Gapping as hypothetical reasoning

Yusuke Kubota
Ohio State University
kubota@ling.ohio-state.edu

Robert Levine
Ohio State University
levine@ling.ohio-state.edu

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Abstract

The scope anomaly observed in sentences like *Mrs. J can't live in Boston and Mr. J in LA* ($\neg\Diamond > \wedge$) and *No dog eats Whiskas or cat Alpo* ($\neg\exists > \vee$) is known to pose difficult challenges to many analyses of Gapping. We provide new arguments, based on both the basic syntactic patterns of Gapping and standard constituency tests, that the so-called 'low VP coordination analysis'—the only extant analysis of Gapping in contemporary syntactic theories which accounts for this scope anomaly—is empirically untenable. We propose an explicit alternative analysis of Gapping in Hybrid Type-Logical Categorial Grammar, a variant of categorial grammar which builds on both the Lambek-inspired variants of categorial grammar and a more recent line of work modelling word order via a lambda calculus for the prosodic component. The flexible syntax-semantics interface of this framework enables us to characterize Gapping as an instance of like-category coordination, via a crucial use of the notion of hypothetical reasoning. This analysis of the basic syntax of Gapping is shown to interact with independently motivated analyses of scopal operators to immediately yield their apparently anomalous scopal properties in Gapping, offering, for the first time in the literature, a conceptually simple and empirically adequate solution for the notorious scope anomaly in Gapping.

Keywords: Gapping, coordination, Type-Logical Categorial Grammar, Abstract Categorial Grammar, scope, split scope

1 Introduction

Gapping is a particularly odd instance of non-canonical coordination in which a verb (or some larger string containing it) is missing from the non-initial conjunct(s):[1]

[1] The licensing condition for Gapping is often formulated with reference to a finite verb, whatever other additional material is missing from the righthand conjunct. But instances of Gapping with nonfinite verbs can indeed be found: both 'What—me worry?' sentences and infinitival optatives, neither of which contains a finite verb, can undergo Gapping:

(i) a. What—Robin eat vegetables and Leslie whole-grain bread?? You're dreaming!
b. Oh, for Robin to be convicted of fraud and her bootlicking minions fired!

We also find infinitival subject clauses parallel to (ib):

(1) Leslie bought a CD, and Robin ∅ a book.

What distinguishes Gapping from other kinds of non-canonical coordinations such as argument cluster coordination (ACC) and Right-Node Raising (RNR) is that the strings which