is merged in the matrix clause. We have two possibilities: either it is present or it is not. If it is not present, internal merge at the C head is not possible; hence the structure in (4) is not derivable. If the adjunct is present, on the other hand, the *is* it contains is not accessible for internal merge at the level of the matrix CP, the reason being that adjuncts and subjects, being non-selected, are spelled out separately and attached as already linearized domains onto the structure in the main work space (Uriagereka 1999). Since spelled out domains are inaccessible to computations from outside the domain, it follows that a constituent inside an adjunct or subject cannot be targeted for internal merge at a position outside such domains. Because of the nature of Merge, therefore, it follows that the structure in (4) is underivable under any alternative for the merging of adjuncts. The fact that no child produces sentences of such a form is therefore attributable to the design of the architecture in Figure 1. The sentences in question are never produced because the design of the FLN and the strictly cyclic way in which it interacts with the two interfaces does not allow it. No other principle needs to be invoked and the design becomes more plausible from an evolutionary point of view.

4.1.2 *Case study 2: The principle regulating extraction out of strong islands*

As is well known, at least since Ross's (1967) work on syntactic islands, extraction out of some syntactic domains leads to ungrammaticality. This restriction is exemplified by the examples below.

(5) a. 007 went to Boston after the FBI identified the terrorist.
b. *Who did 007 go to Boston after the FBI identified __?
c. *Who did 007 go to Boston after __ identified the terrorist?

(6) a. John's crashing my car got me fired?
b. *What did John's crashing __ get me fired?

(7) a. Bill confronted the man who gave his wife a flower.
b. *What did Bill confront the man who gave his wife __?

These examples show, respectively, that a position inside and adjunct (5b–c), a subject (6b), or a relative clause (7b), cannot be questioned. During the government and binding stage of the P&P approach these facts were taken to follow from the effects of a universal principle, hence part of UG, known as the empty category principle (ECP). Notice that all these examples have one thing in common: the position of the gap is inside a non-selected domain (i.e. a subject or an adjunct). Since non-selected domains are linearized separately (Uriagereka 1999), and since the interior of such domains is not accessible from outside the domain, there is no way for internally merging an argument in the position of the gap in (5)–(7) in the spec of the matrix CP. Like the facts in the previous section, the deviance of the unacceptable examples in (5)–(7) follows from the nature of Merge and the cyclic fashion in which the FLN transfers information to the other interfaces of FLB. In other words, the deviance of the relevant examples above follows from the design of the architecture in Figure 1. Again, nothing more needs to be said to explain the fact that native speakers never produce such examples.

5. A problematic principle: The case of the Overt Pronoun Constraint

In the two previous sections, we have seen how some universal principles can be shown to follow from the architectural design of the FLB. The question is whether every principle can be shown to follow from such a design so that we can essentially defend a simple conception of the initial state without language specific principles to guide the process of language acquisition other than those principles attributable to properties of the design itself or some of its related aspect. An interesting case in this connection is the Overt Pronoun Constraint (OPC) of Montalbetti (1984), which has been argued to be a universal principle. Montalbetti discovered that there are contexts in which a quantificational antecedent can bind an overt pronoun in [–null subject] languages like English or French, but not in [+null subject] languages like Spanish or Japanese. This is illustrated below.

(8) English
No man$_i$ thinks that he$_{i/j}$ is smart.

(9) Spanish

a. *Ningún hombre$_i$ piensa que Ø$_{i/j}$ es inteligente.*
No man thinks that is smart

b. *Ningún hombre$_i$ piensa que el$_{*i/j}$ es inteligente.*
No man thinks that he is smart

Since English does not allow null subjects, the pronoun in the embedded clause in (8) has to be overt: witness the unacceptability of **No man thinks that is smart*. Spanish, on the other hand, has the choice of using a null pronoun as in (9a) or an overt one, as in (9b). The English example in (8) is ambiguous. The pronoun can receive a bound variable interpretation in which its value is determined by the value of *no man*, or it can pick its value directly from the value of some salient entity in the domain of discourse. The bound variable reading is represented by co-indexation of the pronoun with the quantifier. Under the discourse specified reading, the pronoun bears the index of a sentence external entity. That is the situation expressed by the index j in (8)–(9). As the co-indexation in the Spanish examples in (9) indicates, the embedded null pronoun in (9a) can be either bound by the quantifier in the matrix clause, or it can refer to a sentence external entity. The embedded overt pronoun in (9b), on the other hand, cannot be interpreted as a bound variable: that sentence cannot be interpreted to mean that no relevant man believes in his own intelligence. The only available interpretation for that sentence is that in which no man believes in the intelligence of some salient sentence-external male individual. The same facts obtain in other null subject languages like Japanese (Kano 1997, 1998). The overt pronoun constraint can be formulated as in (10).

(10) Overt Pronoun Constraint (OPC): an overt pronoun cannot receive a bound variable interpretation in contexts where a null pronoun could occur.

The fact that OPC effects are found in typologically different languages like Spanish and Japanese suggests that such effects must follow from some universal principle of language. However, attributing such a principle to the initial state, together with the FLN and its main operation Merge, will render the initial state more complex and its emergence will be more difficult to explain in evolutionary terms. The best possible outcome from the evolutionary perspective would be to show that the OPC too follows from the design of the architecture of the FLB given in Figure 1. In the next section I will follow Agüero-Bautista (2012) in arguing that the OPC is the result of an interface strategy induced by the effect of the weak crossover (WCO) principle. The latter principle in turn will be shown to follow from the design of the architecture in 1 and the cyclic way in which the C_{HL} maps representations to the interfaces.

5.1 The Weak Crossover principle

Agüero-Bautista (2012) reviews the literature on WCO phenomena and concludes that the principle responsible for WCO effects is the one in (11).

(11) Overt Variable Constraint (OVC)
A variable v cannot depend on an operator O if v is overt and it is spelled out in the same spell-out domain of O or any of the copies (traces) of O.

(12) *Dependence*
α *depends on* β iff whenever the value of u changes, u a variable bound by β, the value of α changes as well.

The OVC resembles the OPC, but the two principles are not identical. First, the OVC rules out dependent pronouns rather that just bound pronouns, and it rules them out everywhere, rather than just in some contexts as the OPC does. Bound pronouns are dependent pronouns (see the definition of dependence in (12)), but a pronoun may depend on an operator without directly been bound by that operator. For instance, in a situation in which an operator binds a dependent expression which in turn binds a pronoun, the pronoun can be said to depend on the operator by transitivity, given the definition in (12), since every time the value of the operator changes, the value of the dependent expression will change and since the latter expression binds the pronoun, the value of the pronoun will necessarily change as well. So bound pronouns are a subset of the set of dependent pronouns. The domain of the OVC is thus a superset of the domain of the OPC. Agüero-Bautista 2012 shows that the OVC account of WCO has a greater empirical coverage than the alternative proposals found in the literature. For instance, the OVC account explains the contrast in (13) without any addition.

(13) a. *?Who$_i$ did his$_{*i/j}$ crashing a car get t$_i$ in trouble?
b. Who$_i$ did PRO$_i$ crashing a car get t$_i$ in trouble?

The contrast in (13) seems to show that overt pronouns resist having a bound variable interpretation in [−null subject] languages like English as well. The data discussed in Agüero-Bautista (2012) suggest that these cases might have been analyzed, incorrectly, as signaling a problem on the part of the quantifier to simultaneously bind its trace and a pronoun preceding the latter. (13b) shows that if the pronoun is the null element PRO, the interpretation in which the operator binds both the pronoun and its trace is in fact available. The problem, therefore, cannot be a problem of the conceptual intentional interface. The OVC places the unacceptability of the sentence in (13a) on the overt nature of the pronoun. So the WCO effect must at least implicate the phonological interface. One question that arises is how come operators can bind overt pronouns when there is some distance between the operator and the pronoun as in (14), the counterpart of (13a).

(14) Who$_i$ t$_i$ crashed his$_i$ car?

The OVC allows sentences like (14) because it only rules out overt dependent pronouns that belong to the same spell-out domain as an operator or its traces. Agüero-Bautista (2012) assumes the multiple spell out model defended in recent minimalist approaches mentioned earlier. Recall from that earlier discussion that the two phases are vPs and CPs and that the spell-out domains of those phases are their respective complements (i.e. VP and IP). The structure of (14) in the multiple spell-out approach is as in (15), where the different spell-out domains are indicated with Arabic numerals.

(15) [3 CP Who$_i$ [2 IP [vPt$_i$ crashed[**1** VP his$_i$ car]]]]

There are three spell-out domains in (15), the structure associated with (14). The first spell-out domain is the complement of the causative verb v associated with mono-transitive constructions (see e.g. Chomsky 1995). The second domain is IP, the complement of the C head. The third spell out domain is the spec of the root CP, which might be taken to be spelled-out when the root CP is sent to the interfaces as the complement of a null-performative head (Chomsky 2001; Nissenbaum 2000). It can be seen clearly in (15), that the overt pronoun, the trace, and the operator belong to different spell out domains as required by the OVC in (11).

As mentioned above, the OVC-based account of the WCO effect has a greater empirical coverage than the alternatives found in the literature. For instance, the approach can account for a puzzling asymmetry concerning the effect that embedding the pronoun has on the severity of the WCO effect. Consider the following examples.

(16) a. ?*Who the hell$_i$ does his$_i$ mother love t$_i$?
b. ?*Who the hell$_i$ does his $_i$ mother's brother love t$_i$?
c. Who the hell$_i$ does his$_j$ mother's brother love t$_i$?

(17) a. ?*Who the hell$_i$ does his$_i$ washing Bill's car upset t$_i$?
b. Which employee$_i$ did Bill's crashing his$_i$ car get t$_i$ fired
c. Who the hell$_i$ does Bill's washing his$_i$ car upset t$_i$?

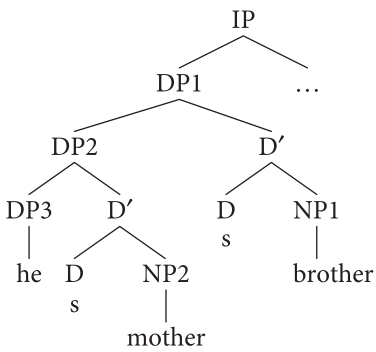
The example in (16a) exemplifies the regular WCO effect in which a *wh*-phrase cannot bind an overt pronoun in the spec of a possessive DP if it has been internally merged in Spec, CP from a position lower than the DP containing the pronoun. (16b) shows that if we embed the pronoun further, by placing it in spec of a DP that is itself in the spec of the subject DP, the WCO effect does not ameliorate: (16b) is as deviant as (16a). (16c) shows that the deviance associated with (16b) must be due to the bound interpretation of the pronoun given that the deviance of the sentence disappears under a deictic or contextually specified interpretation of the pronoun. To say the same thing in other words, embedding the pronoun in a left-branching structure, as in the possessive-of-a-possessive construction, causes no amelioration of the WCO effect. But notice now the contrast in (17). The crucial example here is (17b). Its acceptability shows that embedding a pronoun by pushing it lower in a right branching structure inside the subject DP takes away the WCO effect entirely. Examples like (17b) can easily be constructed. The examples in (18) are from Higginbotham (1980), those in (19) are from Agüero-Bautista 2012.

(18) a. Mary's seeing his$_i$ father pleased every boy$_i$.
b. The teacher's writing to his$_i$ father annoyed every child$_i$ in the class.

(19) a. The teacher's writing to his$_i$ parents got each child$_i$ in my class in trouble.
b. The IRS' scrutinizing his$_i$ finances exposed each candidate$_i$ as a tax-evading fraud.
c. The TIME's publishing her$_i$ nude pictures (on the cover) cost each contestant$_i$ dearly
d. Michael Moore's investigating her$_i$ company gave each CEO lots of troubles.

So, while embedding in left-branching does not ameliorate the WCO effect, embedding in right-branching structure does. Why should there be such an asymmetry? In order to answer that question we need to look at the structure of the subject DP in (16b). The relevant structure is that in (20).

(20) Left Embedding Structure for the Subject DP in (16b).



The question is whether the OVC allows binding of the pronoun in a structure like (20). It allows it only if the pronoun does not belong to the same spell-out domain as the trace of the operator or the *wh*-operator itself. One open question in the current stages of the MP is whether DPs are phases. We need not settle the question here. They either are or they aren't. If they are, the pronoun in the Spec of DP2 will not be spelled out in the spell-out domain corresponding to the DP2 phase, because the spell out domain of a phase is the complement of the head of the phase, hence NP2 in the case of DP2. By the same reasoning, since DP2 is in the spec of DP1, the pronoun still remains outside the spell-out domain of DP1. The pronoun in the spec of DP2 must therefore be spelled out in the spell-out domain of the matrix CP even if DPs are phases. Notice, however, that the spell-out domain of the matrix CP is the IP domain, which contains a copy of the *wh*-operator (i.e. the copy in Spec, vP). The structure in (20) therefore violates the OVC because the pronoun still belongs to the same spell-out domain as one of the copies of the operator despite having been embedded.

Let us see now why the embedding in (17b) ameliorates the WCO effect. The structure of that sentence is (21).

(21) [Which employee$_i$ did [Bill's [vP **crashing** his$_i$ car]] get t$_i$ fired]

The pronoun in this structure is inside the vP phase (in boldface in (21)) of the subject gerundive nominal. Since the *wh*-phrase extraction has not proceeded from inside that domain, there is no way for the pronoun to belong to the same domain as the *wh*-operator or its trace. The OVC can therefore account for the asymmetry in (16)–(17) in a principled manner. Left embedding does not ameliorate the WCO effect because it doesn't push the pronoun into a spell-out domain different from the one of the matrix clause. Right embedding, on the other hand, can push the pronoun into a different spell-out domain. The OVC predicts that only when that happens will the embedding take away the WCO effect. Notice that the asymmetry just discussed cannot be explained by the leftness condition (LC) of Chomsky (1976), the Bijection Principle (BP) of Koopman and Sportiche (1982), or the independence principle (INP) of Safir (2004), to name just a few of the alternatives found in the literature. The LC fails for an obvious reason: in all the relevant examples (i.e. (16)–(19)) the pronoun occurs to the left of the trace and yet not all of them are ill-formed. The BP fails because, like the LC, it predicts all the relevant examples to be unacceptable as the *wh*-operator would have to Ā-bind two variables, something that the BP disallows. Like the LC and the BP, Safir's (2004) INP fails to capture the asymmetry as the phrase that contains the pronoun c-commands the trace of the *wh*-operator in all the examples, something that is disallowed by the INP. The fact that some of the examples are acceptable contradicts the predictions of that putative principle. It seems them that the OVC seems to be the correct principle underlying the WCO effect.

Can we derive the OVC from properties of the language design schematized in Figure 1, including the cyclic fashion in which the FLN maps structure to the interfaces? This question is the same as the question of what goes wrong in the architecture of the FLB during the derivation of sentences in which an operator binds an overt pronoun as in (13a = **?Who$_i$ did his$_{*i/j}$ crashing a car get t$_i$ in trouble?*). One possibility considered by Agüero-Bautista (2012) is that binding of the pronoun by the operator in such an example might cause problems with the procedure responsible for the linearization of chains. When successive cyclic *wh*-movement (i.e. multiple occurrence of internal merge) takes place, the structure contains multiple copies of the displaced item. Since only one copy is pronounced, it must be that all the copies, but the one in the spec of the root CP are deleted, presumably due to reasons of economy and considerations of linearization along the lines discussed by Nuñez (2004). We might assume, then, that such considerations require the FLB to execute a procedure like the one in (22).

(22) If an item I is spelled out at a cycle C, deletes all copies of I in previous cycles.

We may assume that deletion takes place under identity, as usual. Consider now the fact that pronouns are collections of ϕ-features (Reuland 2011, among many others) and as such are amenable to receiving a bound variable or dependent interpretation. To receive such an interpretation, however, pronouns must agree in ϕ-features with their antecedents. But once a pronoun is bound, it not only agrees with its antecedent in ϕ-features, but also in terms of identity of variables (Reuland 2011). For all relevant purpose, therefore, the system might see a bound pronoun essentially as a copy of the binding operator. If so, obeying the procedure in (22), as required by economy considerations, demands that pronouns belonging to a spell-out domain through which its antecedent has been through be deleted. But deleting the pronoun in a sentence like **?Who$_i$ did his$_{*i/j}$ crashing a car get t$_i$ in trouble?* leads to ungrammaticality: the sequence **?Who$_i$ did s$_{*i/j}$ crashing a car get t$_i$ in trouble?* is hopeless. So keeping the overt pronoun in such sentences is a violation of economy, and deleting it violates the principle dictating that certain domains must have a subject, a kind of the +OCC or EPP feature of Chomsky (2001, 2008). As a result of these contradictory requirements, there is no convergent way to bind an overt pronoun in examples like those just discussed.

Notice that in examples like (17b), with the structure in (21), following the procedure in (22) will not demand deletion of the pronoun inside the highlighted domain, the reason being that the *wh*-phrase has never been through that domain; hence the relevant domain cannot count as a previous cycle in the sense intended in (22). What we have seen, thus, is that the principle underlying the WCO effect (i.e. the OVC) can be shown to follow from the architectural properties of the language design and the cyclic way in which the FLN maps structures onto the interfaces. In particular, the principle is attributable to the mechanisms responsible for the linearization of chains, which operates on the output of the cyclic transfers to the interfaces. The WCO principle is therefore a consequence of the design of language, rather than a principle in itself. Children do not need to learn to use such a principle, because their FLB can't do anything other than implementing the principle underlying the WCO effect by virtue of its design.

5.2 The OVC and the OPC

A consequence of the OVC is that it is computationally more costly to use an overt pronoun under the bound-variable interpretation than it is to use a null one in the same conditions. The reason for this is that felicitous use of an overt pronoun requires checking of the structure for compliance with the chain linearization procedure in (22). Since null pronouns need not be phonetically deleted, for obvious reasons, their use does not require an inspection of the structure for compliance with the procedure in (22). Using a null pronoun is therefore more economical than using an overt one. In contexts that allow a null or an overt pronoun, the more economical option (i.e. the null pronoun) will be allowed. Thus, the OPC reduces to an interface strategy of economy of the kind discussed by Reinhart (2006) and Di Sciullo and Agüero-Bautista (2008). This way of looking at the phenomenon predicts, correctly, that bound overt pronouns can only occur in contexts that do not violate the condition in (22) and where null pronouns are excluded. Notice that such an interface strategy is a side effect of the WCO principle, this latter reduced to the requirement imposed by the phonological component on the FLN in the form of the condition in (22). OPC effects therefore reduce to properties of the architecture in Figure 1, as these properties interact with language independent principles of efficient (economical) computations. What we have seen then is that, at a preliminary stage, an attempt to reduce former principles of UG to properties of the design of FLB promises to be successful, and should therefore be pursued given its plausibility from an evolutionary perspective.

6. Non-native acquisition and language design

At this point it is pertinent to recall the closing line from our earlier quotation from Lenneberg's (1967) seminal work on the biological foundation of language. He warns us that the fact that a 40 year old can learn a foreign language is not problematic for a biologically motivated maturational approach to language because "the matrix for language skills is present." Lenneberg assumes that the "basic neural organization necessary for language learning has already taken place during childhood." In the year that followed publication of Lenneberg's monograph, many scholars have objected to his maturational approach to language. The objections found in the literature are of two kinds. On the one hand, some researchers have sought to show that there isn't a critical period for language learning. On the other hand, various scholars have attempted to show that there are no fundamental differences between L1 and NNA. Without a model of language at hand, it is difficult to interpret what Lenneberg's remarks mean in terms of the model, and without an understanding of this, it is impossible to know what one is objecting to. Let us therefore adopt the architecture in Figure 1 as a model of language in order to try to evaluate what Lenneberg's warning means in terms of such a model.

If the initial state is just the first state of the architecture in Figure 1, and if language learning reduces to lexical learning, parameter-setting being restricted to the lexicon, we can interpret Lenneberg's statement that "the matrix for language learning is present" in a 40 year old foreign language learner to mean that the architecture in Figure 1 is present in such an adult learner. Having the tools for language learning, however, is different from actually undergoing the process of language learning. In the context of the model in Figure 1, having the tools for language means having that architecture. Language learning in such a model means that the state of the FLB changes through the process of parameter-setting, which might just be a matter of lexical learning. To say that language acquisition is subject to a critical period, therefore, might just be claiming that the process of parameter setting (possibly just lexical learning) is subject to a critical period. Understanding the difference between issues relating to the structure of the FLB and those issues pertaining to the process of state changes is fundamental for an understanding of how human language works. Yet it seems to me that the objections that have been raised to a maturational approach to language are based on a misunderstanding of the distinction. As an illustration of this point, consider the issue of knowledge of phrase structure discussed in Section 4.1.1, and exemplified in sentences like (4) = (23).

(23) *Is the boy that __ sitting on the floor is eating?

Since children never produce utterances of the form in (23), we concluded before that the principle that ban the fronting of the first *is* in that sentence is universal and need not be learned; hence it must be innate. But we also concluded that the principle reduces to properties of the design of the FLB and the way that FLN works. Essentially we concluded that the way that Merge works does not allow the derivation of such a sentence as an item cannot be internally merged from an inaccessible domain.

Suppose now that we find a 70 year old whose native language has no subject auxiliary inversion in question as in English. Imagine further that after 5 years of exposure to English, we test our subject and find that he never produces sentences like (23), and (even better) rejects them systematically whenever he encounters such sentences in the experimental conditions. Can we conclude from that evidence that language acquisition is not subject to the critical period? I believe the answer to this question is no. Any biolinguistic approach adopting an architecture like the one in Figure 1, predicts that as long as the 70 year old has a FLB, he will not be able to produce sentences like (23), given the nature of the FLN and the manner in which its operation Merge works. But language acquisition is not just using the FLN. If it involves at least parameter-setting at the lexical level, it is possible that representations like (23) will be excluded even if the 70 year old has only partially learned the meaning of the lexical items involved in the derivation. Given this possibility, the most that we can conclude from the success of our 70 year old language learner is that the way the FLN (i.e. syntax) works and the manner in which it maps expressions to the other interfaces is not subject to a critical period, a conclusion that some researchers have reached from a different perspective (see for instance Martohardjono & Flynn 1995).

To consider another illustration of the problem of not having a clear model of language in objecting to a maturational approach to language acquisition, consider the use that scholars have made of Montalbetti's (1984) OPC. There is agreement that OPC effect involve so abstract and subtle properties of the structure that their knowledge cannot be determined by anything in the input, hence knowledge of such effects constitute a classical poverty of the stimulus (POS) argument for the innateness of the principle. Several researchers have sought to show that foreign language learning is necessarily constrained by innate principles of UG, by showing that foreign language learners of languages with OPC effects can acquire such effects (see e.g. Perez-Léroux & Glass 1999; Kano 1997, 1998). In the relevant studies, the L1s of the subjects chosen lack OPC effects. These studies have generally found that their subjects do have knowledge of OPC effects, a knowledge that cannot be attributed to knowledge of their L1s, given that the L1s in question lack the relevant effects. Can we conclude from these findings that foreign language learning is not subject to a critical period or that NNA and L1 acquisition are identical processes? Again the answer is no. We saw above that OPC effects are attributable to a combination of properties of the language design and principles of economy of computation. In particular, we saw that OPC effects are a side effect of the WCO principle, which is in turn a consequence of the cyclic way in which the FLN maps representations to the interfaces and how the procedure that linearizes chains is sensitive to such cyclic transfers. Since such properties are not learned, they cannot constitute the basis for comparing processes of state change or language growth (i.e. the issue of language acquisition). Given this, if we wish to compare the processes of NNA and L1 acquisition, we need to look in the area where language learning is expected to take place. In a framework incorporating the architecture in Figure 1, with no principles of the initial state other than those resulting from the properties of the design itself, as required by evolutionary concerns, the area to look for differences between first and NNA is that area where parameter-setting takes place, namely the area of lexical learning. The question is empirical, but if the current remarks turn out to be correct, studies comparing first and NNA have been misguided by searching for differences in the two learning processes by looking at areas of language that needs not to be learned. To remedy the situation one might shift the perspective from the acquisition of syntax and other similar areas to an investigation of how the learning of lexical items might impact the generation of native-like expressions. I suspect that much of the differences between first and NNA will show up in such an area.

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Interface ingredients of dialect design

Bi-*x*, socio-syntax of development, and the grammar of Cypriot Greek*

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This paper addresses the difficulty of investigating language development in a non-codified linguistic system, Cypriot Greek, the local dialect spoken natively by Greek Cypriots whose official language is Standard Modern Greek, which in turn is not natively acquired by the population. The situation is further complicated by a lack of consensus with respect to the status of bi(dia)lectism vs. bilingualism as well as to which are the varieties that underlie these terms. Here the cover term "bi-*x*" is introduced. Aiming to uncover the dialect design in the case of Cyprus, the Socio-Syntax of Development Hypothesis brings together different factors that may affect the acquisition of direct object clitic placement and relates the grammar of Cypriot Greek with the continuum that informs the process of first language acquisition in a dialectal context. Establishing the connection between biolinguistic implications behind language development and the dialect design, the call behind the present discussion of the acquisition of clitic placement in Cypriot Greek is to approach the point where language-external factors meet – and affect – the way language is put to use through choosing one out of a range of gradient syntactic variants that belong to different varieties existing in a continuum.

* This paper is based in parts on the first author's invited presentation at the *Language Design* conference in Montreal ("The Dialect Design: Socio-Syntax of Development and the Grammar of Cypriot Greek") and in parts on on-going work by both authors – with input from members of the Cyprus Acquisition Team (http://www.research.biolinguistics.eu/CAT) – on "bi-*x*" and the relevance of Cypriot Greek for language development (Grohmann & Leivada 2011; Leivada et al. 2012; Rowe & Grohmann 2012). It draws also on data collected through a range of experiments (Grohmann et al. 2010; Leivada et al. 2010; Grohmann 2011; Grohmann et al. 2012). We thank all audiences where materials contained here have been presented: Barcelona, Chicago, Hamburg, London, Montreal, Nijmegen, Nicosia, Thessaloniki, and Tours. The testing tools leading to what we perceive as intriguing results would not have been possible without participation in COST Action A33, chaired by Uli Sauerland, and WG1 "Binding and Clitics" in particular (see Varlokosta et al. to appear). Thanks to you all! Finally, we acknowledge financial support from the University of Cyprus for funding the Gen-CHILD Project awarded to the first author (grant no. 8037–61017). All errors, inaccuracies, and other shortcomings as well as interpretations are solely our own.

1. Introduction

Studying first language acquisition involves paying close attention to the developmental progression of a child's acquisition of the (morpho)syntactic properties of his or her mother-tongue – in the present case the variety of Modern Greek spoken in the Republic of Cyprus (henceforth, Cypriot Greek). This raises an additional difficulty: How to investigate a non-codified linguistic system? This paper addresses some fundamental issues relating to Cypriot Greek native language acquisition along several axes. The core revolves around the notion of the "socio-syntax of development", that is, social-at-large factors that may influence the first language acquisition process and subsequent development of (morpho-) syntax in a non-codified native variety. The guiding line should be familiar from generative grammar: Dialects are languages; or rather, since a language is a system of abstract rules that govern a speaker's I(nternal)-language, then, if a corresponding E(xternal)-language is something called a "dialect", so be it. Note that this carries no implications whatsoever for the nature of I-language (especially if "internal" is understood as "individual"). All linguistic variants (i.e. languages, dialects, idiolects) acquire their status as such through social conventions. Accepting that E-language entails a socio-cultural perspective, whereas I-language entails a cognitive perspective, there is "only one human language on the planet" (Boeckx 2010: 5) and no relevant dialect(s) to speak of.[1] However, the "dialect design" does have important implications for the process of language acquisition itself – given that the latter is mainly informed by sociolinguistic, educational, or even social-at-large (i.e. language-external) processes – because the dialect is invested with variables that are absent from the process of acquiring of a "language", such as linguistic continua, possible lack of codification, and so on.

On the socio-linguistic side, some of the perennial problems burdening formal investigations of dialects is sketched (e.g. the "low" status of Cypriot Greek as opposed to the "high" variety of Modern Greek, of which no Greek Cypriot is a native speaker, discussed further below). On the morpho-syntactic side, some interesting properties of Cypriot grammar are briefly sketched (such as wh-question formation, focusing strategies, and object case issues), concentrating

1. For an interesting recent discussion of E- versus/and I-language, see Lassiter (2008), Lohndal & Narita's (2009) reply, and Lassiter's (2010) rejoinder. Also, putting these "old" issues into a new context, Ludlow (2011) enriches our terminological and conceptual repertoire with the notion of "Ψ-language". We will not return to these issues but simply assume our approach to be justified and fully in line with underlying biolinguistic issues of language design. In addition (and this we will return to), it addresses an interesting new interface issue, in some sense picking up from where Cornips & Corrigan (2005) left off: the socio-syntax of development.

on the perhaps most widely studied property of CG: clitic placement. Despite all (political) efforts, Greek Cypriot children normally grow up acquiring the local variety, and it is only at the onset of formal schooling, around the ages 5 to 6, that the normative language is systematically used, largely through instruction. The developmental part of this paper presents some systematic research carried out by the Cyprus Acquisition Team with a special emphasis on the Socio-Syntax of Development Hypothesis applied to the acquisition of clitic placement drawing from experimental data with typically developing children aged 2 to 7.

The linguistic reality of the Republic of Cyprus is traditionally described as diglossic, where the sociolinguistically "low" variety of Cypriot Greek (CG) co-exists with the "high" Standard Modern Greek (SMG), which is the variety also spoken in the Hellenic Republic (i.e. Greece). The two varieties show many differences in all domains of grammar; one of the more studied ones is the placement of pronominal clitics. This paper draws insights from the findings of two recent studies that investigate the acquisition of direct object clitic placement in CG (Grohmann et al. 2010; Leivada et al. 2010; Grohmann et al. 2012, summarized in Grohmann 2011) to discuss gradience in grammar through the perspective of syntactic variants possibly existent within and affected by a dialect–standard continuum (cf. Cornips 2006 for such a discussion of Standard and Heerlen Dutch). Findings of a picture-based elicitation task administered to different populations residing in Cyprus shed light on the process of constructing a socio-syntactic repertoire in diglossic environments such as the one in Cyprus, but one that goes beyond mere diglossia or the issue of bidialectism vs. bilingualism. The cover term chosen here and in related work is "bi-*x*", an umbrella for quasi-bilingual but certainly bilectal settings involving two very closely related varieties.

Gradience is approached from a generative perspective: Linguistic variants might often appear with blurred edges and in effect give rise to gradient phenomena in all levels of linguistic analysis (Bolinger 1961a, 1961b). Ever since Chomsky (1955), generative linguists assume varying degrees of acceptability of grammaticality judgments as well as classify linguistic categories in non-discrete scales "more often than not" (Fanselow et al. 2006: 1). One crucial factor of "dialect design" is intimately intertwined with gradience, especially in cases where bidialectism – or rather bilectalism, as one of the defining properties of diglossia is that the "high" variety is a language rather than a mere dialect (Rowe & Grohmann 2012) – revolves around the use of a sociolinguistically "high" variety or acrolect and a sociolinguistically "low" variety or basilect (and even possible mesolects in between), a typical characteristic of diglossic contexts. It has been argued that in contexts that involve the co-existence of a standard and a regional variety, syntactic differences gradually fade away in favor of an intermediate (Cornips 2006) or "diaglossic" (in terms of gradience and fluidity) speech repertoire (Auer 2000, 2005) and variants pertinent to the two varieties exist along a standard/dialect continuum. The performance of the group of adult Greek Cypriots, used as a control group with the aim of providing insights as to what surfaces as *target* clitic placement in an elicitation task such as the one employed in the two experiments discussed here corroborates this hypothesis and suggests that indeed the boundaries between the syntactic variants that belong to the two varieties are not so clear-cut, even in adult populations.

As far as Cyprus is concerned, the situation is further complicated by the lack of consensus with respect to the status of bi(dia)lectalism vs. bilingualism as well as to which are the varieties that underlie these terms. Numerous studies portray adult Greek Cypriots as bidialectal or even bilingual, having constant exposure to both SMG and CG, despite the fact that there are indications that in a great number of cases what counts as standard is in reality a standardized form of CG. What appears as "Cypriot Standard Greek" in Arvaniti (2010) or "*koine*" in Terkourafi (2004) is a variety that is not SMG but still has a greater level of proximity to SMG compared to the level of proximity between SMG and CG. In this context, the cover term "bi-*x*" is introduced and tied in with the process of constructing a socio-syntactic repertoire. Aiming to uncover the dialect design in the case of Cyprus, the Socio-Syntax of Development Hypothesis brings together different factors that may affect the acquisition of direct object clitic placement and relates the grammar of CG with the continuum that informs but also affects the process of first language acquisition in a dialectal context.

2. Unweaving the implications of bi-*x*

CG has been argued to be "the last surviving Modern Greek dialect" (Contossopoulos 1969: 92, 2000: 21). Regardless of whether one subscribes to this view or not, when coupled with the fact that CG has the prerequisites to be considered a language (in the Weinreichian sense[2]) but has not yet acquired official status, its study and the connections with the "high" official variety become intriguing.

The sociolinguistic status of the Republic of Cyprus has been linked, depending on the study and the perspective behind it, with bidialectism, bilingualism, and even trilingualism. What is usually agreed upon is the status of diglossia, the latter typically following Ferguson (1959). Numerous studies have discussed the

2. An army and navy, following the frequently quoted "a language is a dialect with an army and a navy" (Weinreich 1945).

diglossic status of Cyprus,[3] the sociolinguistic aspects of "high" and "low" variety, and the relationship between them (e.g. Davy et al. 1996; Moschonas 1996, 2002; Papapavlou 1998; Papapavlou & Pavlou 1998; Tsiplakou 2004).

However, the current linguistic reality of Cyprus is far more complex than a simple co-existence of a "high" and a "low" variety might imply. According to article 3 of the constitution of 1960, SMG is only one of the two official languages of (the Republic of) Cyprus, with Turkish being the other one.[4] Hence, Cyprus exhibits *de jure* bilingualism, but the vast majority of Greek Cypriots do not speak Turkish – even those who speak Turkish are generally only familiar with the local variety, which differs from Standard Turkish. As Arvaniti (2006: 26) points out, the relationship between Cypriot Turkish and Standard Turkish (discussed in Georgiou-Scharlipp & Scharlipp 1998; Kizilyürek & Gautier-Kizilyürek 2004) in the northern parts of the island that are not under the effective control of the Republic of Cyprus exhibits interesting parallels to the linguistic situation that exists in the (Cypriot) Greek-speaking part of the island.

Moreover, it has been proposed that Cyprus shows *de facto* trilingualism in Greek, Turkish, and English (Arvaniti 2002) or bilingualism in SMG and CG (Newton 1972; Vassiliou 1995) or bidialectism in SMG and CG (e.g. Pavlou & Christodoulou 2001; Yiakoumetti et al. 2005; Tsiplakou et al. 2006). Vassiliou (1995) does not make an explicit claim for bilingualism. However, she quotes Newton's (1972) view that certain groups of Cypriot Greek speakers develop what Newton refers to as "fluent bilingualism", and she also argues that there is no mutual intelligibility between speakers of SMG and CG. The criterion of unintelligibility is usually put forth to advocate a distinction between different languages and not between different varieties of the same language, hence we interpret Vassiliou's stance to be in support of bilingualism rather than bidialectism. Arvaniti (2006b: 26) also assumes unintelligibility "without adequate previous exposure", despite the fact that she attributes to CG the term "dialect" and not "language". However, her claim is not identical with Vassiliou's, since Arvaniti suggests that unintelligibility is not mutual, but one-way. In addition, the issue of what counts as adequate exposure is not always straightforward: If very limited exposure is shown sufficient to enable full comprehension in the case of a Hellenic Greek

3. Or "former diglossic", since Karyolemou (2006) argues that there is a recent (or perhaps ongoing) re-allocation of domains that allows speakers to combine features of the two varieties and mix them depending on the (linguistic) circumstances.

4. Throughout this paper, references to the linguistic reality of "Cyprus" aim to describe the linguistic situation in the southern territories of the island that are under the control of the Republic of Cyprus and not to the entire island, unless stated otherwise.

(monolingual in SMG) being exposed to CG, but not in the case of the same person being exposed to any other language for the same amount of time and receiving the same amount of linguistic input in both cases, then these two varieties of Greek are intelligible with degrees of comprehension varying and depending also on individual, socio-culturally driven motivations to (not) understand and related biases towards the one of the two varieties.

The cover term "bi-*x*" is here, once more, taken to be a descriptive umbrella to capture such terminological confusion – but also to go beyond breaking up the terminological logjam in bringing together a range of socio(linguistic) factors that determine the context-specific character of language acquisition and development in Cyprus (see also Grohmann & Leivada 2011 for an attempt of further explanation in terms of "competing motivations"). At the very minimum, bi-*x* could be taken to stand for "(discrete) bilectal", since in diglossic societies, speakers should not really be assumed to be "bidialectal"; after all, the sociolinguistically "high" variety should by definition be a language proper (see Rowe & Grohmann 2012 for further discussion).

Arvaniti (2006: 26) draws a revealing comparison between studies that assume the characterization "diglossic" and those that assume a "dialect continuum" or "bilingualism". In her words, although the characterization diglossic "appears clear to some researchers [...] it is not shared by all; many scholars describe the linguistic situation in Cyprus as a "dialectal continuum" of some sort [...] or as bidialectalism". However, following Fishman (1980) and thereby going beyond Ferguson's (1959) original formulation, we interpret diglossia as potentially disjoint from bilingualism; hence, there should be no issue of whether the linguistic reality of Cyprus entails one or the other for some researchers. The terms "diglossia" and "diglossic" refer to and describe the sociolinguistic situation, respectively, and not speakers' performance. Therefore, speakers can only demonstrate bilingualism, not diglossia.

The availability of both terms, "bidialectism" and "bilingualism", to describe the same situation illustrates another issue that characterizes the sociolinguistic status of CG in relation to SMG. In the absence of sociopolitical reasons advocating otherwise,[5] it is the criterion of mutual intelligibility between two varieties that is usually employed to decide between the two terms. One-way intelligibility, namely Greek Cypriots understanding SMG, is necessarily entailed by any approach that assumes Greek Cypriots as bilinguals/bidialectals – or, as we will call them from now on, bilectal speakers (in the absence of a cleaner definition

5. The case that linguists traditionally evoke in this discussion is that of the many Chinese "dialects".

of "bi-*x*"). What is usually disputed is whether Hellenic Greeks understand CG upon their first exposure to it. Opinions significantly vary as to whether there is intelligibility from that perspective. However, it should be taken into account that if one makes a claim of CG and SMG not being mutually intelligible, one should also make a claim about why a monolingual Hellenic Greek is able to understand CG, if not from the beginning, sometimes after limited exposure to it. One should also provide an account of why a certain amount of time or input is sufficient for attainment of full comprehension of CG, especially if CG refers to the form of the dialect that is spoken in the urban areas, as opposed to the time needed for achieving comprehension in another language.

Encountering unknown lexical items does not suffice to make a claim for mutual unintelligibility between speakers of the two varieties or a claim for an average SMG speaker not being able to understand a CG speaker, when the latter uses his native variety, because the issue of encountering unknown lexical items arises even among Greek Cypriots. Admittedly, the dialect is not homogeneous; distinct names are used for its varieties by different people (cf. Newton 1972: 19; Le Page & Tabouret-Keller 1985: 182; Terkourafi 2004: 1) and many speakers in the urban centers make a claim of not understanding parts of the speech of people from rural areas of the island. Finally, if CG refers to "Cypriot Standard Greek" (Arvaniti 2010) or "*koine*" (Terkourafi 2004), then mutual intelligibility will inevitably arise due to the close level of proximity between this variety and SMG.

Some Greek Cypriots arguably appraise SMG higher than CG, in terms of finding SMG more expressive, kind, or correct, and, above all, the language that educated people use (Sciriha 1996; Sivas 2004). The link with education and the fact that SMG is viewed as the educated people's language uncovers the notion of overt prestige that the use of SMG conveys. Still, Greek Cypriots do not overall reject CG or show such a strict dichotomy of properties by attributing to CG only negative characteristics and to SMG only positive ones. As Papapavlou (2001: 493) suggests, speakers of SMG are considered by Greek Cypriots to be "educated, attractive, ambitious and intelligent" yet "not found to be more sincere, more friendly, or kinder, or to be more humorous than Cypriot dialect speakers". Therefore, an assumption that Greek Cypriots reject their native variety altogether is not accurate in the sense that it fails to capture the covert prestige that CG carries as well as the choice of younger speakers not to dissociate themselves from CG, especially in transplanted settings (Gardner-Chloros et al. 2006). The claim about covert prestige being attached to a non-standard or a vernacular variety of a language is neither new nor pertaining exclusively to the linguistic reality of Cyprus; Labov (1972) and Trudgill (1974) discuss different cases and environments.

In this sense, "bi-*x*" does not simply stand for "either bidialectal or bilingual". Rather, it is meant to cover further reaching consequences of the co-existence of two closely related varieties. As such, it should not be restricted to the Cypriot context either, but such implications remain to be addressed in the future. For present (practical) purposes, we use the term so as to not get entangled in the bilect(al)ism–bidialect(al)ism–bilingu(al)ism debate, but the hope is to flesh out the notion sufficiently to gain theoretical meaning as well, beyond the context of Cyprus (see also Kambanaros et al. to appear for a developmental perspective).

3. Bi-*x* and the dialect design

From a generative perspective, a language is minimally defined as the set of abstract rules that predict all the grammatical structures (and rule out all ungrammatical ones) in this grammar (e.g. Kayne 2000: 7). In this sense, CG is a *bona fide* grammatical system – whether called "language", "dialect", or "variety" – and further comparative investigation of child and adult language, looking at parametric or otherwise derived differences between the (adult) grammars of both CG and SMG, might reveal purported or suspected properties of CG that develop early on and thereby constitute actual core properties of the "language" (Grohmann 2011: 183; Grohmann et al. 2012).

If, in addition to SMG and CG, the existence of a Cypriot Standard is put forth – and the examples Arvaniti (2010) lists are quite compelling in this respect – defining the target grammar is a demanding task. It should not go unnoticed that even if one makes an argument in favor of the presence of Cypriot Standard Greek in certain formal registers, exposure to SMG (e.g. via school textbooks that are imported from mainland Greece and through television programs from Greece) remains an undeniable reality. Taking into account the fact that *systematic* exposure to SMG typically occurs with the entrance in the primary education sector, that is, only after age 5 for pre-school and age 6 for primary school, the question that arises is whether SMG is acquired as a second language, limiting first language acquisition and the long-standing claims for bidialectism/bilingualism to CG and Cypriot Standard Greek. The gradient nature of linguistic variants and the heterogeneity of the dialect itself makes the boundaries difficult to pinpoint on the continuum and results in a lack of solid understanding with respect to how many, and which, target adult grammars there might be. This lack, coupled with the need to place language acquisition and development in such a setting in its right sociolinguistic context (by which it is unequivocally affected and facilitated), eventually gave rise to the use of the cover term "bi-*x*" (see also Grohmann 2011; Grohmann & Leivada 2011; Grohmann et al. 2012), understood minimally as "bilectalism" (Rowe & Grohmann 2012).

Drawing on insights from issues pertaining to language design, several questions arise, including whether more than one sort of formal grammar is part of the language design, perhaps distributed in different components, or possibly available within narrow syntax itself. The dialect design is additionally invested with sociolinguistic factors that affect the developmental pattern. Relating the status of bi-*x* to dialect design, this term could refer to bi-glossic/dialectal/lingual individuals, and sociolinguistic variables such as the schooling factor come into play and may have an impact on the linguistic development of bi-*x* populations. In the case of Cyprus, SMG is one of the varieties used in the classroom environment, if not through instruction (at least, not always and exclusively, as prescribed by the ministry), certainly through educational material. From the perspective of the Cypriot Ministry of Education and Culture, SMG is the only variety used in classroom; however, many studies have indicated the use of CG by students in both oral and written discourse (see Loukaidou 2004; Pavlou & Fousias 2005; Yiakoumetti et al. 2005; Ioannidou 2007, among others; for a recent re-assessment, see Leivada et al. 2012).

The question that arises is how to define the acquirable grammars when different forms of the dialect and the standard exist in such a continuum. More recent inquiries into the field of socio-syntactic research postulate that sociolinguistically determined strategies facilitate the process of choosing between syntactic variants, hence to some extent bleach the traditional distinctions between sociolinguistics, psycholinguistics, and theoretical linguistics (Grondelaers & Speelman 2007; Grondelaers 2009; Grondelaers et al. 2009). The necessity to advocate a modular, interdisciplinary approach has recently been formulated by Cornips & Corrigan (2005: 20), who predict "the coming-of-age of "Socio-Syntax" as a discipline in its own right".[6] This paper can be seen as a contribution to this new type of interface study, the role and relevance of social (at large) factors in first language acquisition and development. Although the fields of sociolinguistics and syntax are well established in their own rights, "socio-syntax of development" is the interface that relates sociolinguistic impact on the acquisition of syntactic properties. As such, its methodological tools can be (and are, in the experiments discussed here) those utilized in research carried out in the area of language acquisition. In addition, its theoretical predictions and empirical

6. Although the focus of the paper is on the nascent discipline of socio-syntax, it should not go unnoticed that there is research on the acquisition of such variation in the domain of phonetics and phonology, studies of which have a longer tradition in sociolinguistics, starting with Payne (1976), for example. We are grateful to an anonymous reviewer for raising this point.

findings can bear potential interest for all three sub-disciplines: sociolinguistics, formal syntax, and language acquisition.

At the same time, this interface between sociolinguistics and theoretical linguistics is concomitant with the current biolinguistic call. The latter's central research questions purport to uncover how knowledge of language is acquired and how that knowledge is eventually put to use (Boeckx & Grohmann 2007: 1; following Chomsky 1986). Establishing the connection between biolinguistic implications behind language development and the dialect design, the call behind the present discussion of the acquisition of direct object clitic placement in CG is to approach the point where sociolinguistic factors meet – and affect – the way language is put to use through choosing one out of a range of gradient syntactic variants that belong to different varieties existing in a gradient continuum.

On the morpho-syntactic side, the two varieties exhibit a range of differences. Among them, there is the existence of (i) accusative-only direct objects in SMG, whereas the very same verbs take a direct object in genitive case in CG (1), (ii) focus movement in SMG in contrast to focus clefting in CG (2), and (iii) 'normal' *wh*-movement in SMG versus the *embu*-strategy in CG (3):

(1)	a.	*Ksejelo*	*tin*	*Anna.*			SMG
		deceive.PRES.2SG	the.ACC	Anna.ACC			
	b.	*Jelo*	*tis*	*Annas.*			CG
		deceive.PRES.2SG	the.GEN	Anna.GEN			
		"I deceive Anna."					
(2)	a.	*Ton*	*PETRO*	*iða.*			SMG
		the.ACC	Peter.ACC	see.PAST.1SG			
	b.	*En*	*ton*	*Petro*	*pu*	*iða.*	CG
		is	the.ACC	Peter.ACC	that	see.PAST.1SG	
		"It is Peter that I saw."					
(3)	a.	*Ti*	*ipes?*				SMG
		what	say.PRES.2SG				
	b.	*Ti*	*embu*	*ipes?*			*CG*
		what	it.is.that	say.PRES.2SG			
		"What did you say?"					

To our knowledge, the first property has not yet been observed and discussed in the literature, while the second and third have received quite some attention in recent years. They illustrate, however, that besides the well-known phonetic and lexical differences between the two varieties, CG and SMG also exhibit substantial differences in the morphosyntax. It would thus be interesting so investigate these differences further from a developmental perspective, and in particular, whether interference or even transfer effects can be observed.

4. The acquisition of direct object clitic placement in CG

In the largely understudied variety of CG, theoretical explorations of the syntax of cliticization as well as the acquisition of object clitic placement are two of the more explored domains of CG grammar. The two varieties display a different clitic placement pattern in certain syntactic environments. Focusing on indicative declarative clauses, (4) illustrates a simple transitive construction for CG and SMG (both null-subject languages, ignoring morpho-phonological differences):

(4)	(*O*	*Jannis*)	*ðjavazi*	*to*	*vivlio*.	CG & SMG
	the.NOM	John.NOM	read.PRES.3SG	the.ACC	book.ACC	
	"John reads the book."					

With pronominal object clitics, CG is largely enclitic as opposed to proclisis found in the respective environments in SMG. In SMG, the only environment that licenses enclisis is imperatives, which is also enclitic in CG. Yet, in CG, other syntactic environments enforce post-verbal clitic placement as well. The basic contrast is thus the one shown in (5):

(5)	a.	(*O*	*Jannis*)	*θcavazi*	*to*.	CG
		the.NOM	John.NOM	read.PRES.3SG	CL.ACC	
	b.	(*O*	*Jannis*)	*to*	*ðjavazi*.	SMG
		the.NOM	John.NOM	CL.ACC	read.PRES.3SG	
		"Jannis reads it."				

Based on the findings of their longitudinal study, Petinou & Terzi (2002) argued that children master CG clitic production at around 32 to 36 months of age. Grohmann et al. (2012) employed a picture-based elicitation task (from COST Action A33) to investigate the acquisition of direct object clitics in monolingual Greek Cypriot, typically developing and language-impaired children between 2;0 and 6;11 years of age, and suggest that for typically developing children, acquisition of object clitics in indicatives occurs by age 3;0. The relevant details of the children participating in this study are given to Table 1, sorted by age group as follows:

Table 1. Participants; Monolingual CG

Age group	Age range	Number of participants	Mean age	Standard deviation	Gender	
					Male	Female
AG1	2;0–2;11	6	2;9	1 month	4	2
AG2	3;0–3;11	20	3;6	3 months	11	9
AG3	4;0–4;11	21	4;10	3 months	10	11
AG4	5;0–5;11	50	5;8	3 months	22	28
AG5	6;0–6;11	20	6;7	2 months	9	11

All children are "monolingual" bi-*x* speakers of CG, that is, from Greek Cypriot-only family backgrounds, not acquiring English, Russian, or any other language at the same time. They were randomly recruited from several Greek-speaking nurseries and (pre-)primary schools, public and private, in the districts of Limassol and Nicosia, upon written parental consent and after the approval from the Ministry of Education and Culture. For all practical purposes, each child participant had typical language development (although we did not administer any language tests), with no recorded or reported history of neurological damage, emotional or behavioral problems, no obvious learning and motor difficulties, and with hearing and vision adequate for testing purposes, as reported by parents or teachers; none of the children received speech and language therapy services, neither during nor prior to the time of testing.

Following 2 warm-up stories, for which the target answer was given as feedback if not provided by the child/participant, children (and adults in the control group) had to complete 12 test sentences and 5 fillers. The test sentences all followed the pattern illustrated below:

Experimenter: *The man painted the house and the house became blue. Why is the house blue?*

> *The house is blue because the man…*
> (o a^{n}dras epoʝatise to spiti tʃe to spiti eʝine ^{m}ble. ʝati to spiti eʝine ^{m}ble?
> To spiti e ^{m}ble ʝati o a^{n}dras…)[7]

Child: … *painted it*. (epoʝatise ^{n}do) V CL

Graph 1 reports on the overall results. The increase of (non-target for CG) pre-verbal clitic placement grows stronger as the child proceeds to the next level of schooling where, as mentioned already, SMG is the language of instruction from 1st grade:[8]

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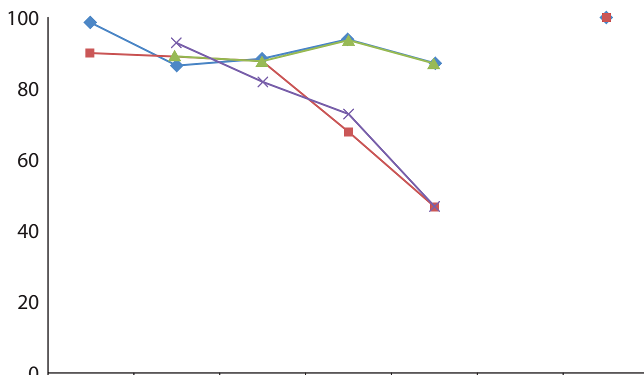
7. As a reviewer notices, there are three morphological variants of the word *eʝine* 'became' in CG: *eʝini(n)*, *eʝinike(n)*, and *eʝine*. While the first two are CG-specific, the latter is also used in SMG. Despite the availability of the former two, *eʝine* is also in use in CG and its presence does not entail switching to SMG. Still, the fact that the relevant test structure employed *eʝine* over one of the other variants illustrates the (bi-*x*) problem that arises when attempting to maintain a sharp distinction between the varieties in Cyprus (and the gradient variants belonging to them).

8. According to the Ministry of Education and Culture, all instruction takes place in SMG, yet many studies have indicated that students frequently use CG. However, it remains a matter requiring further research whether instruction does take place solely in CG from the perspective of teachers and whether teachers show (near-) native proficiency in SMG. First findings of a written task that requires cross-varietal classification of utterances that involve subtle

Figure 1. Test structure 7 in the CG version: Test picture and test sentence



	2;0–2;11	3;0–3;11/ nursery	4;0–4;11/ pre-pre-primary	5;0–5;11/ pre-primary	6;0–6;11/ 1st grade		Control group
Overall clitic production (Chronological age)	98.6	86.7	88.5	94.3	87.3		100
Target (post-verbal) production (Chronological age)	90	89	88	68	47		100
Overall clitic production (Schooling age)		89.6	88	93.6	87.3		
Target (post-verbal) production (Schooling age)		93	82	73	47		

Graph 1. Clitic production and placement across groups (adapted from Grohmann et al. 2012)

dialectal phenomena suggest that teachers do not perform at ceiling especially in the areas of syntax and semantics (Leivada et al. 2012), given that they classify utterances that resemble Arvaniti's (2010) Cypriot Standard Greek as SMG. In this context, the role of the teacher as a mediator in relation to language acquisition may provide valuable insights in understanding which are the varieties existing behind the bi-*x* status of Greek Cypriots today.

Leivada et al. (2010) replicated this experiment and readdressed the issue of acquisition of object clitic placement, by approaching it from the other aspect of diglossia in Cyprus, that is, by examining the acquisition of object clitics in (i) Hellenic Greek children (i.e. children from mainland Greece, native in the "high" variety, born in Greece and at the time of the experiment schooled in Cyprus), (ii) Greek Cypriot children (born and schooled in Cyprus), and (iii) binational children (born in either Greece or Cyprus, with one parent from each country, and schooled in Cyprus), by presenting the three different populations with two versions of the same task – one for each variety. Three groups participated in the study: 40 monolingual Hellenic Greek children, divided into 4 sub-groups (10 in each of the following age groups: 3;0–4;5, 4;6–5;11, 6;0–7;5, and 7;6–8;11), 30 binational children (one age group, 3;5–9;1, mean age 6;5), and 40 Greek Cypriot children, divided into 4 sub-groups (10 in each of the following groups: 3;0–4;5, 4;6–5;11, 6;0–7;5, and 7;6–8;11).

Employing the same picture-based task from COST Action A33, children had to complete 12 sentences, inside a *because*-island, by producing a verb and a (direct object) clitic.[9] The experiment consisted of two parts: the SMG version and the CG version (also used by Grohmann et al. 2012). The two sessions of the experiment were carried out in the school environment by two experimenters, each native in the variety tested, and were expected to elicit different answers in terms of clitic placement. The working hypothesis, based on what previous studies reported, is that CG requires enclisis in indicatives, whereas SMG requires proclisis.

According to the findings of this study, some Greek Cypriot children, who performed 100% *non*-target placement in the CG version of test commented on their performance or on the experiment's pictures in CG. We view this result as suggesting that especially in bilectal populations, children are metalinguistically aware of the marginalized nature of their native variety. This awareness is evident through the alignment of these children with the "high" variety which is conveyed by their choice of the placement that pertains to it. Assuming that Crain & Fodor (1987) are right in arguing that metalanguage is innate as a medium of representation used to encode observations about language, the link between enhanced metalinguistic abilities and multilingualism established by Bialystok (1991) and Jessner (2005) becomes relevant also for diglossic environments that involve a state of bi(dia)lectism, as argued also in Papapavlou & Kouridou (2007) for CG

9. See Varlokosta et al. (to appear) for a detailed discussion of the COST A33 experimental design and why an island context was chosen.

and Ibrahim et al. (2007) for Arabic. The question is whether the performance of Greek Cypriot children that was elicited by the task, is an instance of code-mixing, as a result of bilectalism, or a conscious demonstration of linguistic awareness driven by linguistic insecurity to (show that they are able to) speak "properly", since they receive explicit directions for using the "proper" variety (i.e. SMG) at least in the class environment.

Regarding Greek Cypriot children, entrance into public school could explain the sudden rise of proclisis percentages witnessed at age 4;6–5;11. This could potentially be associated with sociolinguistic factors; however, findings of the second experiment, given in Tables 2–4, do not relate this performance with factors such as the school as a social institution or the unfamiliarity of the children with the experimenter, that could result to the use of "formal" language, that is, SMG and proclisis. All children were tested in identical environments, hence the same sociolinguistic factors were relevant for Greek Cypriot children, aged 4;6–5;11, in both rounds of testing; still, children switched significantly from enclisis to proclisis when taking the different versions of the test.

Table 2. Clitic production and placement of Greek Cypriot and Hellenic Greek children

Age groups	Hellenic Greek children				Greek Cypriot children			
	SMG version		CG version		SMG version		CG version	
	clitic prod.	*target placement (proclisis)*	*clitic prod.*	*target placement (enclisis)*	*clitic prod.*	*target placement (proclisis)*	*clitic prod.*	*target placement (enclisis)*
3;0–4;5	85.0%	100%	85.8%	2.9%	90.8%	50.5%	73.3%	95.5%
4;6–5;11	91.7%	100%	95.8%	0.8%	97.5%	98.3%	90.8%	39.5%
6;0–7;5	95.0%	100%	100%	0%	98.3%	83.1%	96.7%	50.9%
7;6–8;11	100%	99.2%	100%	3.3%	95.8%	100%	96.7%	40.5%

Table 3. Clitic production and placement of binational children

Binational children (mean 6;5)			
SMG version		CG version	
clitic production	*target placement (proclisis)*	*clitic production*	*target placement (enclisis)*
93.6%	97.3%	96.4%	25.1%

Table 4. Clitic production and placement of adults

Hellenic Greeks				Greek Cypriots			
SMG version		CG version		SMG version		CG version	
clitic prod/	*target placem. (proclisis)*	*clitic prod.*	*target placem. (enclisis)*	*clitic prod/*	*target placem. (proclisis)*	*clitic prod.*	*target placem. (enclisis)*
100%	100%	100%	33.3%	100%	98.6%	100%	76.6%

5. Constructing a socio-syntactic repertoire and the SSDH

Reflecting on Enfield's (2002: 3) view that "[e]ncoded in the semantics of grammar we find cultural values and ideas, we find clues about the social structures which speakers maintain", such cultural values are not exclusively bound to the *semantics* of grammar, but are also found to be interwoven in the choice of one *syntactic* variant over another. This choice might have no effect on semantics – as is the case with proclisis vs. enclisis appearing in indicative declarative structures – especially in bi-*x* environments, where variants may just entail or mark different levels of proximity to the "unmarked" norm that exists in the standard, "high" variety. In light of this view, certain morphosyntactic choices, apart from signaling politeness strategies and register shifts (Tsiplakou et al. 2006: 271) or delimiting different registers, point to the necessity to explore the *context-specific* character of language acquisition that may be accounted of in terms of competing factors that affect acquisition across different environments (cf. Bates & MacWhinney 1987) through taking into account the impact of sociolinguistic implications on the process of syntactic development.

This impact can be witnessed in the adult placement percentages given in Table 4. A look at the target placement in their native variety explains the surprisingly good target performance of Greek Cypriot children, aged 3;0–4;5, in the SMG version of the test and their related not-at-ceiling performance in the CG version: In the second experiment, Greek Cypriot adults did not exhibit 100% enclisis in indicative structures when tested in their native variety. The question is whether this performance suggests that children receive proclisis input from "monolingual" (bi-*x*) adult speakers of CG in that specific syntactic environment, well before they enter in primary school. It should be noted that mixed input and the existence of proclisis in adult production of indicatives need not necessarily imply exposure to SMG for children, especially since this placement is combined with the use of lexical items (i.e. verbs) that in some cases are CG-specific (6a) or appear bearing distinctive characteristics of CG phonology, such as /ʃ/ in (7a).

(6) a. *Kniθi* *ton*. CG
scratch.PRES.3SG CL.MASC.ACC.3SG

b. *Ton* *ksini*. SMG
CL.MASC.ACC.3SG scratch.PRES.3SG
"(He/she) scratches him."

(7) a. *Eʃepasen* *ton*. CG
cover.PAST.3SG CL.MASC.ACC.3SG

b. *Ton* *scepase*. SMG
CL.MASC.ACC.3SG cover.PAST.3SG
'(He/she) covered him.'

Therefore, it is possible that this proclisis in indicatives can be viewed as a licit option in ("standard"?) CG – and that mixed clitic placement is legitimized in that it reflects different positions in the dialectal continuum, further suggesting that syntactic variants pertinent to the three purported varieties (SMG, CG, Cypriot Standard Greek) are not entirely clear-cut, even in adult populations. This assumption is further consistent with much of the literature on code-switching and code-mixing. For example, with respect to speakers of CG, Tsiplakou (2007: 15) lays out how "complex patterns of morphosyntactic mixing make it extremely hard to define a matrix language and the types of 'departures' from it".

Based on the reports of previous studies on the acquisition of clitics in CG, it was initially expected that target placement would be proclisis in SMG and enclisis in CG declarative indicatives. However, the findings of the second experiment do not support this expectation. A comparison between Graph 1 on the one hand and Table 4 on the other reveals an important difference with respect to adult target placement. Our interpretation of this divergence is aligned to the assumption of the gradient nature of the continuum on which the available varieties exist. More specifically, adult target placement is possibly 100% enclitic in the basilectal pole of the dialect continuum, but since standard CG displays a greater level of proximity to SMG, proclisis might optionally arise to varying degrees in mesolectal positions, probably increasingly while moving towards the acrolectal pole, where SMG lies (or "Cypriot Standard Greek", if the focus is on local varieties). We therefore do not interpret the remaining 23.4% of proclitic placement, in the last column of Table 4, as the result of Greek Cypriots code-switching to SMG when tested in their native variety by a native speaker of this variety. Given that these adults were tested in the house of one of the experimenters, there is nothing that should make us expect the use of SMG and proclisis in such an informal environment, especially since all participants made use of CG immediately before but also during the test session.

Tsiplakou (2007) concludes her discussion on code-switching and -mixing with respect to the dialectal continuum in Cyprus by articulating a series of key questions that are linked first to the nature of the continuum in relation to the status of one of the two official varieties (i.e. SMG) of the state and second to the ways through which this context-specific nature frames language acquisition in diglossic environments in general:

> Is it at all possible to have continuum-external code-switching, if part of Standard Greek is taken to belong to the Cypriot continuum, or if we are dealing with a "fused lect"? How do acquisition factors enter the picture? And, finally, do such data allow us to make a case for competing grammars, and, if so, what is the precise nature of the competition? (Tsiplakou 2007: 25)

The answer to the first question depends on whether one views the acrolect of the continuum to involve SMG or Cypriot Standard Greek. The second and the third questions are interrelated according to the findings of the two experimental studies discussed above. More specifically, acquisition factors enter the picture through the context-specific character of the process of constructing a socio-syntactic repertoire in diglossic environments. Of cardinal importance to this process are (i) the gradient nature of syntactic variants and (ii) the schooling factor which, in cases like Cyprus, plays a major role not only because it signals the onset of exposure to a "high" variety, but primarily because it marginalizes the "low" variety which in effect raises children's awareness of the sociolinguistic functions and registers that each variety facilitates.[10] Putting all these parameters together, the linguistic development of children can be approached through a working hypothesis: the *Socio-Syntax of Development Hypothesis*.

10. As an anonymous reviewer points out, it would also be interesting to investigate how Greek Cypriot children develop in the absence of Greek-medium schooling; our research group is currently preparing a study in Cypriot communities in the UK. In the absence of a better testing scenario, Grohmann et al. (2012) adapted the Spanish version of the COST A33 clitics tool for Galician and tested children growing up in Galicia, that part in northern Spain in which two closely related languages are spoken which differ in terms of clitic placement: Spanish, like most modern Romance varieties (and SMG), is proclitic in the relevant environment, while Galician, like European Portuguese (and CG), is enclitic. They also address possible shortcomings as well as suggestions for more comparable linguistic environments, such as Asturias (where, at least sociolinguistically speaking, Asturian seems more CG-like than Galician).

The Socio-Syntax of Development Hypothesis (SSDH) aims to account for language acquisition in bi-*x* environments by taking into account its context-/domain-specific character, as this is affected by the schooling factor. Note also that clitic placement is fully acquired by age 3 (see Varlokosta et al. to appear for references and discussion), well before schooling begins; in this context, Grohmann (2011) suggests that interference from SMG in the school environment causes CG grammar to get "muddled", a claim which we examine empirically in this study.

Even if there exists a state of interlanguage such as the one Tsiplakou (2009) identifies, it remains to be explained why this interlanguage does not show up in similar ways in our different child populations, since all of them receive mixed input by being exposed to both varieties on a daily basis. If either interlanguage or code-mixing is the outcome of simultaneous exposure to the "high" and the "low" variety, Hellenic Greek, Greek Cypriot, and binational children educated in Cyprus should go through similar stages and show similar developmental patterns; something that is not confirmed across these three groups. In other words, while the SSDH works for Greek Cypriot children, it is an issue requiring further explanation why the socio-syntactic development of Hellenic Greek children does not show to proceed through the same stages: Their target clitic placement does not get "muddled" despite the fact that they get exposed to CG input from classmates.[11]

Our current view of the SSDH captures the linguistic development of Greek Cypriot children by assuming that their process of building a sociolinguistic repertoire primarily involves the need to resolve linguistic anxiety and adjust to the "high" variety. The linguistic development of Hellenic Greek and binational children involves the need to remain faithful to the "high" variety, so they are motivated to decipher different sources of input. Put more formally, the SSDH approaches the acquisition of syntactic variants that pertain to different varieties, in bi-*x* environments, as proceeding through the existence of competing motivations that arise depending on the level of proximity (in the dialectal continuum) existing between the variety that the child is exposed to prior entering school and the one used in school – that is, even beyond the 'normal' period of native language acquisition (see also Kambanaros et al. to appear).

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11. This is reminiscent of Ash & Myhill's (1986) study of African Americans and European Americans living in neighborhoods predominantly inhabited by members of the other group. According to their study, while speakers of the non-prestige variety (African American English) adopted many phonological and syntactic features of their European American neighbors, European American speakers only adopted a small subset of the features of African American English. We are grateful to an anonymous reviewer for pointing out this parallel.

6. Summary and outlook

This paper discussed the socio-syntactic development of children in Cyprus through focusing on object clitic production and placement elicited in a experimental setting through the use of a picture-based elicitation task. This development takes place in a linguistic context that we term "bi-*x*" – typically referred to as bivakietalism, bidialectalism, and/or bilingualism but also intended to incorporate other issues pertinent for linguistic environments in which two or more closely related varieties are used by speakers; or simply (discrete) bilectalism (Rower & Grohmann 2012).

The first aim was to report on several first studies carried by the Cyprus Acquisition Team, a recently founded research initiative that aims to investigate aspects of first language acquisition of CG, the Cypriot variety of Modern Greek, in (a)typical language development – so far, very much neglected. The linguistic reality of Cyprus is particularly intriguing in involving varieties whose boundaries are not so clear-cut. In this context, the current call for defining the right sociolinguistic variables that have an impact on the developmental pattern is closely related to aspects such as the gradient nature of syntactic variants when these belong to different varieties existent in a continuum that involves both standard and non-standard forms. The acquisition pattern is also affected by the schooling factor which in Cyprus involves at least one "high" variety that is different from the one children are exposed to at home, that is, SMG through imported textbooks; it remains an issue requiring further investigation whether instruction takes place solely in SMG.

Putting all these parameters together, the linguistic development of children is approached through a working hypothesis, the *Socio-Syntax of Development Hypothesis*, which aims to account for the socio-syntactic/-linguistic development of children in bi-*x* linguistic communities by assuming that the process of constructing a sociolinguistic repertoire reflects different needs across different child populations residing in Cyprus and subsequently results in competing motivations that inform the process of language acquisition in such contexts.

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PART V

Experimental studies

What sign languages show

Neurobiological bases of visual phonology

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The chapter presents analysis of the motion properties of the environment that humans use to parse natural scenes, and the kinematics of articulator (hand) motion in American and Croatian Sign Languages, asking whether the kinematic distinctions between linguistic categories in sign languages are important to phonological and syntactic systems in sign languages. Based on motion capture and neuroimaging data from native signers and sign-naïve non-signers, we propose that sign languages grammaticalize perceptual features already available from the human visual system for the phonology-syntax interface.

1. Introduction

Human languages differ from all other stimuli in the natural environment in that they rely on rapid spectral changes over varying time intervals (Poizner 1981; Zatorre & Belin 2001). Perception of this type of input is supported by the neurons in the visual and auditory system, which are individually sensitive to specific ranges of spectral information change over time (as characterized by their spectral-temporal receptive fields, or STRFs), which adapt to match the sparsely distributed, informative components of the natural world to make processing informationally and metabolically more efficient (Theunissen et al. 2001; Vinje & Gallant 2000). The features extracted from linguistic input are further processed for extraction of what can be currently construed as linguistic information at the phonological, semantic, and syntactic levels.

While the exact mechanisms of cortical tuning are not yet completely understood, there is more known about the abstract level of visual and auditory processing. For example, both visual and auditory systems activate distinct cortical networks for processing of different sources of signal, such as hands vs. face information in the visual stream, living vs. non-living sound sources in the auditory system (Engel, Frum, Puce, Walker & Lewis 2009; Thompson, Hardee, Panayiotou, Crewther & Puce 2007). At least since Poizner (1981, 1983), sign language researchers hypothesized that kinematic properties of hand articulator movement in sign languages might carry phonological information in sign languages, although high-resolution quantitative kinematic and neuroimaging data were not available until recently. In this chapter, we will review some of the insights gained from the recent inquiries into the question of how perceptual-kinematic properties of the hand articulator motion can be processed as phonological distinctions by signers.

2. Visual adaptation to the processing of sign language

The adaptations of the signers' visual system due to the processing requirements of sign language has been extensively investigated using behavioral, neurophysiological, and neuroimaging methods. ERP and fMRI studies show that ASL signers (both Deaf and hearing) are much faster and more accurate in identifying direction of motion in the right visual field (processed by the left hemisphere), as compared to hearing non-signers, and show increased left hemisphere activation during a motion detection task (Bosworth & Dobkins 1999; Neville & Lawson 1987). Deaf[1] participants are also faster than hearing ones in detecting information in peripheral vision (Loke & Song 1991; Parasnis & Samar 1985; Reynolds 1993). Motion similarity judgment studies (Poizner 1981, 1983) show that movement and cyclicity in dynamic stimuli are more salient for ASL signers than for non-signers, likely due to the fact that cyclicity is an important feature in ASL (Klima & Bellugi 1979; Wilbur 2009).

The adaptations in the signer's visual system can also point to informationally dense (as well as, possibly, linguistically relevant) features of sign language input. In an experiment by (Klima et al. 1999), Deaf signers and hearing non-signers were shown dynamic point-light displays of Chinese pseudocharacters being drawn 'in the air', and asked to repeat them. Deaf signers were much better at distinguishing transitions from stroke components: i.e. while hearing participants were more likely to draw the entire trajectory of the point-light, Deaf signers identified discrete movement strokes, and were less likely to include transitional movements into their representations of the stimuli. Even though earlier research has already shown that lexical identification in sign languages coincides with movement identification, and that handshape change within the sign coincides

1. Use of capital D in Deaf is an indicator of cultural affiliation, including use of sign language as primary means of communication.

with the end of movement whereas between signs it can be completed at any time (Brentari & Poizner 1994), the kinematic markers of transitional vs. linguistic motion are still under-investigated.

3. Kinematic features in sign language phonology

Kinematic features of motion in dynamic scenes, such as velocity and deceleration of actor limb movements, appear to play the leading role in segmentation of scenes into discrete events (Speer, Swallow & Zacks 2003; Zacks et al. 2001; Zacks, Kumar, Abrams & Mehta 2009; Zacks, Swallow, Vettel & McAvoy 2006). Sign languages (SLs) as linguistic interfaces of perceptual and non-speech motor behaviors can provide unique insights into the neurobiological substrate of motion processing. In sign language linguistics, articulator movement is considered to be the core of a syllable, comparable to vowels in spoken language. In (Brentari 1998) phonological model of sign language, sign movements are dynamic prosodic units with autosegmental status similar to tones in contrastive tonal languages. From this perspective, syllables in American Sign Language contain distinctive features which are accessed by phonological rule only in terms of their tiers and syllabic positions (syllable initial, final) without further subdivision or organization (Wilbur & Allen 1991). The segments in the syllable are timing slots (x_1, x_2), onto which phonological features are mapped (cf. Figure 1).

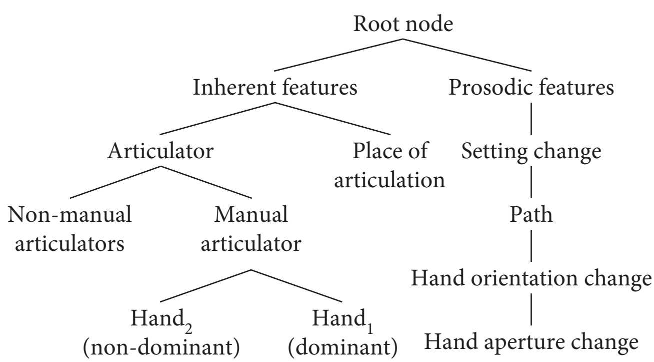

Figure 1. Brentari (1998) Prosodic Model of SL phonology

In Brentari's theory of sign language phonology, telic and atelic ASL verb signs differ in the phonological features which unfold sequentially over time (i.e. dynamic, or prosodic features), and in their syllable structure (Brentari 1998). Specifically, atelic verb signs have the same handshape and orientation specifications for the initial and final positions of the sign, and thus simple syllable structure; telic ASL signs have a more complex syllabic structure, as they always employ one of the following dynamic changes: (1) change of handshape aperture (open to closed, or closed to open); (2) change of handshape orientation; and (3) arc or circular movement orthogonal to the plane of articulation, with an abrupt stop at a location in space (Wilbur 2008). Within Brentari's (1998) Prosodic Model of sign language phonology, telic and atelic signs thus fall into distinct phonological classes, as shown in Figure 2.

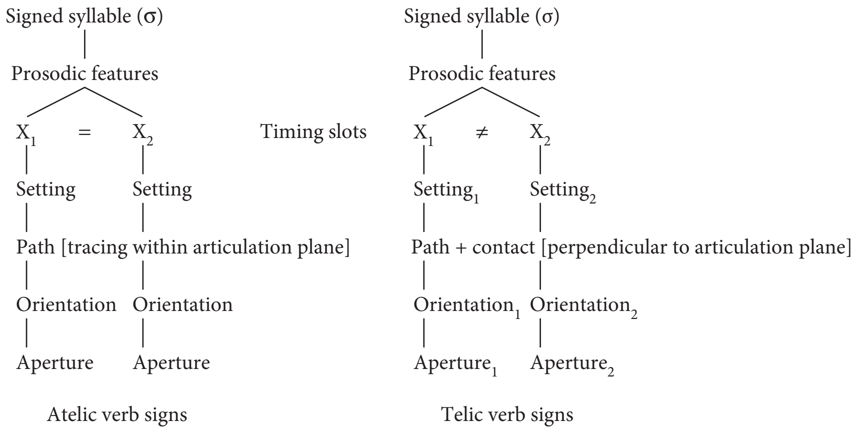

Figure 2. Phonological differences between telic and atelic verb signs

(Wilbur 2003, 2008, 2010) proposed that semantic classes of ASL verbs could be kinematically (and phonologically) marked, formulated as the Event Visibility Hypothesis (EVH). Specifically, internally complete, or telic events (those denoting a change of state, such as *throw, fall*) would have a higher deceleration in their end-motion, reflecting the semantic end-state of the affected argument, as compared to signs denoting atelic events (which typically denote homogenous activities, such as *swim, walk*). This hypothesis was investigated using motion capture method (Malaia & Wilbur in press-a, in press-b), which allows recording the location of the moving hand (articulator) at 60 frames per second in three dimensions. The data was recorded for the dominant (right) hand position during the signing of ASL and Croatian Sign Language (HZJ) verbs in the vocabulary form, in a phrase (SIGN X AGAIN), sentence-medially (SHE X TODAY), and sentence-finally (TODAY SHE X). At the processing stage, the displacement profiles of dominant hand motion, as well as first and second derivatives (velocity and acceleration) were computed for each sign.

Both ASL and HZJ demonstrated the effect of Phrase Final lengthening, whereby the duration of the sign increased significantly in Phrase-Final position (Figure 3). This suprasegmental variable was included in order to filter out spurious kinematic features: as the signers have no difficulty comprehending the signs regardless of their place in the sentence, only kinematic features robust to Phrase-Final lengthening could be phonologically distinctive.

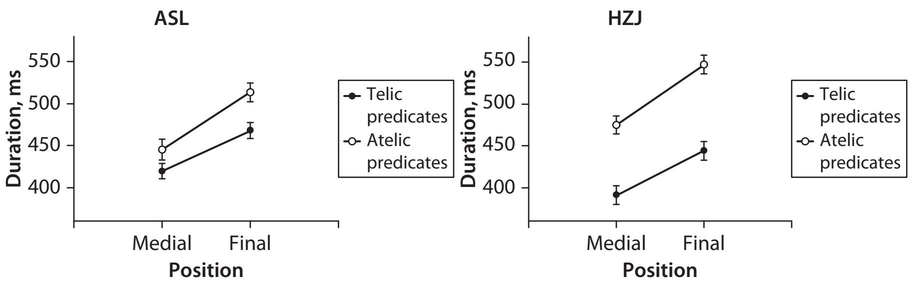

Figure 3. Sign duration in ASL and HZJ, demonstrating effect of Phrase Final Lengthening

Multivariate analysis of variance was conducted to determine the effect of each independent factor (Predicate, Position) and their interaction (Predicate × Position) on each of the dependent kinematic variables. In ASL, the instantaneous deceleration, as well as the overall slope of deceleration within the sign were statistically significant markers of predicate type, unaffected by the sign's position in the sentence. In HZJ, the peak velocity achieved within the sign was similarly significant, and robust to Phrase Final Lengthening (Table 1).

Table 1. Kinematic features significantly different between telic and atelic signs, and not affected by phrase final lengthening, in ASL and HZJ

Kinematic variable	**ASL**			**HZJ**		
	F (1,916)	$p<$	η_p^2	F (1, 1170)	$p<$	η_p^2
Peak velocity				641.448	.001	.354
Instantaneous deceleration	52.614	.001	.054			
Slope of deceleration from peak velocity to the minimum velocity at the end of the sign	29.645	.001	.031			

Overall, the motion capture data on sign production in ASL and HZJ showed that the second slot (x_2) of syllables in predicate signs denoting bounded (telic) events is marked by a rapid deceleration at the end of the sign, made even more prominent by higher peak velocity, as compared to verb signs denoting unbounded (atelic) events (Figure 3), with distinctions of syllable structure being robust to the effect of Phrase Final Lengthening. Signers of both ASL and HZJ mark transitions to end-states within events by articulating them with a higher peak velocity and deceleration, supporting the theoretical proposal that more complex phonological representation of telic vs. atelic verb signs is represented by kinematic features of the dominant articulator – specifically, its velocity and deceleration. The differences between the statistical results of the kinematic feature analysis in the two languages suggest a possibility that neural adaptations to the input of different sign languages might differ somewhat (although not as much as the visual systems of a signer and a non-signer).

4. Neurolinguistic processing of visuo-kinematic markers

Recent neuroimaging studies demonstrate that abstract, modality-independent features extracted from sensory linguistic input (in either spoken or sign language) are processed in the temporal lobe (Bornkessel, Zysset, Friederici, von Cramon & Schlesewsky 2005; MacSweeney et al. 2004; McCullough, Emmorey & Sereno 2005; Shetreet, Palti, Friedmann & Hadar 2007). The question one can pose with regard to motion-related features is then: are kinematic distinctions between telic and atelic verb signs, produced during signing, processed as abstract, phonological features?

The fMRI study based on the video recordings of the signs produced during the motion capture experiment addressed this question (Malaia, Ranaweera, Tamer, Wilbur & Talavage 2009). The 12 Deaf participants were presented with the videos of telic and atelic verb signs in a blocked paradigm, and were asked to identify whether each action was more likely to occur inside or outside the house (ensuring semantic processing). Analysis of brain regions which were more active during semantic processing of telic, as compared to atelic predicates, showed that Deaf participants exhibited highly focused right-lateralized activation in superior temporal gyrus ($p < 0.05$, FDR-corrected), as well as trend-level ($p < 0.001$, uncorrected) activations in the precuneus, and right cerebellum (Figure 4). No brain regions were more active in semantic processing of atelic, as compared to telic, signs.

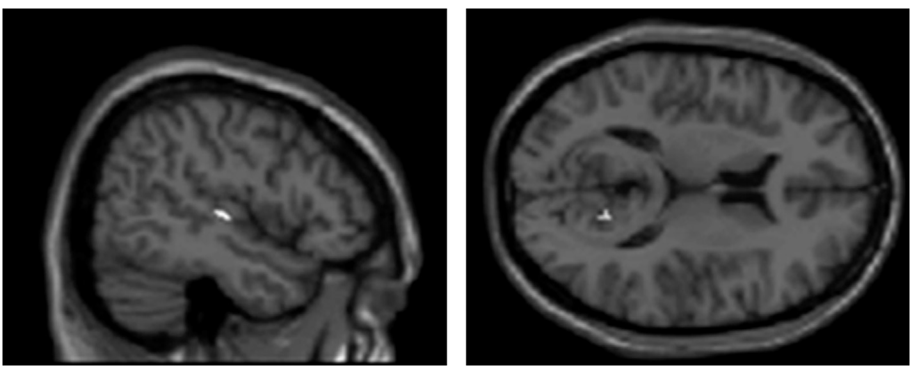

Figure 4. Cortical areas activated by viewing of telic > atelic ASL predicates in Deaf signers: precuneus and STG activation clusters visible ($p < .001$, uncorrected)

Prior sign language research has demonstrated that STG activation is related to representation of abstract phonological representations (Emmorey et al. 2003; Emmorey, Mehta & Grabowski 2007; MacSweeney et al. 2004; Petitto et al. 2000). Thus, higher activation of STG in response to telic verb signs appears to reflect higher complexity of the phonological structure of telic verbs, compared to atelic ones. Trend-level activations in the current data (cluster level $p < 0.05$, uncorrected) also support the hypothesis that telic and atelic verb signs elicit differential phonological processing in Deaf signers. Cerebellar activation, as seen in the telic > atelic contrast, has been previously shown to play a role in linguistic-cognitive processing in both signed and spoken languages (Corina, Jose-Robertson, Guillemin, High & Braun 2003). Right cerebellum has been suggested to modulate activity in the parts of the brain to which it is reciprocally connected, i.e. left language-dominant dorsolateral and medial frontal areas (Marien, Engelborghs, Fabbro & De Deyn 2001); the extent and strength of the activation in the cerebellum was shown to be modulated by the difficulty of the task (Xiang et al. 2003). The right cerebellar-left mediofrontal network has been implicated in various linguistic processing tasks for spoken languages, such as subvocal rehearsal mechanisms of verbal working memory, concatenation of syllable strings into coarticulated sequences (Ackermann, Mathiak & Riecker 2007), and facilitation of phonological processing (Stoodley & Schamahmann 2009). The possibility that the cerebellum is involved in low-level processing of linguistic stimuli is of special interest in the present study. In sign language linguistics, movement is considered to be the core of a syllable, comparable to vowels in spoken language. Thus, more complex kinematic signatures of telic predicates correspond to a more complex phonological representation, as compared to that of atelic signs: the distinction is parallel to complex and simple syllables of spoken languages (Wilbur 2008, 2010, 2011). It is thus possible that the right cerebellar activation seen in cortical response to telic as compared to atelic signs reflects preattentive processing of velocity contour changes within sign-syllables. A similar effect has been observed in the speakers of tonal languages for native tone perception (Krishnan & Gandour 2009), whereby language experience was shown to 'tune' the brainstem to the processing of linguistically-relevant dimensions of native (and only native) pitch changes. Other neuroimaging studies of spoken languages also associated higher syllable complexity with more extended patterns of hemodynamic responses in the language-processing network including the cerebellum (especially its right hemisphere), bilateral opercular/insular junction, left posterior IFG and left parietal cortex (Riecker, Brendel, Ziegler, Erb & Ackermann 2008; Bohland & Guenther 2006).

The telic > atelic contrast also demonstrated increased activation of the precuneus at the trend level. Perceptual studies requiring segmentation of continuous video into discrete events (Zacks et al. 2001; Zacks et al. 2006), as well as studies of event segmentation in text narratives (Speer, Zacks & Reynolds 2007) show increased activation of precuneus at event boundaries. The higher activations of precuneus by telic, as compared to atelic, verbs in the present study may indicate indexing of event boundaries triggered by the semantics of telic predicates, although comparison of neural activations in Deaf signers and hearing non-signers should be made with caution (Meyer et al. 2007). In summary, the fMRI data supports the motion capture studies, by showing that telic ASL signs, which differ from atelic ones by higher deceleration toward the end, are processed as more phonologically complex than atelic signs.

5. Conclusion

The studies on ASL verb sign production and neural activity during comprehension show that signers process the dynamic (velocity and acceleration) properties of articulator motion as abstract phonological features. The precise motion-related features which entail abstract (phonological) processing might differ among unrelated sign languages, and are still under investigation. It is, however, clear, that the processing of spectro-temporal patterns inherent in natural sign languages requires adaptation from the visual cortex, for which a sufficient amount of non-degraded input is necessary during the critical period.

From a biolinguistic perspective, we see naturally-evolved sign languages perfectly adapted to the human visual system. Grammaticalization of distinctions in physical/action characteristics for lexical purposes enables learners to use existing visual system capabilities and fine-tune them through experience with signed input, thus permitting rapid and early neural, cognitive, and linguistic development to proceed on schedule despite the use of the visual modality.

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Indeterminacy and coercion effects

Minimal representations with pragmatic enrichment*

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Central to the investigation of the biological and cognitive capacities underlying human language is to determine how hypothetically distinct linguistic and non-linguistic computational systems interact to yield the representation of the meaning of a sentence. The focus of our chapter is on the comprehension of "indeterminate" sentences, that is, sentences seemingly semantically incomplete – albeit grammatical – such as "The man began the book". While one might understand such a sentence as referring to an event that the man began doing with the book, the actual event cannot be determined. We contend that the interpretation of indeterminate sentences relies on the identification of structurally determined gaps which function to signal higher, non-linguistic cognitive mechanisms to trigger pragmatic inferences. These inferences serve to enrich the output of the linguistic system to give the sentence a meaning fitting with a particular context. Psycholinguistic and neuroimaging (fMRI) data are discussed supporting the view that the source of sentence enrichment is pragmatic – not analytic lexical-semantic decompositions – beyond linguistic computations per se.

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1. Minimalism and indeterminacy at the interfaces

Discussions on the hypothetical interface between linguistic and non-linguistic representations in the process of sentence comprehension have often been cast in terms of where to draw the line between a formal – syntactic, semantic, or logical – representation of a sentence and the type of content it yields. These discussions have permeated much of the philosophy of language, linguistics, and psychology, at least since Frege and Russell, in modern times, but as far back as Aristotle's *Rhetoric* and *Poetics*.

In psychology, for instance, this long-standing debate has motivated the empirical work bearing on the modularity of language – a hypothesis that set the agenda for much of the psycholinguistic investigations since the 1980's. The key idea – which in our view remains a central one – is that linguistic computations are encapsulated or cognitively impenetrable, much like the perceptual computations in vision (Fodor 1983, 2000; Pylyshyn 2003). According to this view, what the linguistic system makes available, as the product of perceptual hypotheses, is a "shallow output". This output is, by hypothesis, mostly void of content – or perhaps it is a logical form of a sentence, or at most a logical form cum denotation of its constituents.[1] But most importantly this output representation is based primarily on linguistic-specific principles for parsing (i.e. the likes of syntax, morphology, phonology, logical form). The enrichment of this supposedly shallow linguistic representation would come as a consequence of the computations performed beyond linguistic analysis; it would be, by hypothesis, the role of a *Quinean*, i.e. holistic, conceptual central system that takes into account virtually everything one knows.[2]

1. We say that the output is void of content only insofar as "broad content" is concerned. The output representations of a linguistic module *a la* Fodor might be referential and compositional, and thus have "narrow content". For instance, the shallow output could be a process of identification of the morphemic constituents of a token utterance and their structural relations – and thus what the linguistic input system outputs to other systems is the content of the morphological constituents and their compositional structure. It is also possible that, if the linguistic system is truly modular, what it does is to operate over the forms of the representations, not the content of their constituents. Although several studies have claimed context effects on parsing operations (e.g. Tanenhaus, Spivey-Knowlton, Eberhart & Sedivy 1995), it would be beyond the scope of the present paper to discuss in detail those findings – and why we see modularity as a standing *hypothesis*.

2. We use "enrichment" throughout this paper as a neutral term among diverse approaches: In Jackendoff (1997) and some of his followers, *enriched composition* is a form of semantic composition that relies on sentence constituents and sentence form but with information provided by internal analyses (semantic features) of lexical constituents (see also Pustejovsky's (1995) *co-composition*); in Recanati (2004), enrichment is used to refer to the processes

In linguistics and philosophy of language, the now classical distinction between *what is said* (*sentence meaning*) and *what is intended* (*speaker's meaning*) has set the agendas for semantic and pragmatic processes, with the former primarily responsible for structuring the basic ingredients of *what is said*, and the latter enriching that information in search of *what is possibly intended* in a given context. Thus, the classical approach postulates that sentences such as those in (1) below, generally speaking, (i) have assigned a context-free *semantic* representation or logical form, and (ii) take the *semantic* representation to be the input to pragmatic processes of enrichment – of implicature seeking (see, e.g. Grice 1989; Searle 1969, for classical examples).

(1) a. It is raining
 b. I am here now
 c. John had breakfast
 d. Mary is not going to die

But in recent years, there have been many attempts to blur this divide – and in particular (even *contra* Grice) to show that semantic representation says little about what sentences actually mean (e.g. Recanati 2004). The general idea is that one cannot evaluate a sentence such as (1a) unless one determines the context *C* of the utterance at time *t*. A similar state of affairs comes up with a sentence such as (1b), which requires moreover that the pronoun be assigned a proper referent – namely, whomever utters (1b). In (1c) and (1d), however, what the sentences *say* appears to require some sort of hidden modifier such as *today* for (1c) and *because of this* or *despite that* for (1d). The suggestion is that a sentence such as (1d) cannot possibly assert Mary's immortality (for we are supposed to know somehow that Mary is not immortal) so its very content comes enriched with what Recanati (2004) calls *unarticulated constituents* – which exert their effects not *after* a literal interpretation has been entertained, but at the expense of it.

A variety of semantic minimalists (e.g. Cappelen & Lepore 2005; Stanley 2000; Borg 2004; Bach 2006) have argued against the view that unarticulated constituents or any other context sensitive properties have an effect on the initial, literal representation of sentences such as (1c) and (1d). In fact, some minimalists assert that "[t]he semantic content of a sentence S is the content that all utterances of S share…no matter how different their contexts of utterance are"

by which the meaning of sentences such as (1) are represented together with "unarticulated constituents" standing for the intended meaning of a sentence (see below). In the sense we will argue for, enrichment comes from pragmatic processes which do not affect sentence meaning but which are triggered by it, as in Grice (1989), where enrichment is attributed to *implicatures*.

(Cappelen & Lepore 2005: 143). What they have rather proposed is that the only allowable *context-sensitive* properties of a sentence are those licensed by linguistic structure, i.e. syntax proper, and overt *indexicals* (Kaplan 1977), such as the pronoun and adverbs in (1b).

While there are many nuances on what would count as the content of a sentence – and certainly the many schools of thought dealing with semantics in cognitive science and philosophy have attested to that – we can establish that, at its lowest boundary, content is a function of the form of a sentence and the denotations of its constituents. It is with this in mind that we focus, in the present chapter, on a phenomenon that has gained prominence mainly in computational linguistics and psycholinguistics, but which to us better embodies the tension between *what is said* and *what is communicated* by a given sentence. Typical sentences appear in (2).

(2) a. The man began a book
    b. The woman wants a beer

These sentences, which we call *indeterminate*, have been used to illustrate the phenomenon known as *coercion* or *type-coercion* or even *logical metonymy* (Briscoe, Copestake & Boguraev 1990; Pustejovsky 1995; Jackendoff 1997; Godard & Jayez 1993). We call them indeterminate because, following Gillon (2004), we assume that sentences such as those in (2) do not allow for a truth-value judgment *if* such a judgment is parasitic on a specific event performed by the man with the book. The idea is that a judgment might be deferred until appropriate contextual information determines the type of event that, e.g. the man began doing with the book or what the woman wants to do with the beer. Alternatively, we may judge the sentence based on whether or not there was anything that John began doing with the book.[3]

There is, to be sure, something we know about the content of sentence (2a). It says something like (3a) – or even (3b), following Davidson (1967), if we want to acknowledge that *begin* introduces an event variable (w).[4]

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3. To clarify, we use *indeterminate* (Gillon 2004) to refer to these sentences rather than an alternative theory-neutral term such as *underspecified* simply because the very activity performed with the object noun cannot be determined from the linguistic material per se. Although it may be suggested that the meaning of such sentences can be determined via coercion, it is generally agreed that the output of the coercion operation is distinct from the overtly specified linguistic content of sentences such as (2). Thus, the term indeterminacy can be taken to apply specifically to the content of such utterances as they are, prior to the deployment of special mechanisms of enrichment – whatever they might be.

4. Notice that in the standard (Davidson 1967) treatment, the variable that the verb *begin* introduces is not the action/event that x began doing with y, but *begin* itself. We are reluctant

(3) a. $\exists$x(=man), $\exists$y(=book) (*begin* (x, y))
b. $\exists$*w* (*begin* (x, y, *w*))

But we do not know its intended meaning, nor do we think it has a default one – no matter how much one is tempted to think about *reading*. Sentence (2a) is so designed that it leaves us wondering what the man began doing with the book. In fact, as observed by Culicover (1970), this sentence has an "infinite ambiguity", for what it communicates cannot be resolved by appealing to its linguistic structure. Contrary to Culicover's early intuitions, however, we argue here that we *can* postulate "hidden" linguistic material which might allow for an interpretation of (2a) that goes beyond what (3) specifies, even if we are *still* to be left wondering about what (2a) communicates.

2. "Coercion" and content

The very idea of nominal coercion came about as an attempt to resolve the "ambiguity" in (2a) by assuming that, because what the verb does is to specify the temporal properties of an event, whatever is in its object position ought to be understood as an event or a process (Pustejovsky 1991). Prima facie, understanding the complement as an event requires that the standard, denotational lexical properties of the noun be deemed unfit for semantic composition, i.e. be deemed as violating the verb restrictions. As the story goes, because the verb specifies an event for its internal argument, an entity (rather than an event) in that position will result in an anomalous representation. Clearly, the sentences in (4) are well formed syntactically and do not violate semantic restrictions, for their gerundial (4a) and infinitival (4b) complements denote events.

(4) a. The man began reading a book
b. The man began to read a book

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to treat a sentence such as (2a) as (3b) tout court because this representation may run into problems accounting for adverbial modification. For instance, *John began a book slowly on Saturday* would be represented as '$\exists$*w* (*begin* (x, y, *w*)) & (*w* was slow) & (*w* was on Saturday)' which might lead to an ambiguity as to what *w* picks out: It might be the case that what John began doing with the book is slow, but the beginning was on Saturday, that is, *slow* does not necessarily predicate the aspectual property of the event, while the time adverbial does predicate *begin*. In short, it is possible that what *w* picks out is different in the two adverbial clauses (see Fodor 1972; Lepore 2003). In the syntactic analysis of (2a) that we discuss below (Section 3), the variable *w* would, by hypothesis, pick out the empty *V* head, not *begin*.

And even when there are no such clear events as gerundial or infinitival phrase complements but a so-called event nominal (5a) or a derived nominal (5b), there is no need for coercion.

(5) a. The man began the fight
b. The man began fighting

These examples suggest in fact that whether or not coercion of the complement occurs – i.e. whether or not the complement is understood as an event – is tied to the properties of its host VP and how the complement disposes information to compose the meaning of the phrase. This view carries two assumptions, which drive much of the coercion work in linguistics and psycholinguistics. The first is that a verb such as *begin* does select for a particular event complement. The second is that nominals that do not conform to the verb's specification need to be "read as", "coerced" or "type-shifted" in order to comply. While we will accept the general thesis of verb restrictions – and in this particular case, there is ample evidence that aspectual verbs combine with events and other complex VPs, as seen in (4) – we are suspicious of the validity of the second assumption.

We turn now to a brief discussion of three alternative accounts of the *coercion* phenomenon, including some of the experimental evidence offered in support of these different accounts.

2.1 Three views on "coercion effects"

In psycholinguistic experiments (mostly employing self-paced reading, and eye-tracking; de Almeida 2004; McElree, Traxler, Pickering, Seely & Jackendoff 2001; Traxler, Pickering & McElree 2002; McElree, Frisson & Pickering 2006) as well as in studies employing neuronal recording (event-related potentials, ERP; e.g. Kuperberg, Choi, Cohn, Paczynski & Jackendoff 2010; and magnetoencephalography, MEG; e.g. Pylkkanen & McElree 2007) and neuroimaging (de Almeida, Riven, Manouilidou, Lungu, Dwivedi, Jarema & Gillon 2012) researchers have attempted to tackle experimentally what constitutes the content of sentences such as (2). These studies, for the most part, have found a behavioral as well as a functional-anatomic difference between indeterminate (e.g. (2a) repeated below) and otherwise fully-determined event sentences such as (6).

(2a) The man began a book

(6) The man read a book

With the exception of a few studies manipulating context (de Almeida 2004; Traxler et al. 2005) as well as those investigating the neural basis of indeterminate versus determinate sentences, most studies have found that it takes longer to process (2a) than (6) at post-verbal positions. This general finding – albeit controversial on methodological grounds (de Almeida & Dwivedi 2008; de Almeida et al. 2012) – is far from illuminating on how a sentence such as (2a) licenses an enriched interpretation, one which follows our intuitions that (2a) communicates something about *reading*. It is this empirical observation – i.e. longer reading times for post-verbal positions in (2a) contrasted to (6) – that we refer to throughout this paper as a "coercion effect". Because we do not support the idea that there is coercion, nor that there is type-shifting of the complement noun, we will use "coercion effect" simply to refer to the experimental finding as well as to linguistic intuitions about what goes on in indeterminate sentences such as (2a).

There have been at least three main types of explanations for why coercion effects occur: lexical-semantic decomposition of the complement noun, type-shifting rule operating over the complement noun, and the one we further extend in the present paper, the verb structural-gap account.

2.2 Lexical-semantic decomposition

The idea that information that enriches the representation of a sentence comes from the decomposition of a verb's complement noun is by far the most popular, at least in psycholinguistics and in computational linguistics (e.g. Briscoe et al. 1990; Godard & Jayez 1993; Pustejovsky 1991, 1995). This view has been discussed extensively in the literature so here we are interested only in providing some of the key arguments for how this approach accounts for coercion effects. Some of the views put forth by the lexical decomposition approach to coercion are often conflated with the semantics rule approach, as we will see in Section 2.3, below.

The main proposal for resolving the indeterminacy of sentences such as (2a) – articulated by Pustejovsky (1995; but also Briscoe et al. 1990) – is that interpreting the nominal complement as an event relies on interpreting it as a *token event*. More importantly, the token event is extracted from the lexical-semantic representation of the nominal and interpolated in the sentence producing an enriched composition (or *co-composition*). This process relies on the nature of the lexical representation for nominals, as proposed by Pustejovsky. In essence, his proposal specifies that lexical representation is an amalgamation of many properties ranging from structural (e.g. argument structure) to meaning-constitutive such as telic role (the purpose and function of the item's referent) constitutive role (the "relation between the object and its constituent parts"; Pustejovsky 1991: 418), and others. Regarding the constitutive role, for instance, Pustejovsky (1991, 1994) notes polysemy even in cases such as *door* (as in *paint the door* – a "physical object" sense – and *pass through the door* – an "aperture" sense), suggesting that nominal interpretation is sensitive to its use in different phrasal contexts. What is more important in the present context is that the representation of nominals are supposed to *contain* information such as the *telic* properties of their referents. The telic properties of a nominal such as *book* specify, say, *reading* as a default (Briscoe et al. 1990) or as the most prominent among other rank-ordered candidates (e.g. Lapata & Lascarides 2003) for things we do with books; thus, it is *reading* that most likely becomes available for interpolation in the "enriched" semantic structure of the sentence.

Early psycholinguistic studies on the coercion phenomenon (e.g. McElree et al. 2001) have sided with this view, assuming that reading delays in post-verbal positions for a sentence such as (7a), when contrasted with (7b) were due to the process of necessary interpolation of the activity information (*read*) extracted from the internal analysis of the complement noun (*book*).

(7) a. The student began the book late in the semester.
    b. The student read the book late in the semester.

The main – and perhaps the most damaging – of the criticisms one can wage against this view stems from the fact that it depends on an analytic-synthetic distinction which many consider a dead-end in affairs of lexical-semantic analysis (Quine 1953; Putnam 1970; Fodor 1970; Fodor & Lepore 2006). Simply put, without a principled distinction, one cannot determine what goes into *lexical* representation and what does not – i.e. what is true in virtue of linguistic (viz., lexical) properties, and what is true in virtue of shared or private knowledge, beliefs, and so on. This distinction would be necessary if coercion were to occur at a *semantic* linguistic level that is separate from general knowledge (akin to what Katz 1972 proposed). And even if one could stipulate what in fact determines the content of lexical representations – viz., limited feature sets or definitions – one would have to (i) specify which properties are made available when the word is used in a given context (for instance which *constitutive role* is accessed); and (ii) determine which, among all possible *telic roles*, is the one to be chosen (and why). Perhaps a no less ambitious project would be to determine (i) and (ii) for all lexical items. Although some see this as necessary for lexical-semantic research (Jackendoff 2002), we see no viable solution in sight vis-à-vis the problem of analyticity: neither definitions for *all* lexical items are feasible, nor would they work without a set of primitive semantic/conceptual constituents.

2.3 Type-shifting rule

A semantic type-shifting rule (e.g. Partee 1986; Partee & Rooth 1983; Heim & Kratzer 1998) in principle does away with lexical-semantic decomposition by imposing constraints on the semantic *types* that enter into well-formed representations. This view of coercion phenomena assumes that a complement of a given semantic type (say, *entity* [e]) might turn into another type (say, *proposition* [$\langle e\langle e,t\rangle\rangle$]), as in (8), following verb demands.

(8) a. Mary$_{\langle e\rangle}$ began a book$_{\langle e\rangle}$ $\rightarrow$
b. Mary$_{\langle e\rangle}$ began a book$_{\langle e\langle e,\, t\rangle\rangle}$

In essence, this type of operation is supposed to be sensitive to verb-argument structure; for, by hypothesis, the argument structure of each verb has to either encode the types of the categories it licenses (or with which they compose) or has to have access to the rules that yield a given predicate composition valid. That is, the proposal is that the verb *begin* (or any other verb of the same class) specifies a type $\langle e\langle e,t\rangle\rangle$ for its VP. In processing terms, when the parsing system detects a mismatch in the verb-noun complement – i.e. when the complement nominal is of type $\langle e\rangle$ – a type-shifting rule applies.

Of course, this view also assumes that there is a type taxonomy that cuts across grammatical categories and in fact supervenes on operations of semantic composition and interpretation. A shifting rule is supposed to operate at the "linguistic level" on the output of or concomitant with syntactic-structuring computations – if semantic rules are in effect during language comprehension, as we might assume they are. In addition, besides serving for translating syntactic into semantic categories and thus complying with classical-compositional processes, a semantic rule operating on *types* does not rest on an account of the analytic/synthetic distinction, assuming that *types* are symbolic primitives. The resulting categorical type representations are at the basis of an intensional logical representation of the event that the sentence denotes, i.e. of the logical form of the sentence, which provides the basic *form* for enrichment without actually enriching the sentence.

Insofar as accounting for *coercion effects*, we see the semantic-rule approach as heuristic at best for it does not specify the source of information that enables the reading of *book* as an event of a certain type, i.e. a particular activity performed with the book. What it does is to specify that a particular event reading of the nominal book should be made without determining what it is – thus without supplying the content of the event itself. It is possible then that coercion effects are simply effects of the *entity* $\rightarrow$ *proposition* shift itself, that is, the computational process of changing types, thus without the necessity of reading the changed *type* as a *token activity*. If so, this process thus preserves a separation between linguistic and non-linguistic computations to yield a non-enriched logical form.

It is in this context that the lexical-semantic decomposition proposal arose: Pustejovsky's (1995) solution to account for the content of a given event while holding the basic type-shifting idea was to rely on *qualia* information as the source of coercion operations, thus yielding for a sentence such as (2a) a representation such as (9) where the NP complement is read as an event *of a certain kind*.

(9) $\lambda e, \lambda x$ [read (e, x, a_book)]

The type-shifting approach *sans* lexical decomposition (see also Fodor & Lepore 2002) can be conceived as a "semantic minimalist" account of coercion effects, for it complies with the idea that the content of *S* is only sensitive to the linguistic properties of *S*, regardless of contextual factors. But as we show below, the structure of the sentences employed in coercion research is deemed to have hidden linguistic structure, which, we argue, might be the basis for pragmatic enrichment. We take our view to be semantic-minimalist as well, for enrichment is structurally determined.

2.4 Structural gap

The third view on why coercion effects occur – even if not consistently so – is the one we develop more thoroughly in the next section, following up on a proposal put forth by de Almeida and Dwivedi (2008) for the distributional properties of the verbs implicated in the *coercion* literature. In summary, the idea is that *coercion effects* are by-products of structural gaps in the host predicates, mostly aspectual verbs. To advance a bit what we further develop below, the idea that there is a *gap* in the structural, linguistic representation of the predicates involved in coercion studies follows from the very idea of syntactically active null elements (as in Chomsky 1981) or an unexpressed argument for which a syntactic position is specified. As in de Almeida and Dwivedi (2008), we do not take this position to be specified only in the logical form of the sentence, but to be specified syntactically as a place-holder for a verb (see also Wurmbrand 2004).[5] The discussion that

5. There is possibly a major difference between proposing that (a) logical form is simply a representation of syntactic relations as determined by the overt and covert syntactically active constituents of the sentence and (b) that logical form is free to include non-syntactically but *semantically* determined constituents. Thus, a sentence such as (1c), *John had breakfast*, would have a logical forms such as '$\exists w$ (*had* (x, y, w))' under alternative (a), and '$\exists w$ (*had* (x, y, w))& (*today* (w))' under alternative (b). In essence the distinction amounts to determining whether or not, say, *today* is an *unarticulated constituent* (as in Recanati 2004). We will assume, without much contention that (a) is the null hypothesis – that only syntactically active (phonologically null or not) positions contribute information to logical form. Of course, it is an empirical question whether or not there is a syntactically active but phonologically null position in sentences such as *John began a book* – some believe there is (de Almeida & Dwivedi 2008), others believe there isn't (Pylkannen & McElree 2006) – see below.

follows elaborates on the linguistic evidence for this view as well as on how the effect arises as a function of *structurally-licensed* pragmatic inferences.

3. Linguistic evidence for the *gap*

In this section, we discuss some linguistic evidence for a structural *gap* in predicates said to produce coercion effects. Some of our discussion is a follow-up on the analysis presented by de Almeida and Dwivedi (2008); thus we begin by briefly recasting some of their arguments.[6] We then present some new evidence for the structural gap in predicates used in coercion studies.

3.1 Restructuring verbs

In a paper discussing the nature of the verb phrases involved in studies investigating *coercion*, de Almeida and Dwivedi (2008) proposed that sentences such as (2a), repeated here as (10a) have a VP structure as represented in (10b).

(10) a. The man began a book
b. [VP [V^0 *began* [V^0 *e* [OBJ *a book*]]]]

This structure assumes that the phrase has an empty *V* head, motivated by the so-called restructuring verbs idea developed by Wurmbrand (e.g. Wurmbrand 2004). We recast below some of the key types of evidence presented by de Almeida and Dwivedi in support of the analysis in (10b).

First, de Almeida and Dwivedi argue that VP modifiers such as the adverb *again* in (11) can have scope over an empty V within a VP. This is the case of sentences often used in coercion studies – with verbs like *prefer* and *attempt* – but also the case of aspectual verbs.

(11) I read *War and Peace* and now I'll start [VP [VP [VO *e*][NP *Ulysses*]] again].

The idea is that *again* has scope over the event that is to be performed, not over *start*, for there is no *start* in the first clause. This sort of elliptic reading of the lower predicate works even better with two aspectual verbs marking the end points of the same event, thus forcing instrumental PPs to modify an empty

6. Some of the arguments for and against the structural complexity of verbs that yield coercion effects were discussed in two papers – de Almeida and Dwivedi (2008; originally submitted in 2005) and Pylkannen and McElree (2006) – which reached different conclusions. We follow most of the argument by de Almeida and Dwivedi (2008) for reasons presented therein.

lower V head which is anaphorically bound to the main V in the antecedent clause, as in (12). That is, the empty V head works as the site for the VP ellipsis of *reading/to read*.

(12) I started reading with my contacts but finished [VP [VP [V0 *e*][PP with my glasses]]]

Second, V-*able* structures allow for VPs (with overt or empty Vs) to raise to subject position. This type of construction might work particularly well with adjectives derived from event verbs (*writable, watchable*, etc.), but, following de Almeida and Dwivedi, we believe the grammaticality of constructions with adjectivized aspectual verbs is also warranted. Thus, for (13a), one can conceive of a complex external argument with an embedded VP structure, as in (13b), yielding a sentence such as (13c) grammatical.

(13) a. This chapter may be finishable
b. [VP [V0 *e*][NP this chapter]] may be finishable
c. [VP [Writing][NP this chapter]] may be finishable
d. NP may be able to finish *V* this chapter

We suppose that adjectives such as *finishable* are morphologically decomposable (and thus paraphrasable) as in (13d). We also suppose that *writing*, as in (13c), might be licensed from an internal-argument position within the aspectual verb's matrix before the adjective derivation.

The third argument put forth by de Almeida and Dwivedi is that VPs (with overt or empty Vs) cannot raise to subject position in so-called unaccusative structures. They argue that we can form unaccusatives with event nominals (such as *war*) but not with entity nominals (such as *book*). However, we have a slightly different view with regards to why this happens. While (14a) as well as (14b) are allowed, a sentence such as (14c) cannot license an unaccusative construction when it has a VP in subject position, as shown in (14d).

(14) a. We began [NP this chapter] in June, well after the deadline
b. [NP This chapter] began in June, well after the deadline
c. We began [VP to write this chapter] in June, well after the deadline
d. *[VP to write this chapter] began in June, well after the deadline

But the ungrammaticality of (14d) arises, in our view, because the VP structure is broken, i.e. the V head is supposed to *stay* within the VP as one of its constituents, allowing its internal argument to move to subject position, thus yielding a so-called middle construction, as the sentences in (15) show.

(15) a. This chapter began to write in June, well after the deadline
b. This meat began to cut smoothly only after it was defrosted

In the next couple of sections we extend these ideas by also briefly discussing two other tests – middle formation and compounding.

3.2 Middles

We have seen in (15) that it appears that middle constructions with aspectual verbs can be formed when the VP structure is full. Middle formation can be a good test of the VP structure discussed above because in middles the surface subject comes from the internal argument position of the main verb. Thus, if the VP of an aspectual verb has a structure such as (10b), it should block middle formation because the nominal complement is the internal argument of an empty verb. For example, it is widely accepted that we can form middles such as those in (16), with rough paraphrases in (17).

(16) a. This chapter reads easily
b. The meat cuts perfectly
c. The bread slices smoothly

(17) a. One can read this chapter easily
b. One can cut the meat perfectly
c. One can slice the bread smoothly

As can be seen in (17), what appears to be the subject of the verb is in fact the object, with structures like in (18), whose internal arguments moved to subject position (see Keyser & Roeper 1984; Stroik 1992).

(18) [$_{\text{NP}_1}$ This chapter] reads [$_{\text{NP}_1}$___] (easily)

But as it turns out, with an aspectual verb (but not with other verbs that produce coercion effects such as *prefer*, *attempt*, and *manage*), middle formation appears to lead us in a different direction. The sentence in (19a), for instance, does not seem to license paraphrases such as those in (19b)–(19d).

(19) a. This chapter begins easily
b. ? One can begin this chapter easily
c. ? The beginning of this chapter is easy
d. ? It is easy to begin this chapter

If (19a) does indeed license one of these paraphrases, it is because its structure is that of an unaccusative (as in *The chapter began*; *The movie commenced*), *not* a middle. Crucially, the felicity of (19a) does not depend on the adverb *easily*, for (19a) can be a statement about the creation of a chapter (as in *writing the chapter*).

Thus, while it appears that a middle can be formed, the usual meaning that arises from having the NP in the subject position moved from its original internal argument position cannot be preserved. Our suggestion is that this change in meaning is due to the NP becoming the surface subject of a verb (*begin*), after moving from its original position as the object of another – covert – verb.

3.3 Compounds

A key characteristic of verbs that supposedly allow for coercion – particularly aspectual verbs – is that they do not obey what has been called the *First Sister* (FS) principle (Roeper & Siegle 1978) for forming verbal compounds. According to this principle, a verbal compound is formed by the incorporation of a word in first sister position of the verb. Briefly, FS assumes that in cases such as those in (20), compounds can be formed because they incorporate adjectives ((20a)–(20b)), adverbs ((20c–20d)), nouns understood as direct objects ((20e)–(20f)), among other lexical categories.

(20) a. grim-acting
b. nice-sounding
c. fast-mover
d. late-bloomer
e. trend-setter
f. bell-ringing

However, other compounds with similar categories are ungrammatical because their modifiers cannot appear in the internal argument (or as modifying adjuncts) of their heads (Roeper & Siegel talk about subcategorization frames). Thus, as we can see (21a) and (21b), the different structures of the predicates *think-e* and *make-N* show the contrast between, e.g. **peace-thinking* and *peacemaker* (from Roeper & Siegel 1978).

(21) a. *She thinks peace → *She is peace-thinking
b. She makes peace → She is a peacemaker

We will not discuss in detail all the arguments for forming verbal compounds, as presented by Roeper and Siegle. We are interested here in focusing on the aspectual cases, as well as in other predicates used to support coercion effects. Thus, for instance, compound formation with predicates such as those in (22a) are allowed because *book* is in the first sister position of the V (or the V selects for the complement N).

(22) a. He reads books → He is a book-reader
b. He makes films → He is a filmmaker

But the cases in (23), we suspect, do not work because the compound needs to be formed with a lower verb which by hypothesis is internal to the aspectual predicate, as predicted by the VP structure discussed above (Section 3.1).

(23) a. He usually begins books on Saturdays →
*He usually is a book-beginner on Saturdays
b. I heard that the man starts the movie at 8 o'clock sharp →
*I heard that the man is a movie-starter at 8 o'clock sharp

If the FS principle is at work in these cases, as we think it is, and assuming the VP structure of verbs such as those in (23) take an internal empty V head, then forming a verbal compound is allowable only when the internal V head is filled, as in (24a).

(24) a. He began to read/reading a book → He is a book-reader
b. He began [VP [VP [V0 *e*][NP a book]] → *He is a book-beginner

The compounding and middle cases presented here, together with the de Almeida and Dwivedi's (2008) analyses, further support the idea that coercion effects found in the psycholinguistic literature as well as linguistic intuitions about coercion might be structurally determined, i.e. an effect of a "hidden" verbal position. Thus we take the cases we discussed in the present section to strengthen the case for a view of coercion effects as triggered by linguistic form rather than by semantic decomposition or even, as it might be, by a type-shifting rule.

3.4 Event nominal complements?

A residual issue in our analysis is that of so-called *event* nominals. If it is the case that there is no type-shifting or that there is no coercion via semantic decomposition, why is it that event nominals do not appear to produce the same coercion effect as entity nominals do (see, e.g. Traxler et al. 2002)? Take for example cases such as (25): it appears that there is no coercion of the complement nominal because it is an *event* nominal, which supposedly provides the necessary information to *fill-in* the interpolated structure. It would seem that sentences in (25) mean something like those in (26).

(25) a. John began the fight
b. Mary started the lecture

(26) a. John began to fight
b. Mary started to lecture

We have at least two arguments against the view that event nominals constitute separate cases – thus that the contrast between entity and event nominals as complements of aspectual verbs can be used in favor of either a type-shifting or a lexical-semantic coercion approach. Our arguments are mostly against the latter approach.

The first is that we do not think sentences in (25) are synonymous with those in (26). In fact, we are sure they are not. There are many ways in which one can start *x* without actually engaging in *x*. We can cause a lecture to start without actually being the lecturer, and we can do the same with a fight – provoking it without getting into it. And it is not clear what actually determines the beginning/start of a given event such as a lecture or a fight – is it the preparation, a petition, an announcement, an actual punch? We do believe, however, that when one begins *to fight* one is actually engaged in it – and so with *to lecture*.

Clearly, an event nominal such as *war*, as in (27a) does not denote necessarily that the agent is actually involved in the hostilities, nor that it is involved in any other way, as interpretations such as those in (27b) and (27c) exemplify, or as the contexts in (28) make clear.

(27) a. The general started the war
b. The general started to fight the war
c. The general caused the war to start

(28) a. By accidently pressing the red button, the general started the war
b. By accidently pressing the red button, the general started to fight the war
c. By accidently pressing the red button, the general caused the war to start

Similarly, when another entity is in the subject position, participation in the event denoted by the nominal complement is not entailed, as shown in (29)

(29) China's veto started (*to fight) the war between the Koreas

There is yet another possibility for the hypothetical difference between event and entity nominals which would support the main tenets of type-shifting and coercion. The idea is that the gap we proposed above is the site for an unexpressed verb which comes from the nominal complement itself. Thus, the lack of coercion effects found in sentences such as (30a) and (31a) could be due to a default filler being supplied by a morphological operation on the deverbal nouns that usually characterize event nominals.[7]

(30) a. John began the fight
b. John began [v to fight [the fight]]

7. The study by Traxler et al. (2002), showing a coercion effect in *entity* vs. *event* nominals, actually employed several derived nominals in the *event* condition (e.g. *fight*, *battle, contest, argument, audit, recital, robbery, show, visit*).

(31) a. Mary began a song
b. Mary began to sing
c. Mary began to sing a song

One of the perils of this analysis is that it conflates a morphological operation with a definitional account of deverbal nouns – that is, it conflates what is a purely derivational analysis of *fight* with the idea that a noun such as *fight* actually incorporates a definition such as what is shown in (30b), i.e. that *the fight* actually means *to fight the fight*, just like *to sing* actually means *to sing a song*, as in (31c), as proposed by Hale and Keyser (1993). Again, we contend that examples such as those in (30) and (31) suggest that event nominals, if they are real, might not provide a filler verb to the empty V position, for the overt sentences with decomposed nouns (e.g. (30b) and (31c)) are not synonymous with their reduced counterparts ((30a) and (31a)). Moreover, this operation cannot yield a local default interpretation, for different agent nominals can produce *n* different intended meanings such as in (32).

(32) a. The conductor began a song
b. The conductor began to play/to sing/to rehearse a song

Yet, although this argument might work for most event complements used in the literature (e.g. Traxler et al. 2002), it might not work for all (e.g. cases of non-deverbal nouns). Nevertheless, we think that this analysis holds to the extent that it can account for the lack of coercion effects found in experiments with event nominals. And even if it is the case that a default filler verb is indeed extracted from the event nominal by morphological decomposition, we contend that this would be an argument in favor of our empty V head analysis: this structural position would be the site of the verb extracted from the nominal complement.

4. Pragmatic *triggers*

We have established that *aspectual* and often other verbs said to produce coercion in their nominal complements might comprise a structurally determined place for an event verb or nominal within their VPs. We turn now to a discussion of what we take to be the role of the proposed structural position in the interpretation of aspectual predicates as well as other predicates said to produce coercion effects.

We have proposed that the structural gaps are *triggers* for pragmatic inferences that allow for enrichment of indeterminate sentences. Although we cannot legislate on the particular types of inferences that might occur, much less on the actual content of particular predicates, we can in principle propose that structural gaps are the very places where the parsing and interpretation mechanisms start off their content-enriching processes. In fact, we take it that *any* enrichment is at first a consequence of structurally-determined gaps in the linguistic representation of a phrase or sentence.

In the particular case we are discussing – of VPs said to produce coercion effects – the proposal is that the effects found in the empirical literature are most likely due to the empty V head we discussed (see also de Almeida & Dwivedi 2008). We take this V head to be the primary trigger to initiate pragmatic enrichment. It is possible that this trigger has the same function of the so-called *unarticulated constituents* we discussed earlier. There is, however, a crucial distinction: while the pragmatic enrichment we allow for comes from positions that are structurally determined at the linguistic level (syntax or logical form), in the case of unarticulated constituents as conceived by Recanati (2004) there are no such positions – or at least they are not tied to any particular syntactically or semantically determined structural position. We see this as a crucial distinction because while the interpretation of examples such as those in (1) and (2) above are determined by either analytic decomposition or by contextual demands, in the present proposal the primary processes of enrichment ought to be *linguistically active* (Grimshaw 2005).

In fact, we assume that high-level enrichment of any given sentence is a natural consequence of linguistic-system output, for the linguistic system cannot be informed about possible contextual manifestations of sentence tokens. Of course, the crux of the matter is to show that a context-free representation actually occurs prior to or concomitantly with possible contextual fitting processes. For no one denies that eventually a given sentence gets disambiguated or becomes properly fitting in a given context. One form of evidence for this view comes from a memory experiment showing that enriched reconstructions of indeterminate sentences emerge over time.

4.1 Context and enrichment: A memory experiment

There are classical experiments in the psycholinguistic literature (e.g. Sachs 1967, 1974) showing that following the loss of verbatim representations in working memory, individuals reconstruct sentences in a manner consistent with their underlying semantic "gist." Although these reconstructions deviate from the verbatim structure of sentences, they reflect what individuals eventually perceive to be the content of a sentence. Following Sach's sentence recognition paradigm, we (Riven & de Almeida 2012) embedded indeterminate expressions such as (33a) within a relatively long discourse context (about 25 seconds of recorded speech prior to the presentation of the probe sentence) that strongly biased an interpretation consistent with (33b) but inconsistent with (33c), and later asked participants whether they recognized the various sentence probes (i.e. (33a)–(33c)) from the passage.

(33) a. *Indeterminate*: Lisa began the book.
b. *Contextually biased interpretation*: Lisa began reading the book
c. *Contextually unbiased interpretation*: Lisa began writing the book.

Crucially, while both (33b) and (33c) represented plausible interpretations for (33a), the discourse contexts only permitted an interpretation resembling (33b) by constraining the range of plausible inferences. For example, the relevant passage stated that "Lisa had been looking forward to the new Grisham novel," before stating (33a), hinting at her intention to *read* as opposed to *write* a book.

We found that participants enriched the indeterminate sentences in a manner that was dependent on the discourse context. In particular, while participants were able to discriminate the various probes in (33) early on with greater than 95% accuracy, they began to falsely recognize (33b) following a 25 second delay, once a verbatim representation of (33a) was lost. Interestingly, participants reported a high degree of confidence (71%) that they were correct when committing such errors of recognition. In contrast, they remained fairly accurate at rejecting (33c), even following an extended delay. These results are presented in Figure 1.

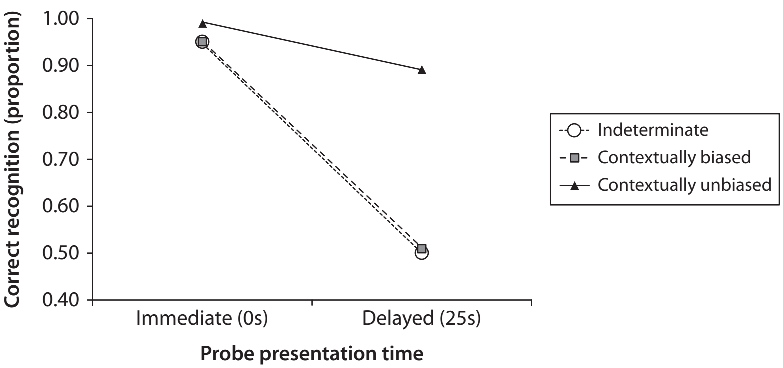

Figure 1. Proportion of correct recognition for each sentence type used in Riven and de Almeida's (2012) experiment

These results were obtained even though a subset of passages biased interpretations that would otherwise be considered less plausible than the alternative in (33c), illustrating that the context trumped any potential *default* mechanism of enrichment proposed to be a central feature of coercion (Pustejovsky 1995). Thus our data suggest that false-recognition was driven by discourse-dependent inferential processes emerging over time, and provide compelling evidence that pragmatic computations enrich these sentences.

The psycholinguistic evidence in favor of coercion has relied almost exclusively on measures of processing time. Typically researchers demonstrate a cost for indeterminate sentences relative to controls (e.g. McElree et al. 2001; Traxler et al. 2002). But while such manipulations provide evidence that the enrichment process might be costly, they cannot definitively illuminate the specific mechanism of enrichment (i.e. whether it is indeed the product of coercion or pragmatic inferences) for they provide no data on the content of enrichment per se. We believe that our memory manipulation addresses this gap in the literature and highlights a possible source of coercion effects. In particular, our study demonstrates that enrichment occurs as a function of pragmatic variables (i.e. a biasing discourse context), providing further evidence for our proposal.

4.2 Neurological bases of indeterminacy

While linguistic and psycholinguistic empirical evidence for the proposal we put forth might suffice to question the lexical-semantic coercion theory, we turn now to an investigation of how indeterminate sentence processing might be implemented in the brain. In a recent study employing functional magnetic resonance imaging (fMRI), de Almeida and Riven et al. (2012) presented participants with sentences such as those in (34), comparing indeterminate structures such as (34a) with fully-determined controls as in (34b) and with sentences which represented pragmatic violations, such as (34c).[8] We investigated the neural activation elicited during the online composition of each verb (e.g. *began/marked/assassinated*) combined with their internal arguments (e.g. *the paper*). The motivation for the study was to investigate whether indeterminate VPs triggered pragmatic processes by showing a similar pattern of activation with those in (34c) and a divergent pattern of activation from those in (34b). The prediction was that (34a) and (34c) would engage right hemispheric structures typically associated with the pragmatic processing of language (see de Almeida et al. 2012 for a review), while (34b) would not (at least not to the same extent).

(34) a. *Indeterminate*: The professor began the paper
b. *Control*: The professor marked the paper
c. *Pragmatic violation*: The professor assassinated the paper

We found that the neural activation elicited by indeterminate sentences shared some features of each of the comparison conditions (see Figure 2). Similar to the control sentences, indeterminate expressions elicited activation in typical

8. Our study included three other categories of stimuli. We focus here on the three main types and summarize the basic findings only.

language areas including Broca's area and Wernicke's area in the left hemisphere (LH). Overall, however, the indeterminate VPs conformed substantively to the network of brain regions involved in the processing of pragmatic violations, engaging significantly more right hemispheric (RH) structures than the control VPs.

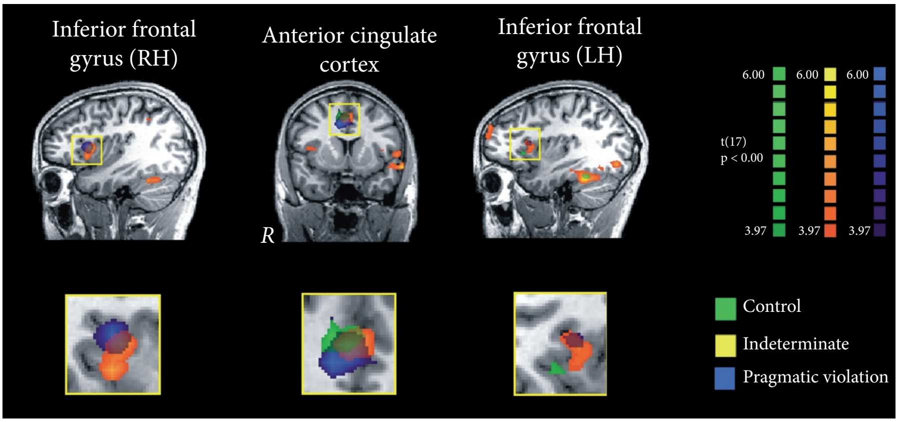

Figure 2. Scan maps from de Almeida et al. (2012). Data was obtained by generating a contrast for each sentence type, which involved the comparison of two sections of each sentence: (1) the pre-verb event (e.g. "The man") and (2) the post verb event (e.g. "began the book."). These intra-sentence contrasts were evaluated against a baseline measure of neural activation, which was obtained when participants read a set of non-experimental sentences used as filler items during the session. The maps show that indeterminate sentences elicit bilateral activation in the inferior frontal gyrus (IFG), engaging both typical language areas on the left (i.e. Broca's area) and pragmatic regions on the right. Notice that all three sentences engage Broca's area, but that indeterminate sentences and pragmatic violations tend to overlap while the control sentences largely occupy a distinct sub-region. Crucially, only the indeterminate and pragmatic violations engage the right IFG, and the activation for indeterminate sentences at the ACC (central map) surpasses the spread and level of activation for the control sentences

The pattern of activation in the LH showed unexpected divergence between the three sentence types, with the fully-determined controls activating an entirely distinct sub-structure of Broca's area than the other two sentences. This suggests that the involvement of typical language areas may have been functionally distinct for the various sentence types, with the indeterminate and pragmatically anomalous VPs presenting a special challenge for structural analysis performed by Broca's area. Crucially, the indeterminate sentence showed a much broader spread of activation in Broca's area than the two comparison sentences, which may be taken to reflect the structural gaps that we have proposed.

These findings may suggest that initially the LH computes a context-free, structurally shallow representation of the sentence, and in turn recruits RH resources for pragmatic enrichment. Interestingly, the process of indeterminacy resolution appears to go beyond recruiting pragmatic resources (typically, RH structures). We also found significant involvement of the anterior cingulate cortex (ACC) during the processing of sentences such as (34a), which exceeded both the spread and intensity of activation observed for the other sentences. The ACC is known to be involved in conflict monitoring and decision-making (Botvinick 2007). We suspect that the activations yielded by (33a) go beyond their pragmatically-anomalous controls (as in the case of (33c)) because they remain indeterminate, no matter how much our abductive apparatus tries to narrow the domain of interpretation.

These results are consistent with MEG studies (e.g. Pylkkanen & McElree 2007) reporting that indeterminate sentences elicit a pattern of neuronal activation that involves LH, RH, and medial regions of the brain. However, differences in methodology (MEG versus fMRI) have yielded differences in results, particularly with regards to the medial regions involved in processing these sentences. The MEG data presented by Pylkkanen and McElree (2007) was linked to a response in the ventro-medial prefrontal cortex (vmPFC), exclusively for indeterminate sentences, leading them to conclude that that particular region was involved in the coercion operation. Our fMRI experiment failed to replicate this finding, but rather revealed activation in the ACC for both indeterminate and pragmatically anomalous sentences. Given that MEG has relatively weaker spatial resolution than fMRI, it is possible that Pylkkanen and McElree's localization analysis in fact picked up activation from the ACC rather than the vmPFC, both of which represent medial regions of the brain albeit occupying distinct transversal coordinates (i.e. the ACC is superior to the vmPFC). Moreover, anatomical studies employing fMRI showed significant connectivity between the vmPFC and the ACC (Margulies et al. 2007), suggesting that MEG effects of vmPFC could actually originate at the ACC, consistent with our fMRI results. Crucially, the activation we observed in the ACC was common to both indeterminate and pragmatically anomalous sentences, suggesting that this region is not likely involved in coercion per se (a process that would be unique to indeterminate sentences), but rather participates in the pragmatic enrichment of sentences (a process that is common to both sentences).

Our fMRI data represent the neurobiological instantiation of indeterminate sentence processing, and suggest that initially the language system is challenged by the proposed structural gaps of indeterminate sentences, deploying pragmatic resources during the comprehension process, beyond that needed to interpret fully-determinate sentences and even pragmatic violations.

5. Minimal representations and enrichment

In the quest for understanding how indeterminate sentences such as (2a) above are interpreted, much has been said in support of either a lexical-decomposition theory of coercion or a theory of semantic type-shifting. In addition, many empirical studies have been offered mainly in support of a lexical-decompositional approach, although much of what has been presented in the experimental literature is far from showing the nature of what we called *coercion effects*.

We have shown that linguistic structure determines a position that might serve as a trigger for primarily pragmatic processes of enrichment. We have also presented evidence that comprehension of indeterminate sentences might be driven by inferences that occur over time and that such enrichment involves neurological structures usually involved in pragmatic processes. In addition, we have observed that the neural network of indeterminate sentence processing extends beyond typical pragmatic regions, recruiting areas known to be engaged in high-level decision-making. Such data suggest that, beyond pragmatic enrichment, the indeterminate sentences require abductive processes for the computation of their implicatures.

We take the basic Gricean picture to stand, and we concur with the main tenets of semantic minimalism: Pragmatic enrichment presupposes literal (thus, minimal) representation. We take this to be true of all cases in (1), of all cases that have been studied as coercion (i.e. indeterminate sentences), and beyond – including classical pragmatic phenomena such as metaphor, irony, indirect speech acts, and jokes. What is intended is represented minimally based on what is said and its structurally determined covert positions.

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Computation with doubling constituents

Pronouns and antecedents in phase theory*

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In the biolinguistics program, syntax has access to only limited and minimal operations such as Merge (and Move) plus local (to Phase) probe-goal, Chomsky (2000, 2001). Under this blueprint, the challenge for implementation is twofold: (1) to show that such a system operating locally can systematically derive complex facts, and (2) that computation, i.e. the selection of the appropriate operation is locally (and perhaps globally) efficient. To this end, available mechanisms may be prioritized to create an unambiguous instruction stream, e.g. Merge over Move. In this paper, we develop a computationally verified implementation of classic Binding Theory facts, including pronoun and anaphor asymmetries for mono- and multi-clausal sentences, possessive DPs, and picture DPs. We take as our starting point Chomsky's probe-goal system plus Kayne's (2002) doubling constituent proposal for pronoun-antecedent coreference relations. Within this framework, maintaining Phase locality between probe and goal forces independent licensing of an r-expression from its pronominal component via an operation of Last Resort theta Merge. We maintain that this Last Resort variant of Merge maintains the computational efficiency of the probe-goal system in that it operates precisely at the limit of probe-goal search domain and it does not introduce any additional choice points into the instruction stream.

1. Introduction

As part of the biolinguistics perspective, the Minimalist Program (MP) (Chomsky 1995) focuses on simple and optimal solutions to the problem of the nature of human language. It is expected that considerations of efficient computation

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(within the constraints of the biological system) should contribute to and help explain the shape or restrictions on the space of possible human languages (cf. Chomsky 2005). An uncontroversial property of this computational system is that it should be recursive, i.e. in principle allow the unbounded combination of a limited number of lexical primitives to form an infinite variety of specific structures that encode the variety of language phenomena. Within the strictures of the MP, it is proposed that simple recursive Merge (external and internal, i.e. displacement) suffices to generate an arbitrary number of structures, and the agree relation that obtains between probes and goals serves to restrict the possible instances (Chomsky 2001).[1] Given that recursive merge can generate arbitrarily complex structures, efficient computation dictates that probe search be restricted in scope to cyclic domains known as phases. In this paper, we show that this computationally-motivated limit on search also serves to explain a variety of Binding Theory (Chomsky 1981, 1986) facts.

Much research has focused on the various restrictions that language imposes on coreference relations. These restrictions have traditionally been accounted for by Binding Theory, exemplified by the famous Conditions A–C (1a–c).

(1) (a) An anaphor must be bound in a local domain.
(b) A pronoun must be free in a local domain.
(c) An r-expression must be free. (Chomsky 1995: 96)

These Binding Conditions accurately describe a wide variety of Binding phenomena. However, these Conditions have, since their formulation, been recognized to be inadequate to account for the variety of coreference phenomena found in language (e.g. see Reuland & Everaert 2001 and references cited within, among many others). In addition, while going a long way towards describing coreference phenomena, they do not explain why the phenomena are the way they are (e.g. why does Condition A hold?). Within the MP, in order to achieve a more adequate account of pronoun-antecedent relations and explain away the Binding Conditions, there have been some attempts to formulate Binding Theory in terms of movement (cf. Hornstein 2001; Kayne 2002; Zwart 2002; Heinat 2003). This paper builds on these analyses, particularly on the work by Kayne (2002). In this work, we describe a computer model that relies on independently motivated elements of Phase Theory (Chomsky 1999, 2000, 2001, 2004, 2006) to account for a variety of pronoun-antecedent relations in a computationally efficient manner.

The organization of this paper is as follows. Section 2 presents an overview of Kayne (2002), which forms the foundations of our analysis. Section 3 explains our proposals. Section 4 describes the computer model that we used

1. Henceforth, we use "merge" to refer to Chomsky's "merge".

to implement these proposals. Section 5 demonstrates how our model accounts for a variety of coreference facts, focusing on mono-clausal and multi-clausal constructions, possessive DPs and Picture DPs. Section 6 presents further evidence for our proposed doubling constituent structures. In Section 7, we give our conclusions.

2. Doubling constituents

This paper builds on work by Kayne (2002) that assumes certain coreference relations result from movement of an r-expression out of a doubling constituent. Kayne, building on movement analyses of control phenomena (O'Neil 1995, 1997; Hornstein 1999, 2001) and Hornstein's (2001) movement analysis of certain pronoun antecedent relations, develops a doubling constituent analysis of pronoun antecedent relations. Kayne proposes that a pronominal element and an antecedent originate within a doubling constituent of the form [Spec Head], such as '[John he]', where the Spec is the antecedent and the head is the pronominal. The Spec can move out of a doubling constituent, but the head cannot. The head of the doubling constituent is licensed in its final surface position and thus has no need to move, whereas the Spec needs to move to obtain a theta-role and case. A crucial component of Kayne's analysis is that the Spec can only move out of a doubling constituent if the doubling constituent has undergone movement. In addition, a reflexive has a structure in which a doubling constituent moves, as in (2).

(2) $[_{DP}$ [John him] [~~John him~~] self]

These proposals derive some typical Condition A-C effects.

The notion that only a Spec can move out of a doubling constituent accounts for Condition C effects. An r-expression cannot be c-commanded by a pronominal element because the pronominal is the head of the doubling constituent. The head is licensed (gets a theta-role and case) in its surface position, whereas the Spec needs to move to get equivalently licensed. For example, the ill-formed (3a) cannot be derived, assuming the base structure in (3b). (3a) is ill-formed because the head of the doubling constituent 'he', not the Spec 'John', has been extracted. 'He' cannot move because then it would get a second theta-role.

(3) (a) *He$_i$ thinks John$_i$ is smart. (Kayne 2002: 137)
(b) thinks [John he] is smart.

Certain Condition B effects are derived as follows. In (4a), with the derivation in (4b), the doubling constituent moves from its base position to the embedded [Spec, TP]. This frees the Spec 'John' for movement to theta-position. Note that 'he' remains free in the lower clause, thus satisfying Condition B.

(4) (a) John$_i$ thinks he$_i$ is smart. (Kayne 2002: 146)
(b) [John thinks [$_{TP}$ [~~John~~ he] is smart [~~John he~~]]]

On the other hand, in (5a), assuming the base structure in (5b), the doubling constituent has nowhere to move before the subject theta-position can be filled. Thus, the Spec cannot move out of the doubling constituent and the subject theta-role is not assigned.

(5) (a) *John$_i$ praises him$_i$. (Kayne 2002: 146)
(b) [praises [John him]]

This analysis also accounts for why an anaphor can be local to its antecedent,[2] in accord with Condition A. In the derivation of (6a), as shown in (6b), the doubling constituent moves within the anaphor, since Kayne assumes that a reflexive has a position within it to which a doubling constituent moves (see (2) above). This movement somehow frees the Spec 'John' for movement to theta-position. Thus, the anaphor is bound locally.

(6) (a) John$_i$ praises himself$_i$.
(b) [John praises [[~~John~~ him] [~~John him~~] self]]

Kayne's system, however, faces some problems. First of all, a crucial component of Kayne's analysis is the requirement that a doubling constituent move in order for the Spec to be extracted. This accounts for the Condition A-C effects in examples (3–6). However, it is not clear why the possibility of extraction of the Spec of the doubling constituent is dependent on movement of the doubling constituent.

In addition, there are some basic data that are problematic for Kayne's analysis. Kayne's analysis appears to predict the opposite grammaticality judgments for (7) and (8). Example (7a) is well-formed, indicating that the Spec 'John' has moved out of the doubling constituent. However, as shown in (7b), there does not appear to be any position that the doubling constituent can move to so that the Spec 'John' can be extracted.

(7) (a) John$_i$ thinks that Mary likes him$_i$.
(b) [$_{v^*P}$ …v* thinks [$_{CP}$ that Mary T [$_{v^*P}$ ~~Mary~~ likes [John him]]]]

Consider (8). Kayne's analysis predicts that it should be possible for 'John' to move out of the doubling constituent and into theta-position, since the doubling constituent moves within the anaphor, as shown in (8b). But the ill-formedness suggests that this is not the case.

1. Note that Kayne's analysis does not account for why an anaphor must generally be local to its antecedent. See example (8).

(8) (a) *John$_i$ thinks that Mary likes himself$_i$.
(b) [$_{v*P}$ John v* thinks [$_{CP}$ that Mary T [$_{v*P}$ ~~Mary~~ likes [$_{DP}$ [~~John~~ him] [~~John~~ ~~him~~] self]]]]

A possible explanation for the ill-formedness of (8) is that *Mary* blocks movement of John, but if that were the case, then it is not clear why *Mary* would not block movement of John in (7). Note that Kayne's analysis thus fails to account for why an anaphor must generally be local to its antecedent.

Next, consider the ECM construction (9a). In the partial derivation (9b), the doubling constituent moves within the lower clause and then to the higher clause. This movement should free the Spec 'John' for movement to theta-position, thus predicting, contrary to fact, that (9a) should be well-formed.

(9) (a) *John$_i$ considers him$_i$ to be intelligent. (Kayne 2002: 146)
(b) [$_{v*P}$ John considers [~~John~~ him] [$_{TP}$ [~~John him~~] to be [intelligent [~~John~~ ~~him~~]]]

Kayne (2002: 146) explains the ill-formedness of (9a) as follows:

> …"raising to object" must apply first and [...] once it does [John him] is too high in the structure for there to be any available intermediate position above it, yet below the subject theta-position of *consider*.

However, it is not clear why raising to the object position of an ECM verb, as well as raising to the subject position of the embedded clause, should not count as movement that frees the Spec of a doubling constituent.

Another problem for Kayne's analysis can be found with possessive DPs. In the well-formed possessive (10a), it is not clear where the doubling constituent can move to in order to enable extraction of the subject 'John'.

(10) (a) John$_i$ likes his$_i$ dog.
(b) likes [John he]'s dog

On the other hand, Kayne's analysis predicts that the ill-formed (11a) should be well-formed, since the doubling constituent can move within the anaphor, thereby allowing 'John' to move to subject theta-position.

(11) (a) *John$_i$ likes himself$_i$'s dog.
(b) John likes [$_{DP}$ [~~John~~ him] [~~John him~~] self] 's dog

In this paper, we present a new proposal of these pronoun-antecedent facts that adopts a version of Kayne's doubling constituent proposal. Also see Zwart (2002)[3]

2. Zwart (2002) assumes (following Kayne 2002), that coreference is the result of merge of an antecedent and a variable referential element. Zwart (2002: 274) writes, "A pronoun α is

and Heinat (2003)[4] for related analyses. Our proposal, however, predicts data that Kayne's analysis can account for, as well as data that are problematic for Kayne's

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coreferential with β iff α is merged with β." Unlike in Kayne's analysis, though, the pronominal element that originates in a doubling constituent must be an anaphor, and all other forms of pronoun-antecedent coreference are considered to be accidental. On the one hand, this analysis does away with the troubling requirement that a doubling constituent move in order for the Spec to be extracted, but on the other hand, it does not provide a principled account of pronoun coreference, which Zwart suggests is subject to certain pragmatic constraints. For example, it is not clear how to account for traditional Condition C effects. Zwart points out that (ia) is ill-formed because if 'John' and 'him' originate in the doubling constituent '[John him]', then it must be Spelled out as shown in (ib).

(i) (a) John_i loves him_i.
(b) John_i loves himself_i.

But then it is not clear why (ia) cannot result from accidental coreference, as in (ii).

(ii) John_i thinks that Mary loves him_i.

3. Heinat (2003) presents a revised version of the doubling constituent proposal in which he too assumes base generation of a doubling constituent and he does not follow Kayne's requirement that a doubling constituent move. Rather, the form of a pronominal (whether it is pronounced as a pronoun or anaphor) depends on whether or not it is sent to Spell-Out at the same time as its antecedent. Heinat's proposal relies on the Phase Theory view that when the edge of a phase is reached, the complement of the head of the phase is sent to Spell-Out (Chomsky 2000, 2001). When the antecedent and the pronominal, which Heinat refers to as a PRONOUN, are sent to Spell-Out simultaneously, the PRONOUN is pronounced as an anaphor. When the PRONOUN is sent to Spell-Out before the antecedent, the PRONOUN is pronounced as a pronoun. One potential problem with this proposal is that it requires there to be object shift in an English construction with an anaphor object. If (ia) has the underlying structure in (ib), then the PRONOUN is sent to Spell-Out when the v*P edge is reached, and 'Mary' will be sent to Spell-Out later – thus the PRONOUN should be pronounced as 'her' contrary to fact.

(i) (a) Mary likes herself. (Heinat 2003)
(b) $[_{CP}$ Mary$[_{v^*P}$ Mary likes [Mary PRONOUN]]]

To get around this problem, Heinat takes the position that the doubling constituent undergoes object shift to the v*P edge, as in (ii) below.

(ii) $[_{CP}$ Mary likes $[_{vP}$ $[[\text{Mary}_{copy}]$ PRONOUN] $[_{vP}$…
(adapted from Heinat 2003)

But this means that the verb must also move out of the vP or else the object 'herself' would precede 'likes'. Yet, it is not clear where the verb would move to. Furthermore, it is not clear that there is object shift in this construction. Heinat presents Chomsky's (2001) claim that object shift can occur in English, as in (iii).

(iii) (guess) what_{Obj} $[\text{John}_{Subj}$ T [vP t_{Obj} $[t_{Subj}$ read t_{Obj} Obj]]] (Chomsky 2001: 26) analysis, without the stipulation that a doubling constituent move, and in a computationally efficient manner. We next turn to our proposals.

3. Proposals

We follow Kayne (2002) in assuming that a pronoun and antecedent originate as a doubling constituent, and we also follow Kayne's idea that constraints on movement out of a doubling constituent account for pronoun-antecedent facts. However, we differ from Kayne with respect to the structure of a doubling constituent and with respect to how movement occurs out of a doubling constituent.

We assume a view of Phase Theory whereby a derivation is broken up into phases that are formed via selection and merge of Lexical Items (LIs) from a numeration. Strong phase heads are C (complementizer), v* (little v) and certain D (determiner) heads (*self* or possessive *'s*). We propose a revised view of the Phase Impenetrability Condition (PIC). In the view of the PIC in Chomsky (2004), when a phase head is merged, the complement of a lower phase head is sent to Spell-Out. In our view, when a phase head is merged, an entire lower phase (not just the complement of the phase head), if present, is closed off, where "closing off" refers to a domain that becomes unaccessible. In (12), when the phase head C is merged, the lower v*P phase is closed-off and becomes unaccessible to further syntactic operations.

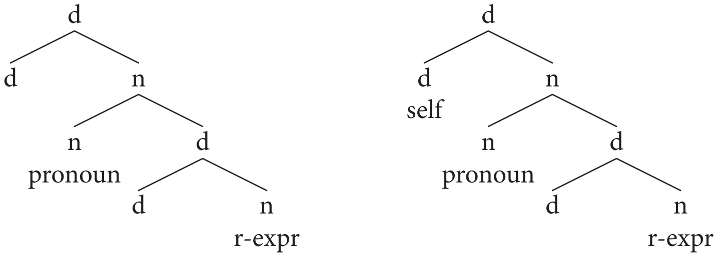
(12) $[_{CP}$ C T $[_{vP}$ v* V …]]

This closing off results from the need to restrict the domain of probe search. Beyond two phases, memory limitations make search inefficient. We demonstrate that, for the constructions discussed in this paper, there is no need to access phase edges.

We propose the structures in (13a–b), where (13a) is a doubling constituent consisting of a pronoun and antecedent r-expression ('r-expr') and (13b) is an anaphor and antecedent r-expression.

However, Chomsky claims that when there is object shift in languages like English "the object must move on beyond the position of OS [Object Shift] (Chomsky 2001:26)." In (iii), Chomsky claims that the object moves to [Spec, CP]. Furthermore, even if there is object shift in a relative clause such as (iii), it is not clear that there is object shift in a simple transitive clause such as (i).

(13) (a) pronoun and r-expresssion (b) anaphor and r-expression



In (13a), the pronoun (e.g. 'he/him') is a noun with an r-expression DP complement (e.g. 'John'). We propose that a DP anaphor, (13b), is a (strong) phase DP with the D phase head 'self'. Morphological affixation between 'self' and a pronoun results in a reflexive; for example, 'self' combined with 'him' results in 'himself' at Spell-Out. The DP in (13a) lacks 'self' and is not a (strong) phase.[5]

Kayne proposes that a doubling constituent moves within an anaphor, as shown in (2), repeated below, but it is not clear where the doubling constituent moves to or why it moves within an anaphor.

(14) [$_{DP}$ [John him] [~~John him~~] self]

Our structure of an anaphor (13b) is clearer. There is no movement within the anaphor doubling constituent, nor is there any requirement that movement occur in order for an r-expression to be extracted.

In addition, we incorporate the idea that the grammar makes available an operation of Last Resort. Last Resort (Chomsky 1995) was originally formulated as an operation that requires movement to involve a feature checking operation. Our version of Last Resort also involves feature checking. Crucially, though, we propose that Last Resort arises when an LI that needs to undergo a feature checking relation is in danger of falling outside the scope of a probe – this condition arises when the LI is contained within a phase that is about to be closed off to higher operations. Last Resort (LR) is defined as follows.

(15) Last Resort (LR): an LI with an unvalued feature that is in imminent danger of falling outside of a probe-goal scope relation can:
(a) preferentially undergo internal merge into an available theta-position
(b) or, go into a buffer for later external merge,
(c) external merge to a theta-position has priority over Last Resort

4. Chomsky (2006), following work by Svenonious (2004) and Hiraiwa (2005), writes that DPs might also be phases.

If an unlicensed LI remains in a closed off domain, then a derivation will crash. To avoid this non-optimal outcome, the human grammar module makes available LR as an escape mechanism. The LI, if possible, is theta-merged (assume that the LI is a DP) with the head of a tree (15a). This is the most optimal operation, since the LI is reused immediately. If that is not possible, which is the case if the head of the tree does not select for a theta-position, then the LI will be set aside for further merge. The grammar has a special buffer that an LI can be placed in (15b), as a Last Resort when merge into a theta-position is not available. From the buffer, the LI can later be selected and merged into a derivation. There is a catch though – this LR operation is blocked by external theta-merge (15c); if external merge into theta-position of a phrase from the numeration is possible, then LR is blocked. This arises out of the need for efficient computation – external merge is more economical than the LR movement process.

The phasehood distinction between the two types of doubling constituents, the non-phase pronoun-antecedent and phase anaphor-antecedent (13a–b) plays an important role in our analysis. Phases are a consequence of minimal computation. Chomsky (2006: 143) writes:

> For minimal computation, as soon as the information is transferred it will be forgotten, not accessed in subsequent stages of derivation: the computation will not have to look back at earlier phases as it proceeds, and cyclicity is preserved in a very strong sense.

Long distance, i.e. unbounded, dependencies borne via displacement from within doubling constituents, therefore require some form of "escape hatch" from phase domains. In Chomsky's proposals, (repeated) displacement to the edge of a phase is used for this purpose. By contrast, in our system, the LR operation functions as an escape hatch, and, via the buffer, it allows long distance dependencies.

Consider (16a–b), in which the LR process, combined with our view that a phase is closed-off when a higher phase head is merged, accounts for the possibility of remerge. '[F:]' represents an unvalued feature of an r-expression; assume that the r-expression lacks case and/or a theta-role.

(16) (a) $[_{v^*}$ v* … $[_{d}$ self … r-expr$_{[F:_]}$ …]]
(b) $[_{c}$ C … $[_{v^*}$ v* … r-expr$_{[F:_]}$ …]]

In (16a), 'self' and v* are phase heads. When v* is merged, the lower DP phase will be closed off. Since the r-expression contains an unvalued feature, it is subject to the LR process and it will be immediately remerged with v*; that is, if external theta-merge is not an option (i.e. there is no other DP available within the numeration). In (16b), both C and v* are phase heads. When C is merged, the lower v*P will be closed off. In this case, the r-expression thus is subject to the LR process.

Note, though, that C does not select for an argument; theta-merge with C is not possible. Therefore, the r-expression will go directly into a buffer, from which it can later be remerged into the derivation.

The computational system has a choice when it comes to selecting between theta merge operations: (a) external merge, (b) the LR operation of immediate remerge, and (c) the LR operation of insertion into a buffer. Our proposals, namely options (b) and (c), do not compromise the optimality of Chomsky's system: in other words, theta merge options are managed such that these options are in complementary distribution, and extra choice points (that weaken the optimality of derivations) are never introduced. Furthermore, the order of preference between these options is directly tied by computational efficiency concerns. The first option (a), external merge directly into theta position, is a primitive of Chomsky's system, and thus the simplest possible operation. It is therefore preferred (when available) over the two remaining possibilities.[6] The second option, (b), a direct theta merge operation after search to the limit of the probe mechanism, is computationally more complex than option (a), and thus is dispreferred. The last option, (c), namely storage into a special buffer for delayed theta merge, still achieves theta merge but is more complex still. It involves additional "hardware" (i.e. the buffer) and multiple copy operations (i.e. copy into and out of the buffer).

The LR process, in addition, has the advantage of increasing computational efficiency because, at least with respect to the examples discussed in this paper, it eliminates the need to (a) move an element to a phase edge, and (b) move an element through an intermediate position. Consider (17).

(17) (a) $[_{c}$ C …$[_{v^*}$ v*…r-expr$_{[F:_]}$ ...]]
(b) LR insertion of r-expr$_{[F:_]}$ into buffer
(c) $[_{v^*}$ r-expr$_{[F:_]}$ v*...$[_{c}$ C … $[_{v^*}$ v*…~~r-expr~~$_{\cancel{[F:\_]}}$...]]]

When C is merged (17a), assume that the lower v*P is sent to Spell-Out. Since the r-expression is not yet licensed, as it lacks case and a theta-role, the LR process is triggered. Since the r-expression cannot be immediately remerged, as it is not selected for by C, it is inserted into the buffer (17b). Then when the matrix v* is merged, the r-expression is selected and remerged in matrix subject position (17c), after which its unvalued features can be checked. Crucially, the r-expression never moves to the edge of any phase. Nor is it ever merged in an intermediate position – it does not adjoin to the embedded CP edge. Under the standard Phase Theory account, it would have to move through each intervening phase edge. However, it is

5. See (35a) and (44) below for examples where direct theta merge blocking LR is crucial to our analysis.

more computationally efficient to avoid these extra remerge operations and simply remerge the r-expression directly in subject theta-position. Our proposals enable this more optimal solution. If our analysis is on the right track, it suggests that there may not be any need to use phase edges as escape hatches, a view which could lead to a simplification of Phase Theory. We leave for further analysis investigation of whether or not there is a need to access phase edges in derivations in general. We demonstrate in this paper that under the appropriate circumstances, LR allows a derivation to converge. Under other circumstances, an LI with an unvalued feature is stranded in a closed-off phase and a derivation crashes.

4. The computer model

We implemented our proposals via a computer model. Computer modeling of generative grammar has many useful aspects. One is verification: a working computer model that faithfully replicates a theory can help to demonstrate its coverage, consistency and coherence. Another is formalization: if pinned down in sufficient detail, this may permit the mathematical modeling of core theory properties, such as formal complexity and descriptive power. Stabler (1997) is an example of the latter; the Minimalist Grammar (MG) framework allows one to build simple yet powerful systems using just categorial selection and ±feature matching.[7] The computer model implemented for this paper is an example of the former aspect, verification. Our computer model faithfully replicates all aspects of the linguistic theory described. In terms of coverage, we attest that all examples described in the following sections of this paper have been verified. However, we have not attempted to mathematically model the computational properties of our theory.

Since linguistic theories are not complete down to every last detail, gaps will exist between the theoretical "blueprint" and a realized computer implementation. It is important to draw a line between theoretical commitments and the necessary pinning down of irrelevant details for the sake of a working computer program. In other words, there will always be features of the computer model to which no

6. We note here that the MG framework can model mildly context-sensitive grammars. It also permits the direct encoding of the feature matching portion of Chomsky's MP (Chomsky 1995), but does not appear to contain the apparatus necessary to encode further developments needed for the theory described in this paper: e.g. probe-goal search and computational reflexes when search limits are reached. In the case of Binding Theory, reduction of these mechanisms to pure feature matching would be of architectural interest but requires empirical demonstration; however, we are unaware of any such efforts in the MG framework.

theoretical import should be attached. Moreover, algorithmically speaking, there are always several ways to concretize an abstract theory. With these caveats in mind, what follows is a brief inventory of the implementation-based assumptions that underpin our computer model.

Basic phrase structure is determined by categorial selection. As is typically assumed in the Minimalist literature, we stipulate that complementizer (c) selects for tense (t). Tense selects for little v (v/v*). Little v selects for verb V (or perhaps another predicate such as an adjectival phrase). V may select for a variety of possible objects if the verb permits an object, e.g. determiner phrase (d) or propositional complement (c or t). In this implementation, selection is encoded using a Definite Clause Grammar (DCG) of the (simplified) form shown in (18).

(18)	c –> c, t.	d –> d, n.
	t –> d, t.	n –> n, d.
	t –> t, {search(g), copy(g)}.	c –> [that, empty complementizer].
	t –> t, v, {search(g), agree(t,g)}.	t –> [t-complete, t-defective].
	v –> v, V {search(g), agree(v,g)}.	n –> […lexical nouns…].
	v –> V.	d –> [the, a, self].
	V –> V, d.	V –> [think, like, …].

The DCG permits a simple (top-down, left-to-right) recursive descent execution strategy. However, the implementation is configured to construct bare phrase structure in a bottom-up (left-to-right) order.[8] Since a DCG is employed, the numeration is effectively constrained to be an ordered multiset. In other words, we assume heads are streamed to the DCG in the (correct) underlying left-to-right order.

In Chomsky's MP, displacement does not create new features (e.g. indices) or distinct phrases (e.g. traces). Our Binding model also does not introduce or rely on any external "marks" to indicate coreferentiality; instead, pronoun-antecedent identification is "baked" into the doubling constituent model. Therefore, implementation of displacement involves just a pure copy operation. For example, the specifier of tense may either be filled by a (pleonastic) noun directly from the stream or from a (phase-limited) search for a noun (phrase) in its complement domain (e.g. a sentential subject in specifier of v*).[9] In the case where search (search(g), g a goal) has returned a suitable candidate, the implementation simply copies it into the specifier of tense. By the no-tampering condition (Chomsky 2006), the complement domain remains unmodified.

7. This bottom-up order is reported in the screenshots shown in this paper.

8. The first option is encoded by the t –> d, t. rule. The second by t –> t, {search(g), copy(g)}.

Agree is implemented at the DCG rules for tense and little v. The probe-goal search operation (search(g)) obtains a goal (g) and the operation agree(head,g) implements uninterpretable/interpretable feature agreement between the head of tense or little (v) and the matched goal (g). If no suitable goal is found, the rule fails to complete and other choices may be explored.

With respect to non-determinism, we should distinguish theory choice points imposed by the linguistic theory and computational choice points introduced as artifacts of the implementation. Architecturally, an ideal implementation will introduce no computational choices of its own. More precisely, given an instruction stream of heads, assembly into a complete phrase should proceed deterministically without backtracking or multiple threading. Our choice of an ordered multiset does not fully implement Chomsky's original (non-deterministic) numeration; e.g. *John likes Mary* and *Mary likes John* are both possible outcomes of the same numeration in Chomsky's model; in our model, these two sentences would be generated by different orderings of the same numeration. Similarly, our implementation does not allow for a free choice of antecedents for a pronoun from a given numeration; the assembly of the doubling constituent is fixed by stream order. In terms of computational choice points, a recursive descent interpretation of the DCG is intrinsically non-deterministic.[10] Different models could be employed to reduce local non-determinism introduced by rule choice points.[11]

This computer model incorporates the LR process, repeated below, in the following manner.

(19) Last Resort (LR): an LI with an unvalued feature that is in imminent danger of falling outside of a probe-goal scope relation can:
- (a) preferentially undergo internal merge into an available theta-position, or
- (b) go into a buffer for later external merge,
- (c) external merge to a theta-position has priority over Last Resort.

Algorithmically speaking, when a phase edge is reached, there is a Last Resort search, skipping past one phase, into a lower phase. This component models the PIC – there is a search into the next lower phase because that entire phase will be

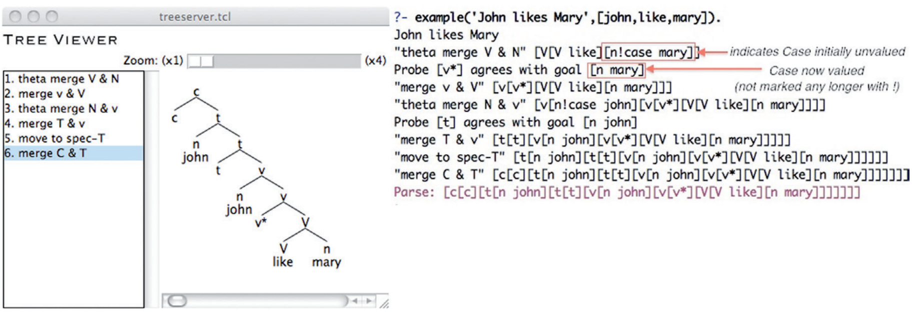
9. The execution model permits multiple rules for a given non-terminal. The order in which they are tried is simply in the order in which they are written.

10. This discussion could extend way beyond the scope of this paper. Many implementation strategies from the formal language and compiler theory literature could be employed. For example, a bottom-up, shift-reduce grammar rule model could replace the recursive descent model. Traditional ambiguity-reducing optimizations such as left-corner or lookahead sets are also possible choice point reduction strategies.

closed off. If no lower phase is present, the Last Resort search process fails. If a lower phase is present, and there is an LI in that phase that has an unvalued feature, that LI is selected. Then, if theta-Merge with the label of the tree is possible, the LI is immediately remerged into the derivation. Otherwise, the LI is inserted directly into a buffer, where it remains until it can be remerged, if possible.

Our model automatically constructs, as described above, the derivation of a sentence from a numeration that it is fed. Example (20) is a screenshot of the derivation of the simple sentence 'John likes Mary'. The left side of the Tree Viewer lists each step of the derivation. The middle of the tree viewer displays tree diagrams of each step of the derivation. The right side shows each step of the derivation in bracket format. Initially, case on 'Mary' and 'John' is unvalued, as represented with 'n!case'. When case becomes valued, the 'n!case' disappears – it is valued and eliminated. V merges with 'Mary'. Then v* merges and assigns 'Mary' case. This is followed by theta merge of 'John', etc.

(20)



We next demonstrate how this model constructs the derivations of sentences with pronoun-antecedent relations.

5. Derivations

In this section, we demonstrate how the LR process accounts for a variety of pronoun-antecedent data. We examine mono-clausal constructions, bi-clausal constructions, possessive DPs and picture DPs.

5.1 Pronoun-antecedent relations in mono-clausal constructions

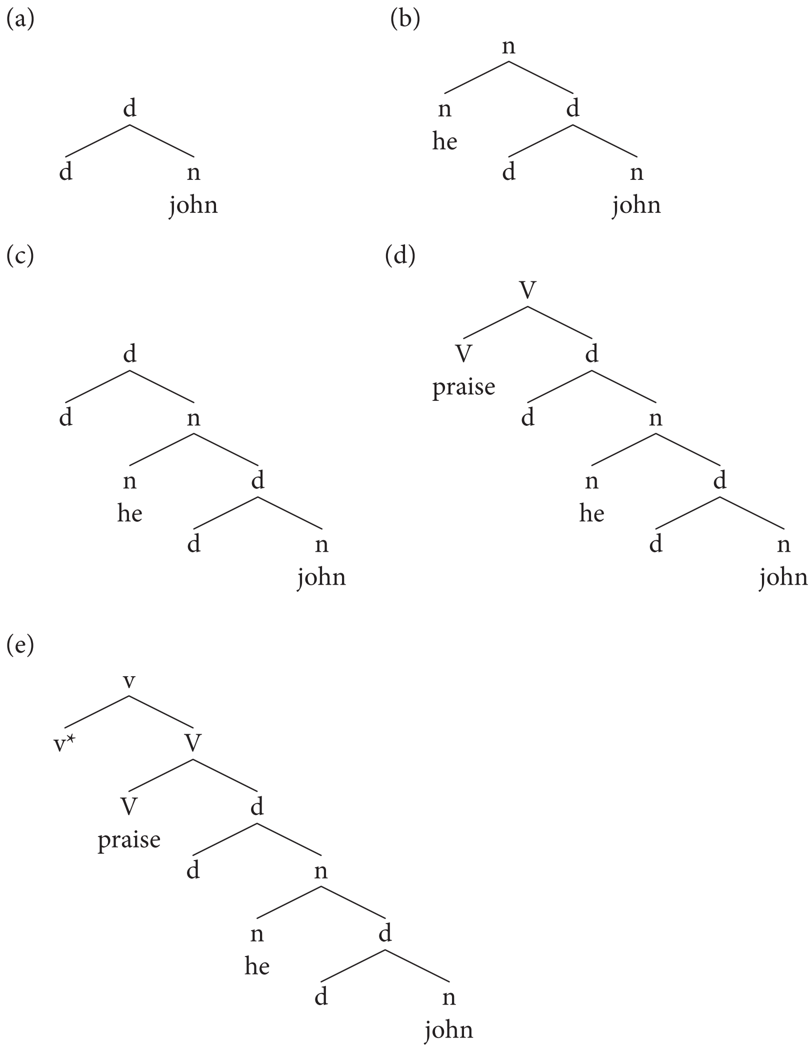
First of all, we account for the complementary distribution of pronouns and anaphors in local relations, as in (21a–b), originally presented as (5a) and (6a) above.

(21) (a) *John$_i$ praises him$_{i.}$
(b) John$_i$ praises himself$_i$.

The distinction between these examples results from the (im)possibility of the r-expression 'John' to undergo the LR process, which depends on whether or not the r-expression is base-generated within a DP phase.

The derivation of the ill-formed (21a) proceeds as show in (22a–e), which are screenshots of the derivation as it is constructed automatically by our model.

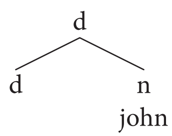
(22)



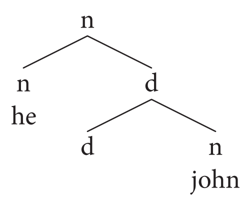
Initially, D and 'John' are merged (22a). This is followed by merge of the pronoun 'he' with the DP (22b), and then merge of a higher D, to form the complete doubling constituent (22c). Next, the V ‘praise’ is merged (22d), followed by v* (22e). When v* is merged, there is no lower phase present and thus no phase is closed off. At this point, the DP ‘John’ has unvalued features, since it lacks case and a theta role (it is not licensed). However, since it is not contained within a phase that is about to be closed of, it cannot undergo the LR process. As a result, there is no DP available for merge with v* and the derivation crashes. Thus, we are able to account for the inability of a pronoun to be bound locally – a Condition B effect.

The derivation of the well-formed (21b) proceeds as in (23a–i). Crucially, the doubling constituent in this example corresponds to an anaphor and antecedent.

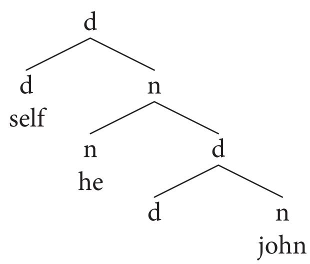
(23) (a)



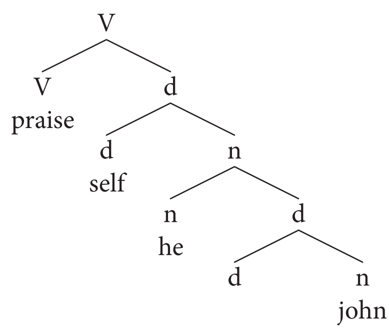
(b)



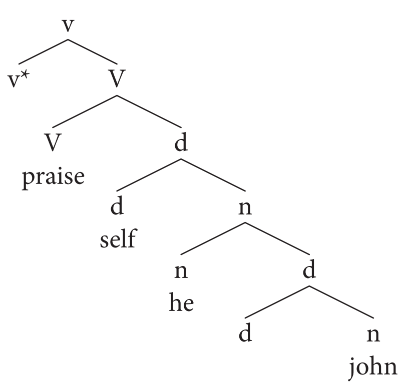
(c)



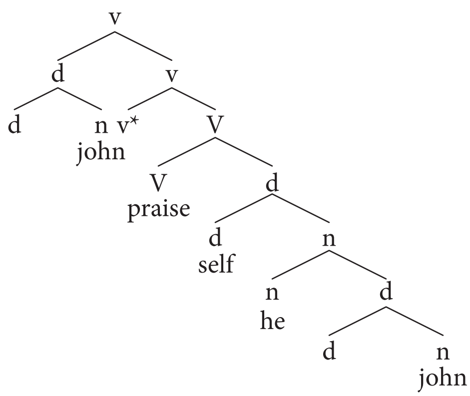
(d)



(e)



(f)


v
d
v
d
n
v*
V
john
V
d
praise
d
n
self
n
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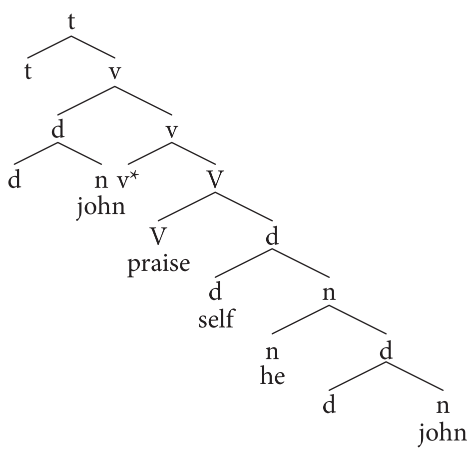
he
d
n
john

(g)


t
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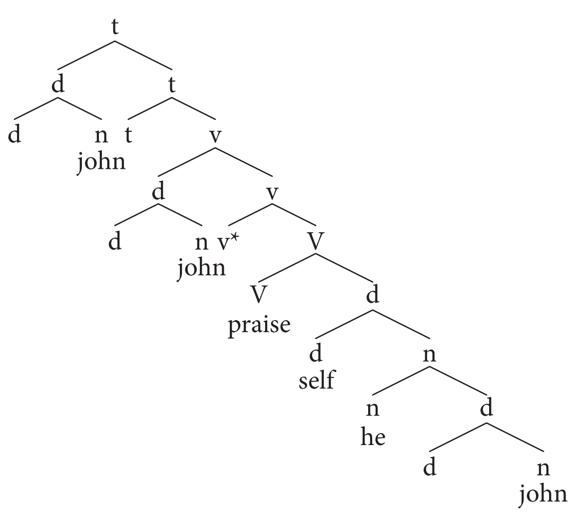
(h)


t
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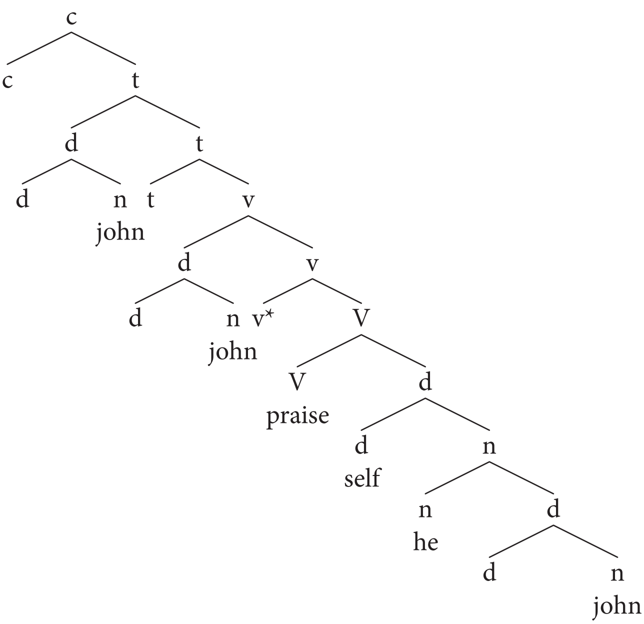
(i)



The doubling constituent is formed in steps (23a–c), and forms a DP phase after merge of the D ‘self’. The V ‘praise’ is merged (23d), followed by merge of v* (23e). Crucially, the DP ‘John’ lacks case and a theta-role. Thus, when v* is merged, since ‘John’ is contained within a lower DP phase that is about to be closed off, and ‘John’ contains unvalued features, it undergoes the LR process. Since v* selects for a subject DP and there is no LI available for external merge, ‘John’ is immediately remerged with v*, thereby landing in subject theta-position (23f). This is followed by merge of T (23g). Then ‘John’ undergoes EPP driven movement to [Spec, T] (23h). Lastly, C is merged (23i) and the derivation converges successfully. We thus account for a Condition A effect, since the anaphor is bound locally.

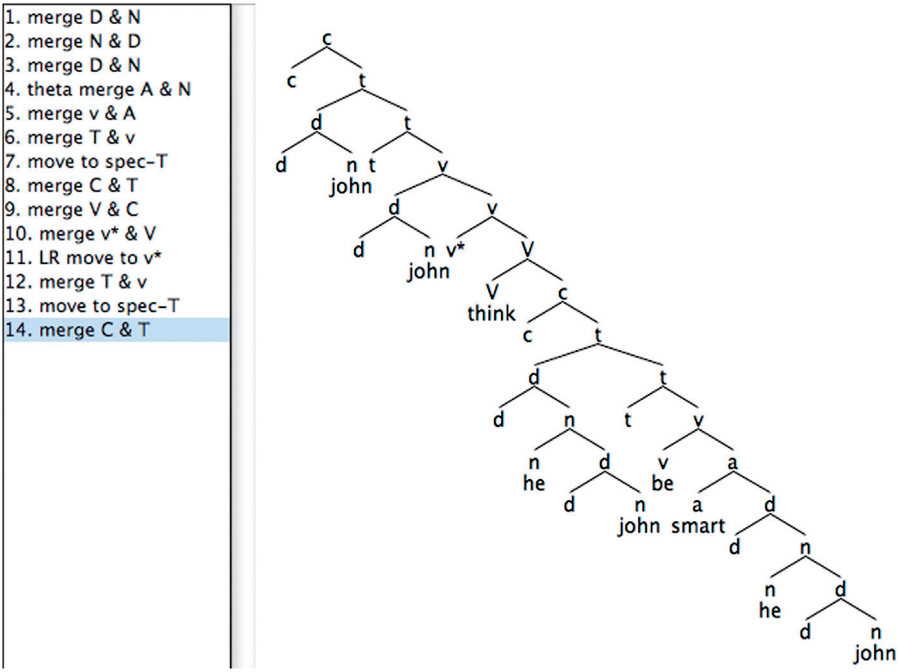
5.2 Pronoun-antecedent relations in multi-clausal constructions

We next turn to pronoun-antecedent relations in multi-clausal constructions. Our analysis accounts for why a pronoun and antecedent can co-occur if they are in separate clauses. Consider (4a), repeated below.

(24) John$_i$ thinks he$_i$ is smart.

The derivation for this example is shown in (25). The left side of the screenshot lists each step of the derivation.

(25)



The doubling constituent '[he John]' is base generated within the adjectival predicate. Then it undergoes EPP-driven movement to subject position of the embedded clause. When the matrix v* is merged, crucially, the lower CP phase must be closed-off. Thus, 'John', which contains unvalued features (it lacks a theta-role and case), undergoes the LR reinsertion process and it is immediately remerged in subject-theta position in the matrix [Spec, v*]; v* selects for DP and there is no other DP available for external merge.

Our analysis also straightforwardly accounts for the impossibility of a pronoun binding an r-expression as in (3a), repeated below.

(26) *He$_i$ thinks John$_i$ is smart.

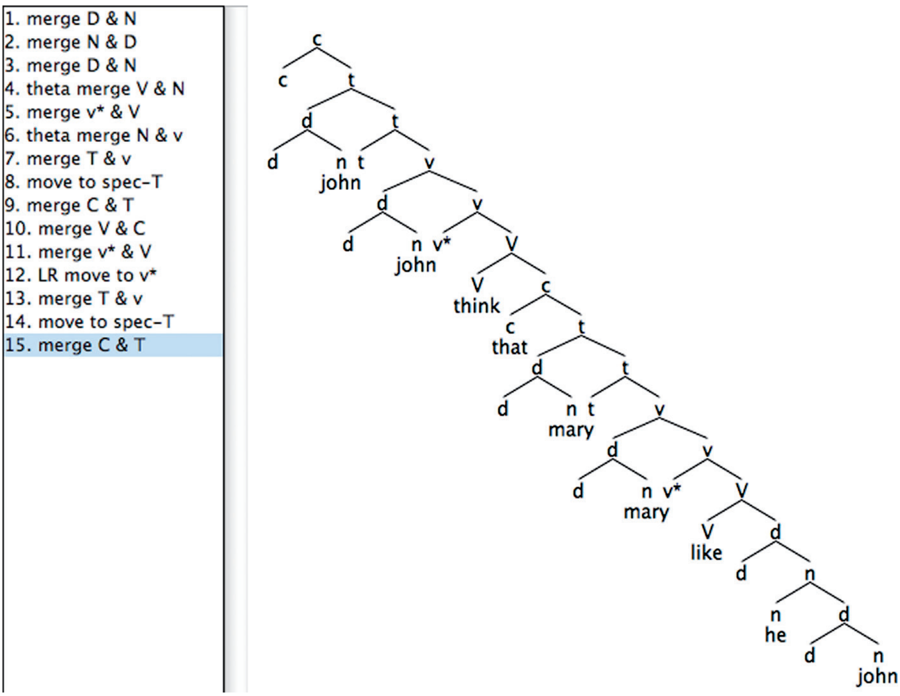
Following Kayne's proposal that the head of a doubling constituent must be a pronoun (see our proposed structure in (13a)), (26) is underiveable. The doubling constituent must have the form (simplified) '[he John]', with the head 'he', and thus, it can only result in the LR movement of 'John', thereby producing example (24) above. Thus, the impossibility of binding an r-expression in this example, a Condition C effect, is accounted for.

In addition, we account for the possibility of long-distance co-reference relations (Condition B effects). Consider (7a), repeated below, which as noted in Section 2, is problematic for Kayne's analysis.

(27) John_i thinks that Mary likes him_i.

The derivation is shown in (28).

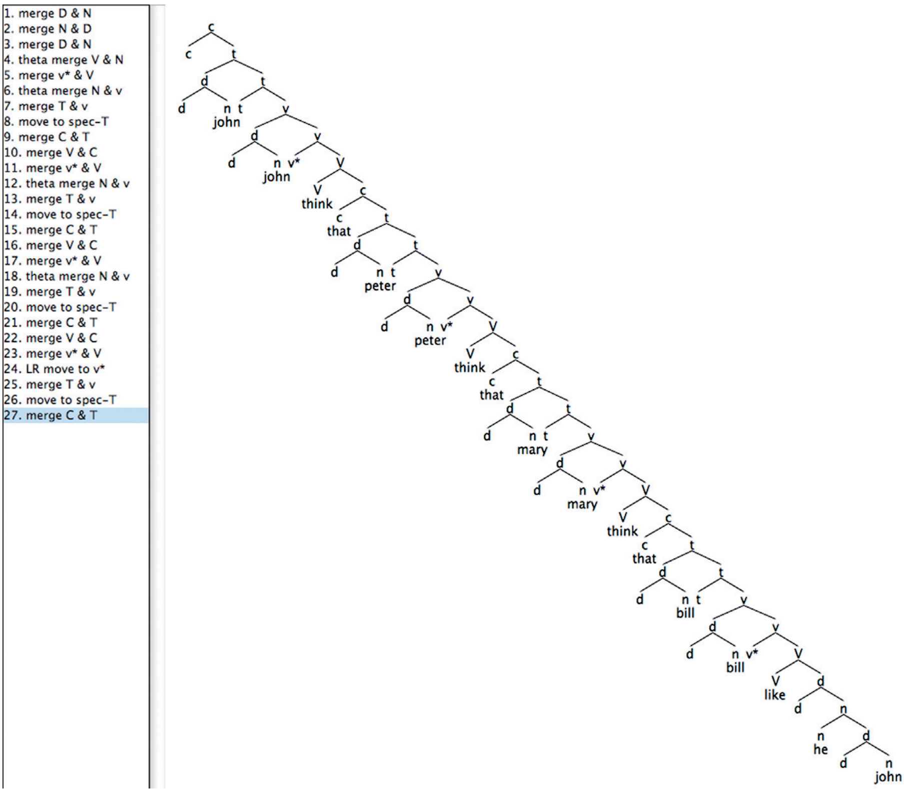
(28)



When the lower v* is merged, there is no lower phase present, and thus 'John' cannot undergo the LR process. When the embedded C is merged, the lower v*P will be closed off. Thus, at this point, 'John', which contains unvalued features, is subject to the LR process. However, the head of the tree at this point, C, does not permit theta-merge. As a result, 'John' cannot be used immediately and be remerged into the derivation. Therefore, 'John' is inserted into a buffer. When the matrix v* is merged, 'John' is selected and merged in subject theta-position, and the derivation converges successfully. Long distance coreference, as in (29)' is accounted for in a similar manner, as shown in (30).

(29) John_i thinks that Peter thinks that Mary thinks that Bill likes him_i.

(30)



In this construction, when the most embedded C is merged, the lower v*P will be closed off. Thus, 'John' undergoes the LR process. Again, since C does not permit theta-merge, 'John' goes into the buffer and then is remerged in matrix subject position. This raises the issue of whether or not an r-expression in a buffer must be merged in matrix subject position.

We suggest that the following holds, with respect to an LI in a buffer.

(31) An LI in a buffer is merged in the highest possible position.

Once a DP is inserted into a buffer, it can potentially be inserted into any theta-position. However, there is a preference for merge in the matrix subject position. (32), in which the r-expression 'Peter', which is coindexed with the pronoun, does not appear in the matrix subject position is marginal.

(32) (?*)John thinks that Peter$_i$ thinks that Mary thinks that Bill likes him$_i$.

We suggest that this preference for a matrix subject is motivated by parsing considerations. The generator, "aware" of parsing considerations, prefers the highest subject. Parsing and generation have different computational starting points (a surface sequence vs. an unordered lexical array) and therefore must rely on different mechanisms (e.g. gap-filling vs. upwards movement). We propose that parsing and generation are not completely independently-derived mechanisms: in fact, there must be some "co-awareness" between them in terms of computational strategy for efficiency. As numerous studies in the psycholinguistics literature have shown, top-down prediction and left-to-right expectation are properties of parsing that have demonstrable impact; e.g. preferences for subject vs. object gap-filling (e.g. see King & Kutas 1995). Top-down prediction logically implies that the matrix subject position will be proposed and filled first from the surface input. That matrix subject must be "remembered" or carried along as parsing proceeds from higher to lower phrases, possibly into lower clauses, until its "gap" or originating theta position is found.[12] (Assuming the framework proposed in this paper, that gap may also occur within a DP doubling constituent headed by a pronoun.) This situation requires working memory. Let us call this working memory a "buffer". We must also deal with the possibility of predicting multiple gaps as parsing proceeds to fill in other open positions from the input, as an additional computational burden, but the matrix subject is the first hypothesized "passenger" of the parsing process.

We propose that generation may also make use of this working memory; in other words, co-opt this buffer resource and respect its preferences. Hence, there is a matrix subject preference when items are placed into the buffer. However, if the LI in the buffer cannot be merged in matrix subject position (e.g. there is a gender mismatch) then it will be merged in a lower position, if possible.

As pointed out by an anonymous reviewer, (33) is fine.

(33) Lucy said that Peter$_i$ thinks that Mary likes him$_i$.

Crucially, due to the gender mismatch between the matrix and higher embedded subject, this does not create a problem for parsing. Since it does not create a problem for parsing, it does not create a problem for generation. In this manner, merge of a subject from the buffer into a non-matrix position is possible if it does not cause a problem for parsing.

We also are able to account for the impossibility of long distance binding of an anaphor, as in (8a), repeated below, which we noted is problematic for Kayne's analysis.

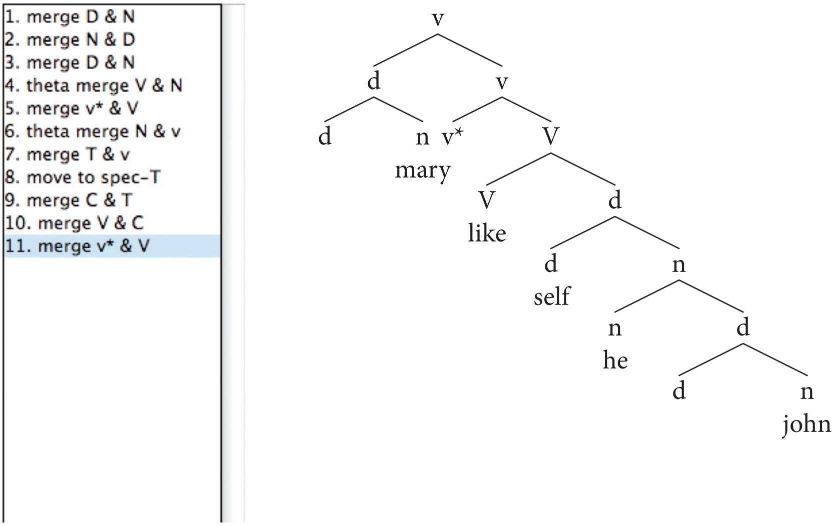
(34) *John$_i$ thinks that Mary likes himself$_i$.

11. We put aside here the case of direct injection of a pleonastic, as in *It rains*.

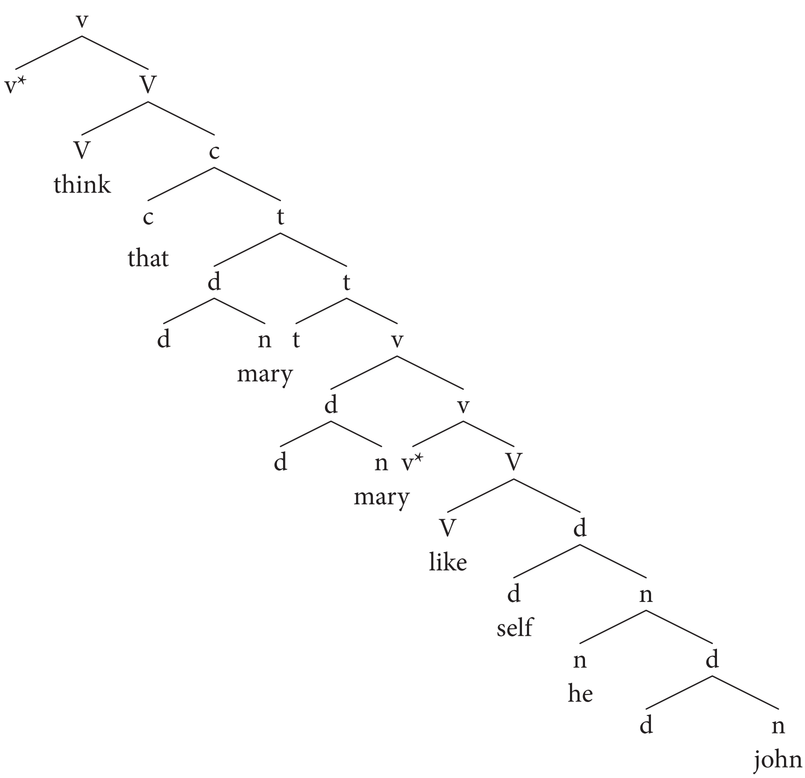
The relevant parts of the derivation are shown in (35a–b).

(35)

(a)



(b)



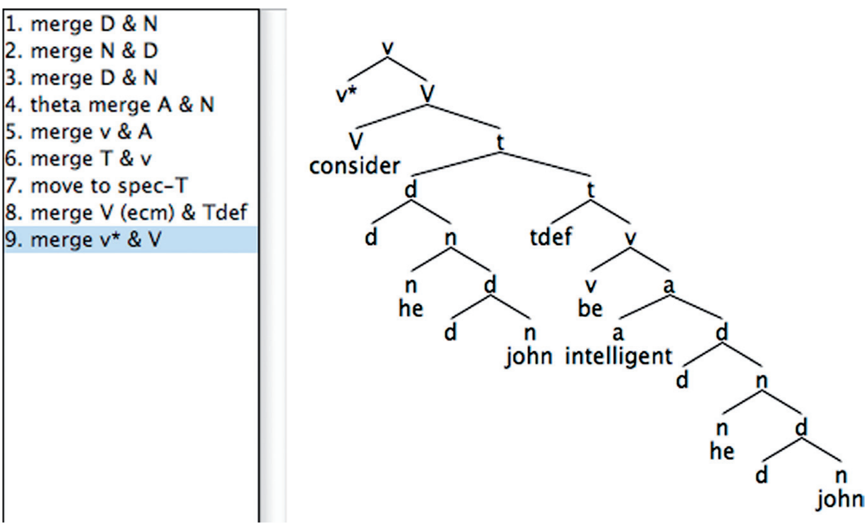
The doubling constituent crucially originates within a DP phase. When v* is merged, the lower DP will be closed off. The DP 'John' contains unvalued features. However, in this case, the direct external merge of the subject 'Mary' blocks the LR process, since external merge is a simpler and more efficient operation then remerge of 'John' in a theta-position or insertion of 'John' into a buffer.[13] As a result, 'John' remains in-situ, and 'Mary' is merged in subject position (35a). Then, when the matrix v* is merged (35b), there is no subject available and the derivation crashes. The impossibility of local binding of an anaphor in this construction, a Condition A effect, thus falls out of our analysis.

ECM constructions, which are problematic for Kayne's analysis, also are accounted for. Consider (9a), repeated below.

(36) *John$_i$ considers him$_i$ to be intelligent.

The relevant part of the derivation is shown in (37). The doubling constituent raises from within the adjectival predicate to [Spec, T] of the embedded clause. Assuming that an ECM lacks a CP (Chomsky 1981), when the matrix v* is merged, the lower TP, which contains the doubling constituent, is not a phase, and thus will not be closed off. As a result, 'John' is unable to undergo the LR process, leaving no matrix subject available, and causing the derivation to crash.

(37)



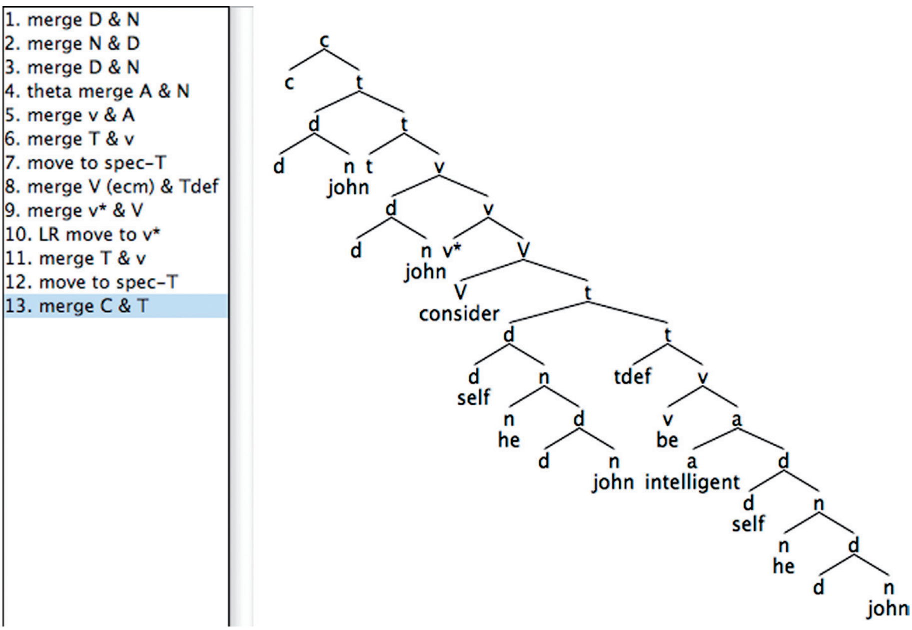
12. This blocking action is crucial. For example, if the buffer is available to 'John', the illicit derivation will go through.

We also predict the possibility of an anaphor in subject position of an ECM clause, as in (38).

(38) John$_i$ considers himself$_i$ to be intelligent.

Unlike in the derivation of (36) above, 'John' is contained within a DP phase doubling constituent. As shown in (39), the DP doubling constituent raises to the embedded [Spec, TP]. When the matrix v* is merged, the DP phase will be closed-off. As a result, 'John' undergoes the LR process. Since v* selects for a subject and there is no other subject available for theta-merge, 'John' is reused immediately and remerged in subject theta-position.

(39)

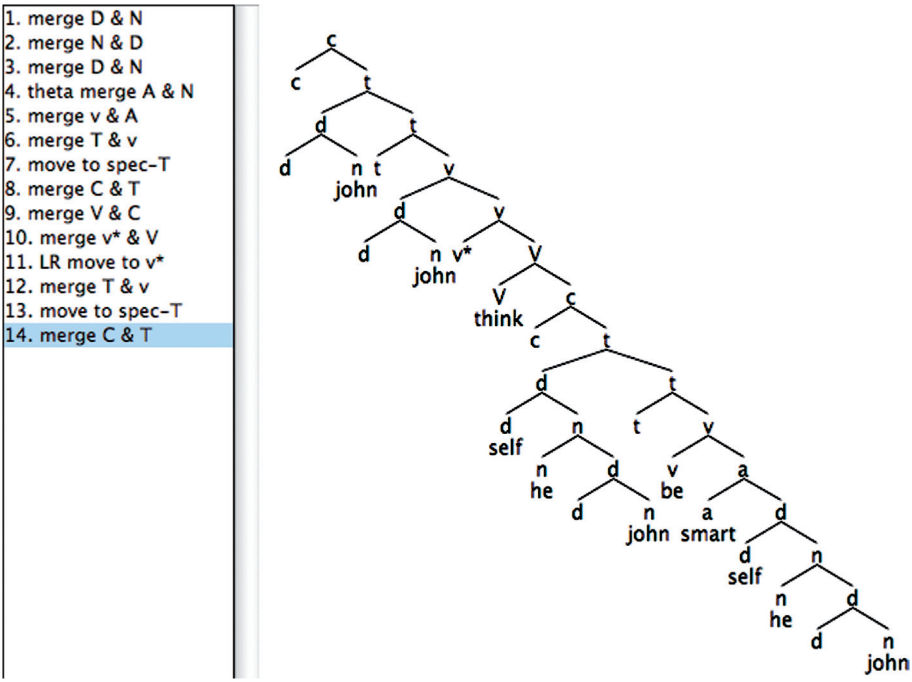


Next, consider the following example, in which 'heself' occurs in subject position of an embedded clause.

(40) *John$_i$ thinks heself$_i$ is smart.

As shown in (41), when the embedded C is merged, 'John' will undergo the LR process and be inserted into a buffer (since theta-merge is not possible), after which it can be merged in subject theta-position.

(41)



We attribute the ill-formedness of this example to an independently motivated ban on nominative reflexives (e.g. there is no 'heself' in English). Rizzi (1990) argues that the impossibility of a nominative anaphor results from an "anaphor agreement effect" – the impossibility of an anaphor to undergo agreement. A subject anaphor in a finite clause in English undergoes agreement with the local verb, thus resulting in ill-formedness. We leave investigation of this anaphor agreement effect for further work, but see Rizzi (1990) and Woolford (1999) for further discussion.[14]

13. Rizzi (1990) presents two possible explanations, which rely on the notion that agreement is a pronominal element, for the anaphor agreement effect. One proposal is that a referential autonomy hierarchy, of the form "R-expressions > pronouns > anaphors (Woolford 1999: 278)" is at play. An anaphor in subject position of a finite clause is an argument and the agreement of the anaphor is a nonargument pronominal. The anaphor and its agreement form a chain. This agreement, being a pronoun, is higher on the referential autonomy hierarchy than the anaphor. The agreement-anaphor chain is ruled out by a ban against a "non argument in the chain which is higher in the referential autonomy hierarchy than the argument (Rizzi 1990: 37)." Rizzi's other proposal is that when an anaphor undergoes agreement, the result is a single binding domain that contains an anaphor, subject to Condition A, and a coindexed pronominal (the agreement) which is subject to Condition B. Since both Condition A and Condition B cannot be met within the same binding domain, the result is ungrammatical. See Woolford (1999) for further discussion of Rizzi's proposals, as well as evidence that anaphors

We have applied our analysis to a variety of pronoun-antecedent facts. We have accounted for the same data that Kayne's analysis can account for (3–6). In addition, we have demonstrated how our analysis accounts for data that are problematic for Kayne's analysis (7–9).

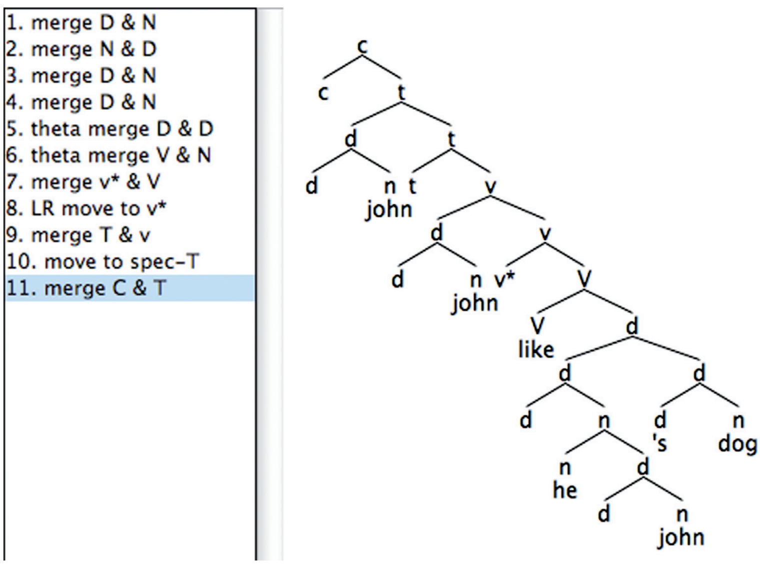
5.3 Pronoun-antecedent relations in possessive DPs

We next turn to possessive DPs. As discussed in Section 2, the possessive DPs in (10a) and (11a), repeated below, are a problem for Kayne's analysis. Our analysis, however, predicts these judgments.

(42) (a) John$_i$ likes his$_i$ dog.
(b) *John$_i$ likes himself$_i$'s dog.

Example (42a) is interesting because the pronoun 'he', assuming that 'he' + ''s' = 'his', appears to be bound locally – a Condition B violation. Our analysis accounts for the well-formedness of this construction as resulting from the possessive DP being a phase. The derivation of (42a) is shown in (43).

(43)



When v* is merged, the possessive DP phase will be closed off. Therefore, the r-expression 'John' undergoes LR and is remerged immediately with v* – a subject theta-role is assigned and the derivation converges.

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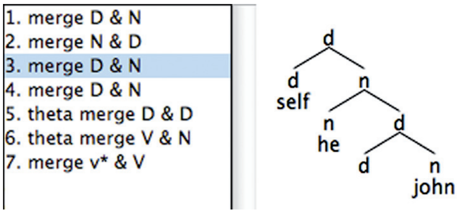
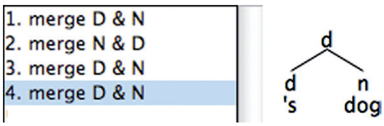
can undergo agreement, but only if this is a special type of anaphoric agreement. We leave for future work the issue of how exactly this anaphoric agreement effect can be incorporated into our doubling constituent analysis.

The relevant parts of the derivation of the ill-formed (42b) are shown in (44a–d).

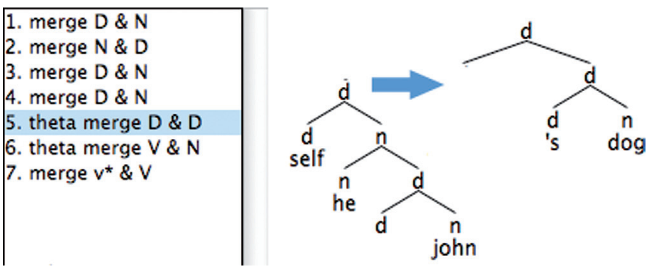
(44) (a)



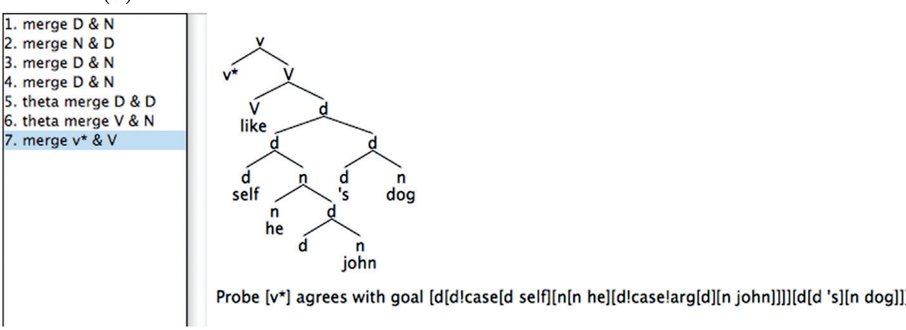
(b)



(c)



(d)



In (42b), we need to explain what prevents 'John' from undergoing internal merge to specifier of v*, the sentential subject position. In fact, we argue that 'John' is blocked from being moved at all from its originating position inside the doubling constituent. First, the anaphor doubling constituent (44a) and the possessive (44b), both phases, are constructed separately. Since both DPs are phases, it appears that it should be possible *prima facie* to raise 'John' to the specifier of possessive ''s' by applying LR. However, internal merge can only apply to already merged syntactic objects; LR itself being a special case of internal merge. If (44a) and (44b) are to be merged first to satisfy this constraint, as illustrated in (44c), the possibility of LR disappears altogether since the target position, namely the specifier of possessive ''s', will be filled by (44a). In other words, merge of the anaphor doubling constituent essentially blocks LR extraction of 'John' from within the doubling constituent. Continuing on, when v* is merged as shown in (44d), 'John' is unavailable for theta-merge to specifier of v* because, being beyond two phase boundaries down, it is inaccessible and LR cannot save it. Without an available subject for v*, the derivation can progress no further, and therefore crashes.[15]

5.4 Pronoun-antecedent relations in picture DPs

We next demonstrate how our model can be extended to account for certain picture DP constructions. An experimental study of native speaker judgments of picture DPs by Keller and Asudeh (2001) found that pronouns and anaphors are in complementary distribution in some cases (45a–b) and (45c–d), but not in others (45e–f).[16,17] Examples (45e–f) are interesting in that subjects found both the pronoun and anaphor to be generally acceptable.[18]

(45) (a) ?*Hannah$_i$ found a picture of her$_i$.
(b) Hannah$_i$ found a picture of herself$_i$.
(c) ?*Hannah found Peter$_i$'s picture of him$_i$.
(d) Hannah found Peter$_i$'s picture of himself$_i$.
(e) Hannah$_i$ found Peter's picture of her$_i$.
(f) Hannah$_i$ found Peter's picture of herself$_i$.

14. Note, in principle the derivation must crash even if a suitable subject is made available for direct merge from the numeration, as in **Mary likes [self he John]'s dog*. In this case, the doubling constituent merges with the possessive DP. After merge of v*, the subject 'Mary' is merged. The derivation crashes because the r-expression 'John' cannot receive a theta role in its (original) doubling constituent position.

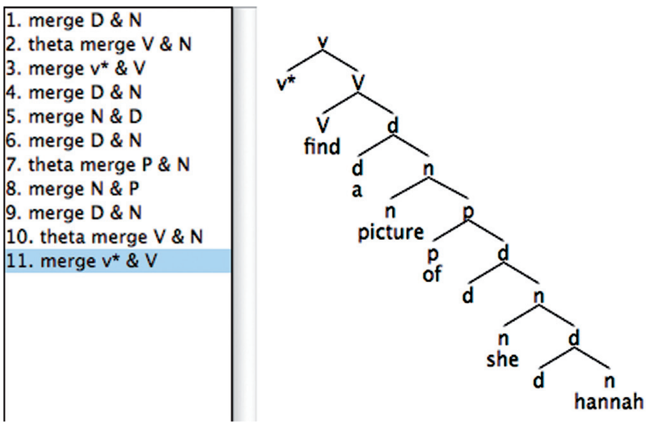
15. The judgments that we give reflect those presented by Keller and Asudeh (2001), as resulting from their study.

16. Phrases containing "picture", generally referred to as picture NPs or DPs, have been problematic for Binding Theory since its inception (e.g. see Chomsky 1981, 1986).

17. We note that (45f) does not seem to be completely acceptable to us – see the discussion of (53). Also, the traditional Binding Theory predicts that this example should be ill-formed (cf. Keller & Asudeh 2001).

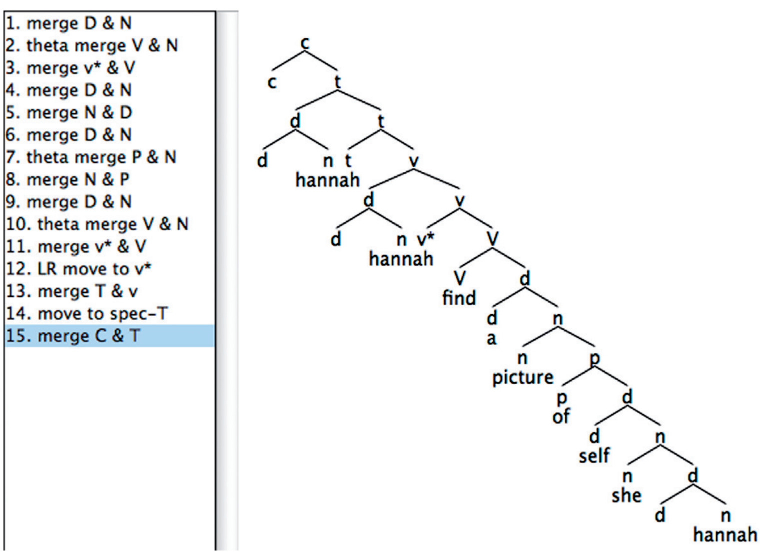
The complementary distribution between (45a–b) depends on the availability of LR movement, as determined by whether or not the r-expression is base generated in a DP phase. In (45a), as shown in (46), when v* is merged, the r-expression 'Hannah' is not contained within a phase that is about to be closed-off. Therefore, it cannot undergo the LR process and no subject theta-role is assigned, causing the derivation to crash.

(46)



In (45b), the r-expression originates within a DP phase. Thus, when v* is merged, since the DP doubling constituent will be closed off, 'Hannah' undergoes the LR process. In this case, it is remerged immediately in subject theta-position and the derivation converges, as shown in (47).

(47)

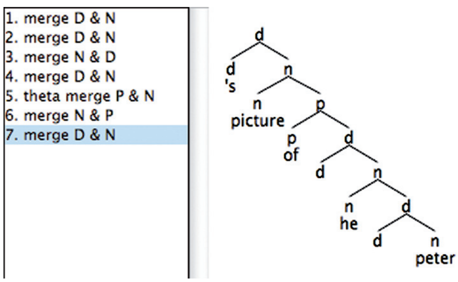


The complementary distribution between a pronoun and anaphor in possessive picture-DPs, as in (45c–d), repeated below, is also accounted for. Crucially, a possessive D ''s' is a phase head.

(48) (a) ?*Hannah found Peter$_i$'s picture of him$_i$.
(b) Hannah found Peter$_i$'s picture of himself$_i$.

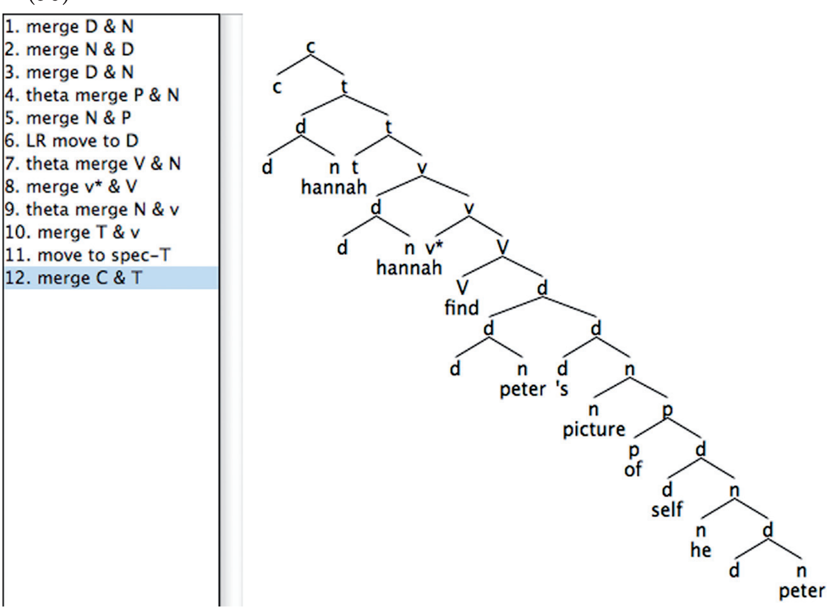
In the ill-formed (48a), when the possessive D ''s' is merged, the r-expression, not being contained within a lower phase, is unable to undergo the LR process and a possessive subject theta-role is not assigned, causing the derivation to crash.

(49)



In the well-formed (48b), 'Peter' is base generated within a DP phase doubling constituent. When the possessive D ''s' phase head is merged, 'Peter' undergoes LR and is remerged in subject theta-position of the possessive DP since ''s' selects for a subject. The derivation converges, as shown in (50).

(50)

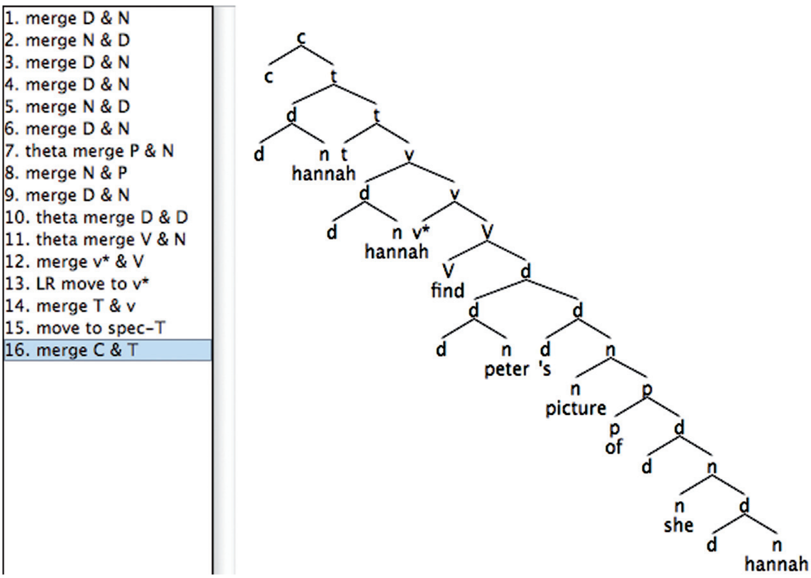


Example (45e), repeated below, is also accounted for.

(51) Hannah$_i$ found Peter's picture of her$_i$.

As shown in (52), the doubling constituent is not a DP phase. However, it is contained within a possessive DP phase. Thus, when the matrix v* is merged, 'Hannah' undergoes the LR process and is remerged in subject theta-position.

(52)

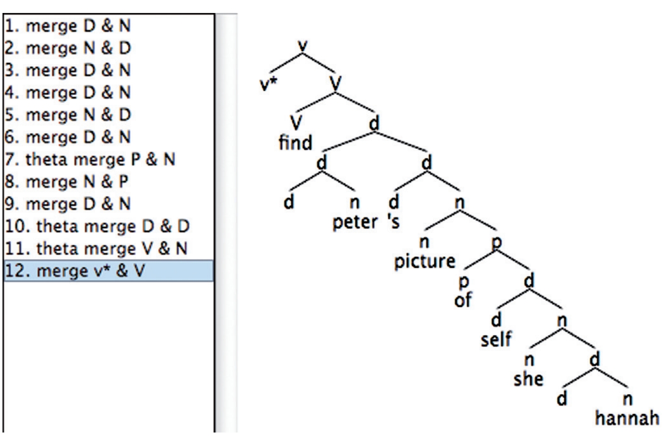


Lastly we turn to (45f), repeated below.

(53) Hannah$_i$ found Peter's picture of herself$_i$.

Our model produces the following derivation, which crashes.

(54)

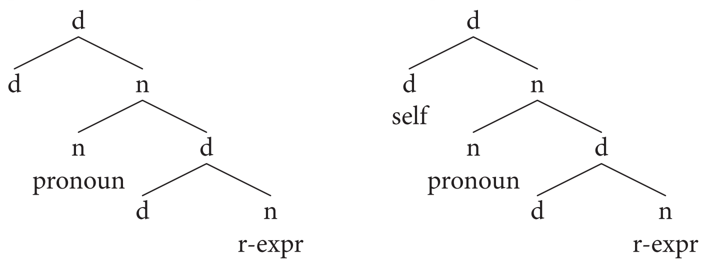


When the possessive D phase head ''s' is merged, the lower DP phase containing 'Hannah' will be closed off. 'Hannah', which contains unvalued features, is blocked from undergoing the LR process because of the possibility of external theta-merge of 'Peter' to subject position of the possessive DP. Therefore, when v* is merged, there is no subject available and the derivation crashes. This is the derivation at work for people who find this example ill-formed; our intuition is that this example is not perfect. However, Keller and Asudeh (2001) found that subjects considered this example to generally be well-formed. For those who find this well-formed, we suggest the following possibility; inherent case assignment may void a phase boundary in order to save a parse. In this construction, 'of' assigns inherent genitive case to its DP doubling constituent complement. This case assignment may, for some people, void the DP phase boundary when there is an LI within it that needs raising, resulting in the DP doubling constituent not functioning as a phase. When the matrix v* is merged, the lower possessive picture DP will be closed off, thus forcing LR to apply to 'Hannah'. Crucially, this phase boundary voiding only works to save a parse; otherwise, LR would not be triggered for (45b,d). This proposal, however, is speculative and requires further investigation.

6. The doubling constituent structure

We next return to our proposed structures for pronouns and antecedents, (13a–b), repeated below, which crucially rely on a difference in phasehood between a pronoun and antecedent doubling constituent and an anaphor and antecedent doubling constituent, the latter being a phase.

(55) (a) pronoun and r-expresssion (b) anaphor and r-expression



There are two basic properties of the structures that are crucial: (a) phrases with 'self' are phases, and (b) the pronoun selects for the r-expression and doesn't move. There may be further structural details that can be elaborated on in future work; e.g. the internal structure of the doubling constituent may be more elaborate than what we propose, but this is not crucial to our analysis. We have demonstrated, in the previous sections, that these structures, combined with the LR process, account for a variety of coreference data.

We next turn to a further piece of evidence that supports the proposal that 'self' is the head of a DP phase; example (56).

(56) John$_i$ is self$_i$-praising.

This example is accounted for if the r-expression and 'self' originate in the following structure, where D*P indicates a phase DP.

(57) [$_{D^*P}$ self John]

In (56), when v* is merged, the D*P anaphor phase is closed-off (58a). LR applies (58b) and 'John' is remerged in subject position. We assume that 'self' affixes onto the verb via a process of morphological incorporation, the nature of which we leave aside.

(58) (a) [$_{v^*P}$ v* praising [$_{D^*P}$ self John]]
(b) LR: Remerge 'John' with v*
(c) [$_{v^*P}$ John praising [$_{D^*P}$ self ~~John~~]]

Thus, (56) is accounted for straightforwardly if 'self' is a phase head, even though it originates in a doubling constituent that lacks a pronoun (57). This example supports our proposal that an anaphor is base generated in a DP with the phase head 'self'.

In addition, Hicks (2009) independently proposes a structure for certain DPs in tough-movement constructions that is very similar to our proposed structure. Hicks proposes that in a tough-movement construction such as (59a), there is a DP with the structure in (59b). There is a null Operator N head with a DP complement 'everyone'. The null operator is licensed in its base position and the DP complement undergoes movement in order to become licensed – to obtain case.

(59) (a) Everyone is tough for us to please. (Hicks 2009: 547)
(b) [$_{DP}$ D [$_{NP}$ [$_{N}$ Op] [$_{DP}$ everyone]]]

See Hicks (2009) for the details of this analysis. The key point that is important for us is that in this proposed structure, there is an N head with a DP complement and the DP complement undergoes movement; i.e. Hicks' proposed structure of a complex-DP in a tough-movement construction, if correct, provides independent evidence for our proposed doubling constituent structures of a pronominal-antecedent construction in which there is a pronominal N that has a DP r-expression complement.

7. Conclusion

Computationally speaking, a system that exhibits unbounded discrete infinity can still exhibit operational efficiency if its primitive operations have bounded or limited scope and there are no unnecessary choice or computational branching points in the system. The merge/agree system, as proposed in Chomsky (2001), exhibits both these properties. The probe-goal mechanism that underlies the agree relation is efficient in the (first) sense since goal search is phase bounded. Our introduction of Last Resort displacement directly to an edge theta position is similarly a local (and thus) efficient operation since it operates just within the same probe-goal search domain. Structure building in Chomsky's system is also efficient in the (latter) sense since selecting whether to externally merge or displace is fixed by the choice of LIs and disambiguating maxims such as Maximize Matching Effects or Merge Over Move. Our proposals continue to preserve this efficiency. Last Resort creates no new computational choice points since by definition it is available only when no other operations apply. Our novel buffer mechanism facilitates long distance displacement of antecedent r-expressions to a target theta position in a single paired operation without recourse to iterated movement. It also does not introduce any extra choice points into the system since the competing operation of external theta merge takes precedence over and blocks its application.

In conclusion, this analysis accounts for more data than Kayne (2002) with fewer stipulations. A wide variety of coreference facts result from base generation of a pronoun and antecedent within a DP, and the possibility of Last Resort movement (that can carry an r-expression into theta-position) as determined within the limits of Phase Theory.

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Concealed reference-set computation

How syntax escapes the parser's clutches

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It has been conjectured that all properties of language beyond recursion can be motivated by interface requirements. One component in this setup is the parser, which is thought to give rise to a preference for computational parsimony. I discuss a mathematical result on reference-set computation, an (allegedly) non-parsimonious piece of machinery, that challenges this assumption and suggests that syntax can sometimes "trick" the parser in order to escape its demands. If reference-set constraints are construed as so-called tree transducers, they do not increase the power of the syntactic machinery. This in turn entails that they can be expressed purely in terms of the Minimalist feature calculus regulating Merge and Move, so it cannot be ruled out that syntax employs reference-set constraints, whereas the parser operates on their less demanding equivalents. In order to demonstrate the viability of this approach for the kind of reference-set constraints found in the literature, I give an implementation of Merge-over-Move.

Keywords: Transderivationality; Merge-over-Move; Minimalist grammars; tree transducers

1. Introduction

A core assumption of the biolinguistic program is that all properties of syntax beyond recursion are motivated by requirements imposed by other cognitive modules (Chomsky 2005; Hauser et al. 2002). This raises the question, though, whether these external factors merely restrict the shape syntax may take or, rather, uniquely determine it. In other words, are there multiple ways syntax may satisfy all interface requirements, or just one? The latter hypothesis is clearly the stronger one and thus more intriguing. As I will argue in this paper, though, it is untenable. In particular, I propose that syntax can trick the interfaces and avail itself of certain tools that conflict with their demands.

My argument is based on a case-study pertaining to the relation between the computability desiderata of the parser and the class of reference-set constraints (RCs; also known as transderivational constraints or global economy conditions). RCs differ markedly from standard well-formedness conditions in that they depend on transderivational comparisons. Given a tree, they determine its set of competitors – called its *reference set* – and pick from said set the optimal tree(s) according to some economy metric. All other trees are filtered out. Among the RCs proposed in the literature one finds the Accord Maximization Principle (Schütze 1997), Avoid Structure (Rizzi 1997), Chain Uniformization (Nunes 2004), Focus Economy (Reinhart 2006), Merge-over-Move (Chomsky 2000), Pronouns as Last Resort (Hornstein 2001), Rule I (Reinhart 2006), Rule H (Fox 2000), Scope Economy (Fox 2000), the Shortest Derivation Principle (Chomsky 1995), Situation Economy (Keshet 2010), and several more. Nonetheless it has been argued that RCs are not part of narrow syntax due to the computational complexity of transderivational comparisons; an abundance of candidates needs to be computed, the majority of which is subsequently discarded (Collins 1996; Jacobson 1997; Johnson & Lappin 1999). It seems, then, that RCs are in conflict with the main requirement imposed by the parser, i.e. efficient computability, wherefore syntax must eschew them.

When studied from a mathematical perspective, however, the transderivational component of RCs turns out to be superfluous. Many RCs can be recast purely in terms of the Minimalist feature calculus, which does not increase the grammar's resource usage. This immediately implies that syntax could in principle flout the parser's demands by using RCs while the parser gets to operate with the more economical alternative. As a consequence, there are two variants of narrow syntax – with RCs and without them – that the interfaces have no reason to treat differently, contrary to the strong hypothesis formulated at the outset that the shape of syntax is uniquely determined by interface requirements.

My mathematical result hinges on the assumption that at least some RCs can be modelled by so-called linear bottom-up tree transducers. In order to convince the reader of the applicability of this formalism to linguistically motivated RCs, I give a rigorous implementation of Merge-over-Move (MOM; Chomsky 1995, 2000), a principle demanding that when given a choice between Merge and Move at some step in the derivation, Merge is to be preferred over Move unless this would cause the derivation to crash later on. The strategy I follow in the implementation of MOM combines ideas that have been successfully used in Graf (2010a,b) to model two other RCs, the Shortest Derivation Principle (SDP; Chomsky 1995) and Focus Economy (Reinhart 2006). Most RCs in the syntactic literature can be viewed as a variation of one of these three constraints. The Accord Maximization Principle, for instance, is obtained from the SDP by prefering longer derivations over shorter ones. Avoid Structure (Rizzi 1997) resembles the SDP in that it also prefers simpler derivations but measures simplicity by the number of functional categories instead of the number of movement steps. These kinds of changes are innocent from a technical perspective, so it is safe to assume that linear bottom-up tree transducers do indeed provide a model for the majority of syntactic RCs.

The paper is laid out as follows: Section 2 provides a gentle introduction to the formal tools that form the basis of my argument, Minimalist grammars (MGs; 2.1) and linear tree transducers (2.2). I also describe the general strategy for modelling RCs, and why RCs can be recast without their transderivational component (2.3). After that, I work through a linguistically motivated example, MOM (3.1). The transducer for this constraint is described in intuitive terms (3.2), with the actual math relegated to the appendix. Interestingly, the most natural transducer implementation of MOM suggests a minor tweak to the constraint that has the welcome side-effect of doing away with certain undergeneration problems of MOM and its reliance on structured numerations, as is discussed in Section 3.3.

2. The mathematical argument

2.1 Minimalist grammars

In an attempt to base my claims on as rigorous a foundation as possible, I use MGs (Stabler 1997, 2011) as a formal model of Minimalist syntax. Actually, this is a slightly inaccurate statement as there are many extensions of the MG formalism comprising a wide range of items from the syntactician's toolbox. Among them we find head movement, affix hopping, pied-piping covert movement, sideward movement, Agree, phases, superiority conditions, islands constraints, complexity filters and even Distributed Morphology. Surprisingly, though, all of them can be emulated by a bare-bones variant of MGs that only uses *Merge*, *Move* and a strengthened version of the *Shortest Move Constraint* (see Graf 2011; Kobele 2011; Stabler 2011 and references therein). Hence I will restrict my attention to these maximally simplified MGs.

Like the standard version of Minimalism predating the introduction of Agree in Chomsky (2000), MGs construct phrase structure trees from lexical items (LIs) via the operations Merge and Move, which in turn are triggered by features on those LIs. In contrast to early Minimalism, however, MGs are more explicit about the nature of features and the structure of LIs in general. First, there is a strict division between features that trigger Merge and features that trigger Move. Second, features come in two polarities, which I indicate by superscripted + and −. Third, an LI may carry several instances of the same feature. Finally, the features of an LI must be checked in a prespecified order that may vary between LIs. A typical MG lexicon might look as follows.

men :: N^-	like :: D^+ D^+ V^-
the :: N^+ D^- nom^-	ε :: V^+ nom^+ T^-
what :: D^-	ε :: T^+ C^-
what :: D^- wh^-	do :: V^+ wh^+ C^-

The symbol before the double colon is the phonetic exponent of the LI; LIs marked with ε are phonetically null. After the double colon we find a string of features associated with the LI, with Merge features denoted by uppercase letters and Move features by lowercase letters. Negative Merge features correspond to category features, while positive Merge features are selector features. For instance, *the* selects a noun and is itself of category D. The verb *like* selects two DPs and is of category V. Crucially, *the* cannot be merged with *like* unless it selects a noun first because its first feature is N^-, not D^+. The category feature D^+ remains inaccessible until the selector feature N^- is deleted by Merge. Move features behave similarly: negative Move features (*licensee* features) mark the LI undergoing movement, positive Move features (*licensor* features) the target. As usual, movement of an LI displaces the entire phrase rather than just the head. Once again, though, a feature cannot be operated on before all the features preceding it have been checked, irrespective of their polarity and whether they trigger Merge or Move. Given this basic feature calculus regulating Merge and Move, a tree is considered to be grammatical if all features have been successfully checked off except the category feature of the highest LI, which must be a C-head.

However, the number of configurations in which two features may enter a checking relation via Move is severely reduced by the Shortest Move Constraint (SMC): at no point in a derivation may two LIs have the same licensee feature as their first unchecked feature. The SMC entails that if some LI has an active movement licensor feature, there is exactly one LI with a matching licensee feature, otherwise the derivation crashes (there must be at least one matching feature, and the SMC rules out that there is more than one). So this constraint is essentially a strengthened version of Relativized Minimality (Rizzi 1990), with the side-effect that Move becomes deterministic. For instance, the SMC can be invoked to block superiority violations such as *What did you say who bought t*. Under the proviso that the feature string of both *who* and *what* is −D −wh, the derivation crashes right after *who* is merged with *bought what* due to an SMC violation, since both wh-words now have −wh as their first unchecked feature. Of course one has to ensure that *who* actually carries −wh, and there are several constructions such as multiple wh-movement which seem to be incompatible with the SMC's strict interpretation of Relativized Minimality. Fortunately, though, these issues have been adressed in the literature (see Gärtner & Michaelis 2010; Graf 2011, among others), so we need not worry about them here. The SMC, then, can be safely adopted as a means for introducing a notion of locality into MGs and keeping Move as simple as possible by making it deterministic.

A bare phrase structure tree produced by our example grammar that also involves wh-movement is given in Figure 1, together with its corresponding derivation tree. The derivation tree is almost identical to the bare phrase structure tree except that (i) LIs are given with their feature component, (ii) interior nodes are labeled by the name of the operation that applied at this stage in the derivation, and (iii) instances of Move are indicated only by the label, i.e. the affected subtree remains in the position where it was originally merged. The simplified representation is possible only because movement is deterministic in MGs, thanks to the SMC – at no point in the derivation may there be any ambiguity as to which constituent is targeted by an instance of Move. The reader is invited to explicitly verify that both the SMC and MGs' feature calculus are obeyed in the example tree.

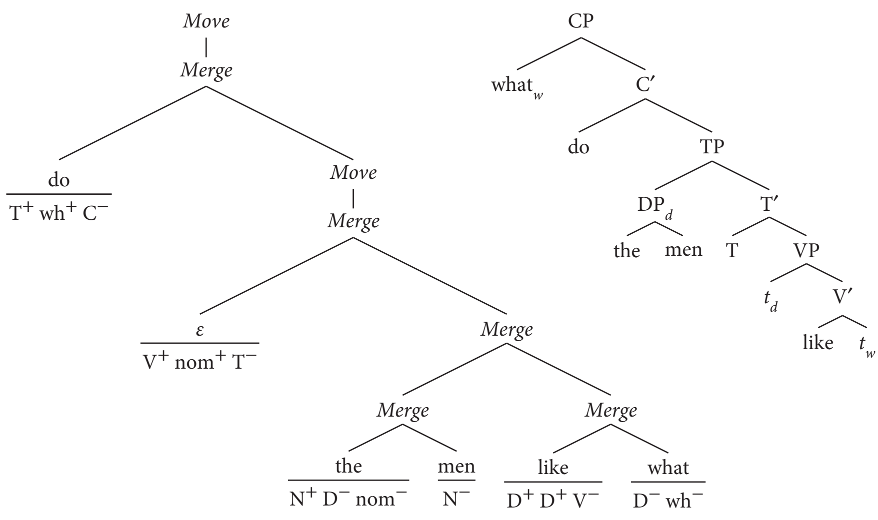


Figure 1. Bare phrase structures tree (right) and derivation tree (left) of a wh-question generated by the example MG

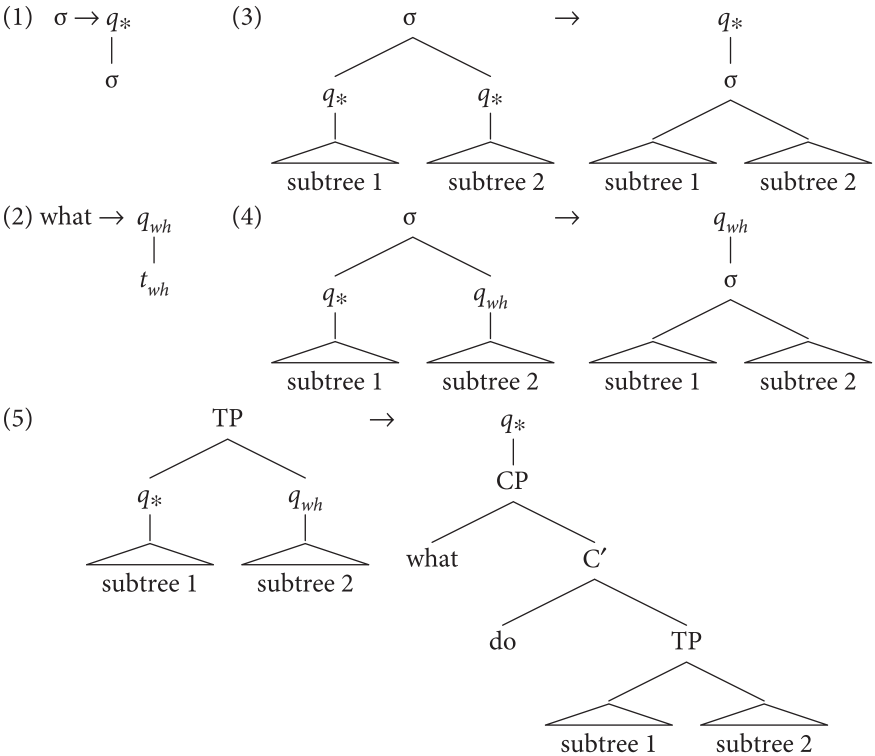
2.2 Linear tree transducers

While MGs serve as a formally rigorous model of Minimalist syntax, RCs are best understood in terms of linear bottom-up tree transducers (which I will henceforth refer to as "transducers" for the sake of brevity). Transducers can be viewed as a particular kind of SPE- or Aspects-style rewriting system. When handed a tree as its input, a transducer moves through said tree in a bottom-up fashion, from the leaves towards the root, possibly relabeling nodes, deleting subtrees, or inserting new structural material. Once it reaches the root, the end result of its modifications is either thrown away or returned as an output tree, depending on whether the end result is deemed well-formed. Sometimes there are several ways to manipulate an input tree, and in these cases the transducer might create multiple output trees. The connection between transducers and rewriting systems brings about an intriguing shift in perspective regarding RCs: rather than filtering out suboptimal trees in an arcane, non-local way, RCs rewrite them into optimal ones using what may be considered a subclass of syntactic transformations.

Even though the main body of this paper is deliberately light in notation and the actual math confined to the appendix, transducers must be discussed in due detail to give the reader at least an intuitive grasp of their capabilities. Table 1 on the following page depicts the rules of a transducer for simple instances of wh-movement. Each consists of a left-hand side, a rewrite arrow, and a right-hand side. The left hand side varies depending on whether the transducer is at a leaf node or a non-terminal node. In the former case, it comprises only the label of said node, as in rules (1) and (2). Otherwise, it specifies the label of the current node, plus special symbols called *states* (by convention written as q with some index) that immediately dominate the subtrees rooted by the daughters of the current node. The state symbols are not part of the input tree but were added by the transducer as a kind of temporary memory – when deciding which rewrite rule to apply, a transducer may only consider (i) the node it is currently at, and (ii) the state symbols said node dominates. So rule (5), for instance, may be applied if and only if the current node is labeled TP, its left daughter is q_*, and its right daughter is q_{wh}.

The purpose of states is easier to fathom once one also takes the right-hand side and its interaction with the left-hand side into account. On the right-hand side of rules (3), (4) and (5), the states dominated in the left-hand side are gone. Instead, a new state was added on top of the new output subtree. Similarly, the right-hand sides of rules (1) and (2) each contain a state dominating the leaf node. This setup allows left-hand sides and right-hand sides to interact as follows in order to push states upwards through the tree during the rewrite steps: First, the transducers reads the current node label and the states it dominates, if they exist. Depending on the applicable rewrite rules, it may leave this part of the tree unaltered (rule (1)), change the label (rule (2)), insert new structure (rule (5)), or delete a subtree (the last option is not featured in our example, but could easily be obtained from, say, rule (4) by removing one of the two subtrees in the right-hand side). Irrespective of how the subtree is rewritten, though, the transducer must put a state symbol on top of it, i.e. closer to the root. Note that this way of rewriting makes it necessary to traverse trees bottom-up. One starts by rewriting leaves

Table 1. Rules of a transducer for simplified wh-movement; only q_* is a final state



adding states on top of them, then one rewrites the mothers of the leaves (which involves removing the old states and again adding a new one on top), after that the next higher mothers, and so on, until one finally reaches the root. The transducer deems the output tree well-formed only if the state dominating the root node is a *final state*. For each transducer one has to specify in advance which states are final states.

Let us work through the example in Table 1 in greater detail now. As I mentioned in passing before, the transducer is supposed to model very simple instances of wh-movement, similar to the MG we encountered in the previous section (wh-movement was chosen because it should be sufficiently familiar to all readers that they can fully focus their attention on the mechanics of the transducer). Only two states are used, q_* and q_{wh}. The former reminds the transducer that it did not change anything in the subtree dominated by q_* – we may call it the identity state – whereas q_{wh} signals that somewhere in the subtree it dominates, a wh-word was replaced by a trace.

The five rules of the transducer can now be paraphrased as follows. First, note that σ is used as a shorthand for any label, so an instruction to rewrite σ as σ instructs the transducer to keep the current label. Consequently, rule (1) tells the transducer that if it is at a leaf node, it should leave said node unaltered and record this decision by adding the state q_* on top. Rule (2), on the other hand, allows for leaf nodes labeled *what* to be rewritten by wh-traces. Naturally we add the state q_{wh} this time. Crucially, the two rules are not in conflict, and the transducer may choose freely between rule (1) and (2) whenever it encounters a leaf labeled *what* (since σ matches any label). Hence the transducer creates several output trees for inputs with wh-words: some with wh-in-situ and some with wh-movement. Rule (3) and (4) are fairly unremarkable insofar as they merely ensure that the transducer does not manipulate non-terminal nodes and that q_{wh} is percolated upwards as necessary. If we did not take care to carry along q_{wh} at every step of the rewriting process, then the transducer would "forget" that it had replaced a wh-word by a trace earlier on. That is to say, it would merely remove wh-words rather than displace them. Finally, rule (5) tells the transducer to add a CP with the wh-word on top of a TP if rule (2) was applied at some earlier point. Note that if q_{wh} is a final state, rule (5) never needs to apply since output trees in which the transducer failed to switch back from q_{wh} into q_* before reaching the root node would also be considered acceptable. Hence only q_* may be a final state if we want wh-words to be reinserted into the tree after they have been replaced by traces.

A transduction using all five rules is given in Figure 2 on the following page. Except for deletion, it shows off all the capabilities of transducers that will be needed for RCs, in particular relabelings, the insertion of new material, and the ability to use states to both memorize limited amounts of structural information and decide whether output trees should be accepted or discarded.

2.3 Putting it all together

So far we have seen MGs as a formalization of Minimalist syntax and transducers as a potential mathematical model of RCs, but it is still unclear how the two combine to reveal something fundamental about RCs. The answer, albeit building on highly technical insights (Engelfriet 1975; Graf 2011; Kobele 2011), is simple: if a transducer is used like an RC to rewrite suboptimal derivations of a given MG G into optimal ones, then the set of these optimal derivations is exactly the set of well-formed derivations of some other MG G'. This implies that RCs that can be modelled by transducers do not increase the power of the MG formalism, and consequently they can be expressed purely in terms of the feature calculus driving Merge and Move.

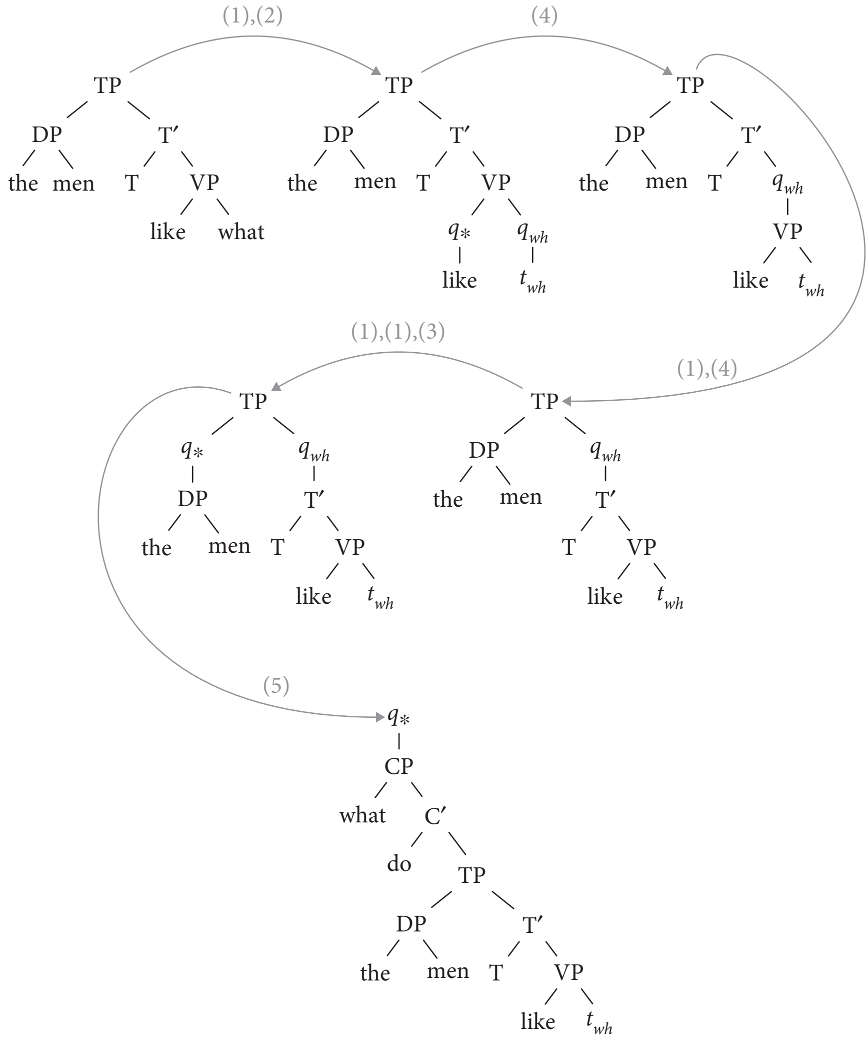


Figure 2. Example of transduction for simple wh-movement

It still needs to be shown, though, that RCs can be implemented as transducers. To this end, I produce a transducer for MOM in the next section. The procedure I use exploits a fact about transducers proved by Engelfriet (1975). Given two linear transducers α and β, we can concatenate them into a single linear transducer τ such that for I and O the sets of inputs and outputs of α, respectively, applying τ to I yields the same set as applying β to O. The reverse is also true: every transducer τ that rewrites a set I of trees as set O can be split into two transducers α and β such that applying α to I yields a set Z, which in turn is rewritten as O by β. So transducers can be concatenated or spliced arbitrarily often and in any conceivable way, the end result of the rewriting procedure will always be the same. This is helpful for our purposes because it allows for RCs to be defined in a piece-wise manner, breaking them into small, easily understood parts that can then be recombined into one big transducer representing the constraint as a whole.

This has already been accomplished for Focus Economy and the Shortest Derivation Principle (Graf 2010a,b), which constitute special cases of the following model. In order to capture an RC, one defines four transducers that are meant to apply serially one after the other. The first one maps each tree to an underspecified structure that implicitly encodes the commonalities of all trees belonging to the same reference set. The second one turns these underspecified structures into fully specified derivation trees again. So when these two transducers are executed one after another, each tree in the input language is rewritten as the trees in its reference set. The third transducer then implements the economy metric by rewriting sub-optimal trees as optimal ones. So if the first three transducers are run in series, every tree in the input language is rewritten as an optimal tree (if there are several, all of them will be generated). Finally, the fourth transducer discards all trees that weren't already included in the input language to prevent accidental overgeneration. In the remainder of this paper, I demonstrate that a strategy along these lines also works for MOM, although the details differ notably from those for Focus Economy and the Shortest Derivation Principle.

3. A practical example: Implementing Merge-over-Move

3.1 Merge-over-Move explained

Modelling MOM is complicated by the fact that there are multiple versions of the constraint, which are seldom carefully teased apart in the literature. Before we can discuss the transducer implementation (Section 3.2) and evaluate its faithfulness and empirical adequacy (Section 3.3), then, some variant must first be agreed upon as the measuring rod.

All definitions of MOM seek to formalize the following intuition: if at some point in a derivation we are allowed to choose between Merge and Move as the next step of the derivation, Merge is preferable to Move. This idea can be used to account for some puzzling contrasts involving expletives.

(1) a. There seems to be a man in the garden.
b. * There seems a man to be in the garden.
c. A man seems to be in the garden.

Recall that in the Minimalist framework of Chomsky (1995), we start out with a multiset of LIs – the *numeration* – that are enriched with interpretable and uninterpretable features, the latter of which have to be erased by the operation of feature checking. Under such a conception, (1a) and (1c) are easy to derive. Consider (1c) first. It starts out with the numeration {seems, to, be, a, man, in, the, garden} (ignoring phonetically null functional categories). Multiple applications of Merge yield the phrase [$_{TP}$ to be a man in the garden]. At this point, the Extended Projection Principle (EPP) demands that the specifier of the infinitival TP be filled by some phrase. The only item left in the numeration is *seems*, which cannot be merged in SpecTP. Hence we are stuck with moving the DP *a man* into SpecTP, yielding [TP a man to be t_{DP} in the garden]. Afterwards, the TP is merged with *seems* and the DP is once again moved, this time into the specifier of *seems* to check the case feature of the DP and satisfy the EPP.

Things are slightly more involved for (1a). Here the numeration initially consists of {there, seems, to, be, a, man, in, the, garden}. Once again we start out by merging items from the numeration until we arrive at [$_{TP}$ to be [$_{DP}$ a man in the garden]]. Now there are two possible continuations: (i) Merger of *there*, which is later followed by moving *there* into the specifier of *seems* and thus yields the grammatical (1a), or (ii) first moving *a man* into the specifier of *to be* and subsequently merging *there* with *seems a man to be in the garden*, which incorrectly produces the ungrammatical (1b). MOM rectifies this overgeneration problem by barring movement of *a man* into the specifier of *to be* due to the existence of a more economical option, namely merging *there*. At the same time, MOM does not block (1c) because it involves no choice between Merge and Move.

Depending on the conditions under which MOM is thought to apply, two variants can be distinguished. The *indiscriminate* version (iMOM) always prefers Merge over Move. As a result, it picks the most economical derivation, even if said derivation will eventually crash. The *cautious* version (cMOM), on the other hand, follows the original proposal of Chomsky (1995) in that only convergent derivations can be chosen. Both iMOM and cMOM use the *Identity of Numerations Condition* (INC) for determining a derivation's *reference set*, i.e. the set of derivations it competes with. The INC states that the reference set of a derivation *d* contains all the derivations that can be built from the same numeration as *d*, and only those.

Evidently cMOM has a distinctly global flavor to it: if MOM is evaluated at every step of the derivation, i.e. before the derivation is completed, then the only way to predict which competing derivations will crash later on – and thus must be discarded for the comparison – is via a filter based on unlimited look-ahead or reference-set computation. The iMOM variant, by contrast, provides a strictly local alternative. It contains not even a modicum of global economy, as it simply prefers Merge over Mover whenever there is a locally licensed choice between the two, no matter what the eventual outcome.

For simple cases like (1) both MOM variants make the right predictions. However, there are cases where they behave differently (Shima 2000).

(2) a. It is asked [how likely t_{John} to win]$_i$ John is t_i.
b. * John is asked [how likely t_{John} to win]$_i$ it is t_i.

The assembly of [is [how likely John to win]] proceeds as usual. Subsequently, a decision has to be made as to whether one wants to move *John* into SpecTP or base-merge the expletive instead. The iMOM variant picks the base-merger route, so we end up with [it [is [how likely John to win]]. This means that iMOM will always block the grammatical (2a), irrespective of how the derivation continues.

The behavior of cMOM is more refined. Assume that base-merger of *it* is favored, yielding [it [is [how likely John to win]]. After this phrase is merged with *asked* and *is*, *John* must move into the specifier of the matrix TP to get its case feature checked. This is when the implicit look-ahead of cMOM comes into play. Unless moving *John* is barred for independent reasons, the derivation for (2b) won't crash, so the initial choice of merging *it* rather than moving *John* won't be discarded by cMOM. As a result, (2b) incorrectly blocks (2a). However, if (2b) is illicit for independent reasons – say, because moving *John* out of [how likely John to win] constitutes an island violation – then cMOM won't consider base-merger of *it* a viable alternative to Move and only (2a) is generated.

There are also cases where both variants make the wrong predictions (Wilder & Gärtner 1997).

(3) a. There was [a rumor [that a man was t_{DP} in the room]] in the air.
b. [A rumor [that there was a man in the room]] was t_{DP} in the air.

Both sentences are assembled from the same numeration, so (3b) should block (3a), since the former converges and violates MOM at a later derivational step than the latter. In order to account for such cases, Chomsky (2000) stratifies numerations such that each CP has its own subnumeration. In the case at hand, (3a) is built from the numeration {{there, was, a, rumor, in, the, air}, {that, was, a, man, in, the, room}}, and (3b) from the minimally different {{was, a, rumor, in, the, air}, {that, there, was, a, man, in, the, room}}. By the INC, then, derivations built from the former do not belong to the same reference set as derivations generated from the latter.

So now another parameter of MOM must be taken into account. A *restricted* version of MOM (rMOM) is part of a grammar where every CP has its own numeration. An *unbounded* version (uMOM) belongs to a grammar with one big, unstructured numeration for the entire sentence. In this system, cuMOM is the version of MOM introduced in Chomsky (1995), iuMOM is its local counterpart, and crMOM is the modification put forward in Chomsky (2000). Out of these three alternatives, crMOM is arguably superior with respect to empirical coverage, so it will be the starting point for the transducer implementation.

3.2 A transducer model of MOM

The general strategy for modelling MOM is slightly altered from the schema I outlined in Section 2.3. Just as described there, I first give a transducer that rewrites derivations as a certain kind of underspecified tree. The idea is that the latter provides an abstract encoding of the former's reference set. These underspecified trees are then immediately turned into optimal derivations (in contrast to the original schema, which posits some intermediate steps). By mapping all derivations to underspecified trees from which only optimal derivations can be obtained, every derivation that is suboptimal with respect to MOM is filtered out – or more precisely, rewritten as an optimal one.

Every variant of MOM, though, poses one major difficulty for transducers, namely the defintion of reference sets via the INC. Consider the utterance *John loves Mary*. Depending on how we interpret the notion of "identity of numerations" invoked by the INC, *John loves Mary* might have the same numeration as *Mary loves John*, so they should be in the same reference set. But the underspecification format I propose cannot encode both derivations in a single tree. In fact, no transducer can map a given tree to the counterpart in which subject and object have been switched unless there is an upper bound on their respective size; this is called the inability to perform *local rotations*. Since DPs can be nested and may contain CPs, natural language arguments have unbounded size, so if the INC is an indispensable part of MOM, one would expect local rotations to be unavoidable, too. This is not the case.

Consider (1) again. MOM's objective is to explain why (1b) is ungrammatical, and it does so by using a metric that makes it lose out against (1a). The grammaticality of (1c), on the other hand, follows from the fact that its numeration differs from that of (1a) and (1b), whence it also belongs to a different reference set by the INC. But identity of numerations is a rather indirect encoding of the relationship that holds between (1a) and (1b). A simpler and more intuitive condition emerges when we look at their derivation trees (see Figure 3). *Modulo* the feature specifications of the LIs, the only difference between the derivation trees of (1a) and (1b) is the timing of Move and *there*-Merger. Switching the positions of these two operations in the derivation does not constitute an instance of local rotation because the size of the moved subtree is at most 2 (*Merge* plus its left daughter *there*) and hence finitely bounded.

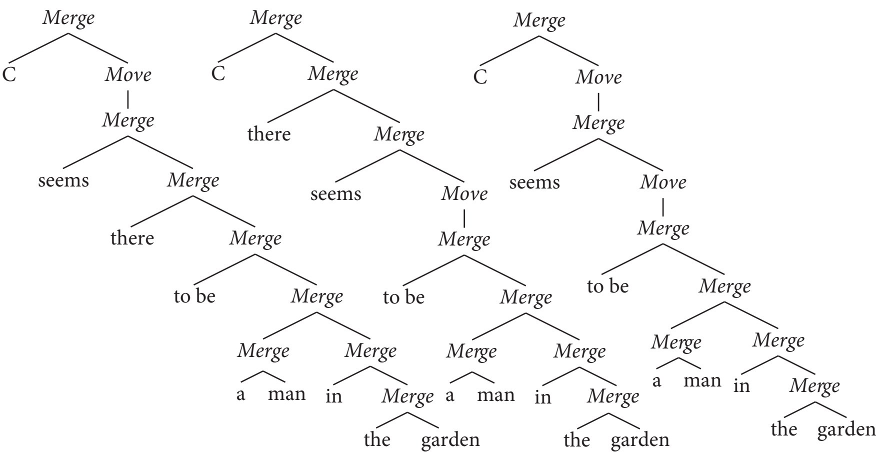


Figure 3. Derivation trees of (1a), (1b) and (1c); features are omitted

Recall that we want the transducer to eventually rewrite the suboptimal (1b) as the optimal (1a). As we just saw, this does not involve local rotations, contrary to what one would expect if the INC was the weakest working solution. But if the INC is indeed ill-suited to defining reference sets, what should supplant it? There are in fact infinitely many alternatives that all yield the same behavior. The most elegant solution is to give up the original partition of reference sets and make (1c) a competitor of (1a) and (1b).

Compare the derivations of (1a) and (1b) to that of (1c). The former are essentially the result of non-deterministically replacing one instance of Move in the derivation tree of (1c) by merger with expletive *there*. Strikingly, though, rewriting the lower occurrence of Move yields the grammatical (1a), whereas rewriting the structurally higher occurrence gives rise to the ungrammatical (1b). Suppose then, that we have an underspecified representation of all three derivations which is identical to (1c) except that the two instances of *Move* are replaced by a new symbol □. Now if we have a transducer that may rewrite □ as *Move* or merger of *there*, then all three derivations can be obtained from the underspecified tree. However, if we furthermore require that □ must be rewritten as *Move* if some other □ has already been rewritten as *Move* earlier on, then only (1a) and (1c) are possible outputs. The derivation for (1b) will never be generated – speaking in terms of RCs, it is filtered out as suboptimal with respect to MOM. From a linguistic perspective, MOM has been reduced to a local well-formedness condition on derivation trees: *Move* must not derivationally dominate an instance of *there*-merger.

The idea just outlined is captured as follows (see the appendix for a more rigorous description): First, our input language is the set of derivation trees of some MG. Then we use a transducer α to map each input derivation to some underspecified tree. For the sake of clarity, α is decomposed into two smaller transducers, *Remove Features* and *Underspecify*.

Remove Features strips away all features from the LIs except their category features. This step is indispensable because every instance of Merge or Move is tied to specific features in an MG, so any two derivations that differ with respect to the timing of Merge and Move also differ in the feature make-up of their LIs. Unless all those features are removed, derivations that should compete with respect to MOM won't be mapped to the same underspecified tree. Category features are kept to ensure that two non-competing derivations with homophonic LIs have distinct underspecified representations. Note that since *Remove Features* involves only relabeling of leaf nodes, it can easily be carried out by a transducer.

Underspecify has slightly more work to do, but only inside TP, where it deletes expletive *there* and rewrites the corresponding Merge node as □. Move nodes in this domain are also rewritten as □. States must be used to detect which nodes must be rewritten or deleted. If a leaf's label is an LI of category T, C or simply *there* the transducer adds the state q_t , q_c, or q_{there} on top of it, respectively. Otherwise it inserts the neutral state q_*. The state q_t is percolated until a sister with state q_c is encountered, which indicates the beginning of the CP. The transducer has several rules for interior nodes, but only two of them do any actual work. The first one rewrites Move-nodes dominating the state q_t as □, i.e. TP-internal Move nodes are relabeled □. The second one applies to Merge-nodes dominating states q_t and q_{there}. This configuration indicates a TP-internal Merge-site of expletive *there*, so we delete the subtree deleted by q_{there} and change the label from *Merge* to □. As *Underspecify* involves only relabelings and deletion of subtrees, it too is a transducer as defined in Section 2.2.

The underspecified trees created by α are then turned into fully specified ones again by the transducer β. As we saw in our discussion of (1a–c), β only recovers the optimal derivations and thus enforces MOM. Just as with α, the workload of β is distributed over two smaller transducers, *Path Condition* and *Restore Features*.

Path Condition is the essential step that captures MOM's economy metric. Upon encountering a □, it may rewrite it as *Move* or Merger of *there*, but with the added condition that once a □ node has been replaced by *Move*, all remaining instance of □ in the same TP have to be rewritten as *Move*, too. Formally, this is handled by having the transducer switch between three different states: q_*, q_{move}, and q_c. The first one is the default and merely encodes that no □ has been rewritten as a Move node yet. For any □ dominating q_*, the transducer may freely choose between *Move* or Merger of *there*. Once it opts for the former, though, it must project the state q_{move}, and every □ dominating this state must be rewritten as *Move*.

The only way for the transducer to stop percolating q_{move} and switch back into q_* is for it to reach a CP, which is encoded by the state q_c. This dependency on q_c "resets" the transducer for each CP and thus avoids overapplication of MOM, similar to the subnumerations of Chomsky (2000).

Two example runs of *Path Condition* are given in Figure 4 and 5. Note how the transducer is locked into state q_{move} in Figure 5 after rewriting the lower instance of □ as *Move* and consequently must also rewrite the higher instance as *Move*, making it impossible to generate the derivation tree for the ungrammatical *There seems a man to be in the garden*. These examples also illustrate that only relabelings and insertions of finitely-bounded subtrees are employed, which – as we saw with our toy transducer for wh-movement – are no problem for a transducer.

The last element of our chain of transducers is *Restore Features*, which undoes the effects of *Remove Features*. This is a non-deterministic process, though, and thus may overgenerate. For instance, the MG on page 4 allows for *what* to be reinstantiated with or without a wh⁻ feature. Hence *Restore Features* generates many ill-formed derivation trees that have to be filtered out later on. The required mechanism also takes care of another source of overgeneration. The non-deterministic rewriting of □ by *Path Condition* allows for two occurrences

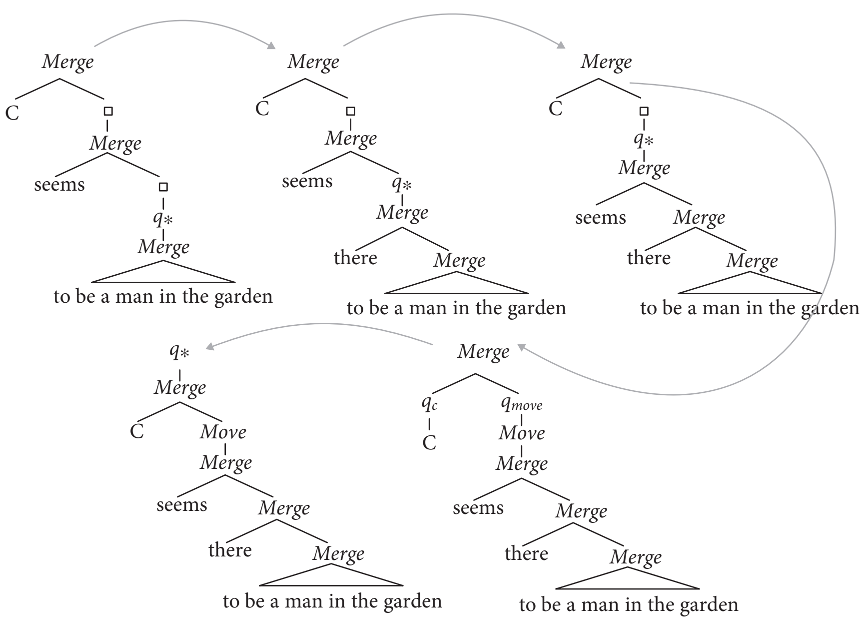


Figure 4. Rewriting the underspecified derivation tree into the derivation tree of *There seems to be a man in the garden*

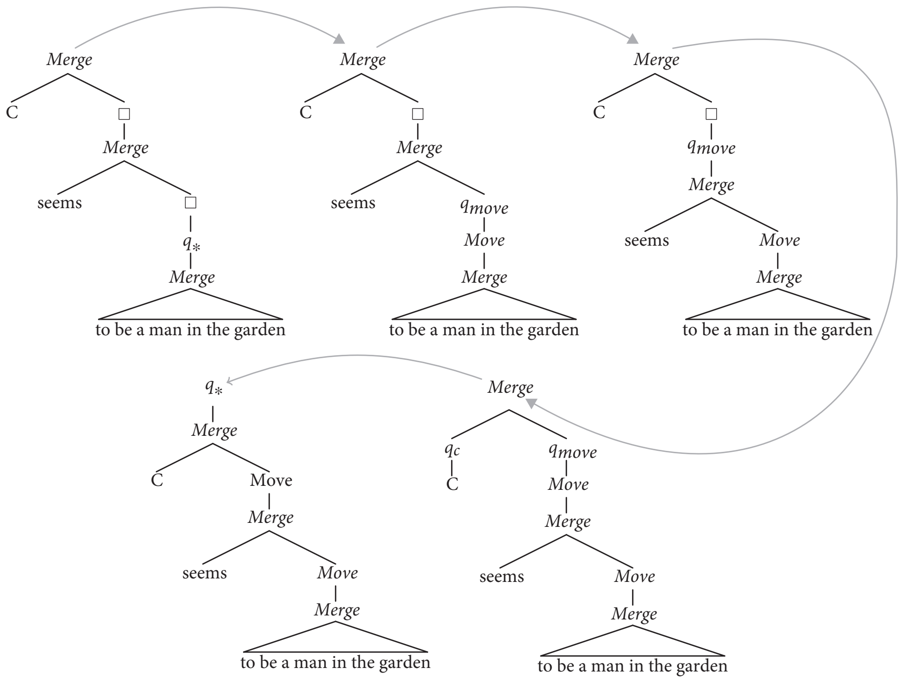


Figure 5. Rewriting the underspecified derivation tree into the derivation tree of *A man seems to be in the garden*

of □ to be rewritten as *there*, which yields the (derivation tree of the) ungrammatical *there seems there to be a man in the garden*. Both kinds of overgeneration are prevented by discarding all derivation trees that aren't licensed by the original grammar. Formally, this is handled by intersecting the output language of β with the input language of α, which can also be done by a transducer.

3.3 Empirical evaluation

As I will show now, the transducer conception of MOM (tMOM) not only performs just as well as crMOM (Chomsky 2000), it is also less prone to undergeneration. The examples in Figure 4 and 5 already demonstrate that tMOM successfully accounts for simple expletive/non-expletive alternations as in (1). So let us look at the more complex scenario in (3), repeated here as (4), which prompted the introduction of stratified numerations in the first place.

(4) a. There was [a rumor [that a man was t_{DP} in the room]] in the air.
b. [A rumor [that there was a man in the room]] was t_{DP} in the air.

Recall that this was a problematic case for pre-Chomsky (2000) versions of MOM (i.e. cuMOM and iuMOM); in the absence of stratified numerations the INC puts (4a) and (4b) in the same reference set, and as a result (4a) blocks (4b).

Under tMOM, on the other hand, (4) is a straightforward generalization of the pattern in (1). The underspecified tree of both sentences is shown in Figure 6. When it is expanded to full derivations again, all four logical possibilities are available: (I) *there*-insertion in both CPs, (II) Move in both CPs, (III) *there*-insertion in the lower CP and Move in the higher one, and (IV) Move in the lower CP and *there*-insertion in the higher one. The last option is available because the transducer, which is in the "rewrite all instances of □ as Move"-state q_O after rewriting the label □ as *Move*, switches back into the neutral state q_* after having passed through the CP headed by *that*. Thus when it encounters the second □ node in the higher CP, it can once again choose freely how to rewrite it. Provided the four derivation trees obtained from the underspecified derivation aren't filtered out by the original MG, the following sentences are generated, all of which are grammatical:

(5) a. There was a rumor that there was a man in the room in the air.
b. There was a rumor that [a man]$_i$ was t_i in the room in the air.
c. [A rumor that there was a man in the room]$_i$ was t_i in the air.
d. [A rumor that [a man]$_i$ was t_i in the room]$_j$ was t_j in the air.

It is worth mentioning that tMOM differs from all other variants in how it groups these sentences into reference sets. The INC of the unstratified cuMOM and iuMOM entails that these four sentences belong to three distinct equivalence classes, one containing (5a), one containing (5b) and (5c), and one containing (5d). The crMOM variant with its stratified numerations, on the other hand, puts each sentence into its own equivalence class. Only tMOM lumps them all together into one equivalence class, which is the most intuitive route to take.

Moreover, tMOM avoids certain undergeneration problems plaguing all other MOM variants, including crMOM (Shima 2000).

(6) a. It is asked [how likely t_{John} to win]$_i$ John is t_i.
b. * John is asked [how likely t_{John} to win]$_i$ it is t_i.

Recall from our discussion in the previous section that iMOM always discards (6a), whereas c(r)MOM only does so if the derivation for (6b) does not crash (and the two even have identical stratified numerations). But tMOM never blocks it, because the grammaticality of the Merge variant has no bearing on the availability of the Move variant. This is so because tMOM is less of an economy-based dispreference for Move and more of a description of the set of possible continuations of a derivation once a choice pro-Merge or pro-Move has been made. The sequence of Merge and Move nodes in (6a) forms a licit pattern – Move is never followed by

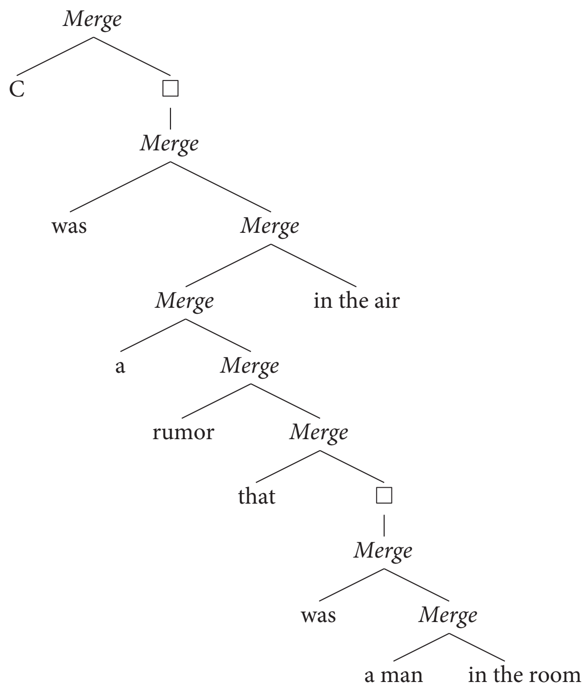


Figure 6. Underspecified derivation tree of (4a) and (4b)

Merge inside a TP-domain – and thus tMOM will never filter out this derivation. It is striking that even though this deviation from crMOM was prompted by the desire to keep tMOM as simple as possible (a completely faithful implementation of crMOM is possible, but would require parts of the Shortest Derivation Principle transducer of Graf 2010b), it actually is better behaved empirically.

Despite this small advantage, though, the behavior of tMOM still closely resembles that of crMOM. In particular, tMOM also fails to mark (6b) as ungrammatical. So both cMOM and tMOM require that the initial MG contains some locality condition that rules out (2b) in order to make the correct predictions. A natural candidate would be the islandhood of [how likely John to win].

Further assumptions about the input grammar must also be made to rule out cases of superraising like (7a) and multiple occurrences of *there* as in (7b).

(7) a. * A man seems there to be in the room.
    b. * There seems there to be a man in the room.

On a conceptual level, this is a defensible move as the deviancy of these examples does not seem to be directly related to MOM. However, if we really wanted to incorporate such restrictions into MOM, at least the ban against double *there* can easily be accommodated by changing from a "once you opt for *Move*, you have to stick with it" version of *Path Condition* to the stricter "once you have rewritten a □, all higher occurrences of □ in this CP must be rewritten as *Move*" (this is accomplished by replacing the rule $\square(q_*(x)) \rightarrow q_*(\mathit{Merge}(\text{there}, x))$ in the appendix by the minimally different $\square(q_*(x)) \rightarrow q_o(\mathit{Merge}(\text{there}, x))$).

3.4 Technical summary

RCs can be implemented using a tree rewriting formalism called (linear bottom-up tree) transducers. Transducers may relabel nodes, delete subtrees, or insert new subtrees of bounded size. They do so by traversing the tree from the leaves towards the root, inserting special state symbols at each step that serve as a storage for a limited amount of information about the subtree they dominate. Modelling RCs as transducers means that suboptimal derivations aren't filtered out but rather turned into optimal ones. In the case of MOM, this is handled by a cascade of transducers that first turns derivations into an underspecified format omitting, in the TP domain, Move nodes and merger of *there*. Crucially, derivations that are competing with respect to MOM all share the same underspecified representation. After that, underspecified representations are turned into fully specified derivations again, but the transducer carrying out this rewrite step is constrained in such a way that only optimal derivations can be obtained. More precisely, no TP may contain a Move node that is dominated by a *there*-Merge node in the same TP. This implementation of MOM has several empirical advantages over the versions proposed in the literature. More importantly, though, transducers do not increase the power of Minimalist syntax as formalized in Stabler (1997, 2011). Consequently, MOM and other RCs can be reimplemented using only Merge, Move, and the feature calculus, so there is an equivalent but computationally more parsimonious way of ruling out the illicit structures.

4. Conclusion and further discussion

This paper started with a very general question – how much influence do the interfaces have on the shape of narrow syntax – and used RCs to debunk the strongest possible hypothesis, namely that syntax is uniquely determined by interface requirements. The foundation of the argument is a mathematical theorem that at least some RCs can be emulated by the Minimalist feature calculus combined with Merge and Move, which contradicts the assumption in the literature that RCs are computationally costly, whence they should be in violation of interface requirements. In order to demonstrate that this subclass of RCs contains constraints from the syntactic literature, I showed how MOM can be implemented using the relevant formal tools (Minimalist grammars and linear tree transducers). In sum, there are syntactic RCs that can be recast with less demanding machinery, so it cannot be ruled out that said RC is used by syntax while the component that imposes the stringent computability demands gets to operate with the local correspondent. It is conceivable, then, that syntax tricks the interfaces whenever it can conceal its offenses against their requirements.

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Appendix

I adopt the definition of MGs and Minimalist derivation tree languages (MDTLs) given in Graf (2011). As shown there and in Kobele (2011), MDTLs are (almost) closed under linear tree transductions, which entails that the image of an MDTL under a linear tree transduction is itself an MDTL (given a suitable refinement of the feature calculus).

The standard definition of linear bottom-up tree transducers is given below. The reader is referred to Engelfriet (1975) for further details, in particular for the rather cumbersome definition of the tree translations realized by a given transducer.

Definition 1. A *linear (bottom-up) tree transducer (lbutt)* is a 5-tuple $A := \langle \Sigma, \Omega, Q, Q', \Delta \rangle$, where Σ and Ω are finite ranked alphabets, Q is a finite set of states, $Q' \subseteq Q$ the set of final states, and Δ is a set of productions of the form $f(q_1(x_1), \dots, q_n(x_n)) \to q(t)$, where $f \in \Sigma$ is a symbol of rank n, $q_1, \dots, q_n, q \in Q$, t is a tree with labels drawn from $\Omega \cup \{x_1, \dots, x_n\}$, and each x_i occurs at most once in t.

For the sake of succinctness (but to the detriment of readability), I adopt the following notational conventions for tree transducer productions:

- $\alpha_{\{x,y\}}$ is to be read as "α_x or α_y".
- $\alpha_{a \dots z}(\beta_{a' \dots z'}, \dots, \zeta_{a'', \dots, z''})$ is to be read as "$\alpha_a(\beta_{a'}, \dots, \zeta_{a''})$ or ... or $\alpha_z(\beta_{z'}, \dots, \zeta_{z''})$".

Example. The production $\sigma\ (q_{ij\{a,b\}}(x), q_{jkc}(y)) \to q_{\{a,c\}}(\sigma\ (x, y))$ is a schema defining eight productions:

$\sigma(q_i(x), q_j(y)) \to q_a(\sigma(x, y))$	$\sigma(q_i(x), q_j(y)) \to q_c(\sigma(x, y))$
$\sigma(q_j(x), q_k(y)) \to q_a(\sigma(x, y))$	$\sigma(q_j(x), q_k(y)) \to q_c(\sigma(x, y))$
$\sigma(q_a(x), q_c(y)) \to q_a(\sigma(x, y))$	$\sigma(q_a(x), q_c(y)) \to q_c(\sigma(x, y))$
$\sigma(q_b(x), q_c(y)) \to q_a(\sigma(x, y))$	$\sigma(q_b(x), q_c(y)) \to q_c(\sigma(x, y))$

I now turn to the implementation of MOM by decomposing it into four linear transducers. I assume that the input to MOM is given by the MDTL L of some MG G with lexicon *Lex*. The first transduction to apply is *Remove Features*. As this transducer only relabels leaf nodes, I omit a full definition.

Definition 2. *Remove Features* is the deterministic (one-state) transducer that maps each LI $l := \sigma :: \gamma c \delta \in Lex$ to $l' := \sigma_c$, where c is a category feature and both γ and δ are strings of features. The set of these simplified LIs is denoted by Λ.

Even though the definition of an MG allows for an LI to have several category features or none at all, no such LI can ever appear in a well-formed derivation tree (cf. Graf 2011; Kobele 2011). Hence *Remove Features* is well-defined. If for some reason multiple category features (or their absence) are indispensable, the transduction can be extended such that each LI is subscripted by the n-tuple of its n category features. In either case, the map defined by *Remove Features* is many-to-one, so Λ is finite by virtue of the finiteness of *Lex*.

Definition 3. *Underspecify* is the lbutt $\mathcal{U}$, where $\Sigma_{\mathcal{U}} := \Lambda \cup \{Merge, Move\}$, $\Omega_{\mathcal{U}} := \Sigma_{\mathcal{U}} \cup \{\square\}$, $Q := \{q_*, q_c, q_t, q_{there}\}$, $Q' := \{q_*\}$, and $\Delta_{\mathcal{U}}$ consists of the rules below. I use the following notational conventions:

- σ_c and σ_t denote any LI $l \in \Lambda$ whose category feature is C or T, respectively,
- the symbol "there" refers to any expletive $l \in \Lambda$ involved in MOM (usually just *there*, but possibly also *it*),
- σ_l denotes any LI which does not fall into (at least) one of the categories described above,
- as derivation trees aren't linearly ordered, rules for binary branching nodes are given for only one of the two possible orders (namely the one that reflects the linear order in the derived structure).

$$
\begin{array}{rr}
\sigma_l \to q_*(\sigma_l) & Merge(q_{c*}(x), q_{t*}(y)) \to q_*(Merge(x, y)) \\
\sigma_t \to q_t(\sigma_t) & Merge(q_t(x), q_{\{t,*\}}(y)) \to q_t(Merge(x, y)) \\
\text{there} \to q_{there}(\text{there}) & Merge(q_{there}(x), q_{\{t,*\}}(y)) \to q_t(\square(y)) \\
\sigma_c \to q_c(\sigma_c) & Move(q_*(x)) \to q_*(Move(x)) \\
 & Move(q_t(x)) \to q_t(\square(x))
\end{array}
$$

Definition 4. *Path Condition* is the lbutt $\mathcal{P}$, where $\Sigma_{\mathcal{P}} := \Omega_{\mathcal{U}}$, $\Omega_{\mathcal{P}} := \Sigma_{\mathcal{U}}$, $Q := \{q_*, q_c, q_{move}\}$, $Q' := \{q_*\}$, and $\Delta_{\mathcal{P}}$ contains the rules below (the same notational conventions apply):

$$
\begin{array}{lr}
\sigma_l \to q_*(\sigma_l) & Merge(q_{c\{c,*\}}(x), q_{move\{c,*\}}(y)) \to q_*(Merge(x, y)) \\
\sigma_t \to q_*(\sigma_t) & Merge(q_{\{move,*\}}(x), q_{move}(y)) \to q_{move}(Merge(x, y)) \\
\sigma_c \to q_c(\sigma_c) & Move(q_*(x)) \to q_*(Move(x)) \\
 & \square(q_*(x)) \to q_*(Merge(\text{there}, x)) \\
 & \square(q_{\{move,*\}}(x)) \to q_{move}(Move(x))
\end{array}
$$

Definition 5. *Restore Features* is the non-deterministic transducer computing the inverse of the transduction defined by *Remove Features*.

Let *id* be the identity function over L (which is guaranteed to a be a linear tree transduction). Now we define τ as the composition of *Remove Features*, *Underspecify*, *Path Condition*, *Restore Features*, and *id*. The image of L under τ consists of all trees that are optimal with respect to MOM, and only those.

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The theoretical proposals brought forward in this book as well as the results from the reported experimental studies present genuine contributions to the biolinguistic program. The papers contribute to our understanding of the properties of the computations and the representations derived by the language faculty, viewed as an organism of human biological. *Towards a Biolinguistic Understanding of Grammar: Essays on Interfaces* adds to the usual notion of interfaces, which is generally understood as the connection between syntax and the semantic system, between phonology and the sensorimotor system. It raises novel interface questions about how these connections are at all possible within the biolinguistic program. It anchors the formal properties of grammar at the interfaces between language and biology, language and experience, bringing about language acquisition and language variation, and it also explores the interaction of grammar with the factors reducing complexity. This book aims to bring about further understanding of the interfaces of the grammar in a broader biolinguistic sense. Written in a language accessible to a wide audience, this book will appeal to scholars and students of linguistics, cognitive science, biology, and natural language processing.

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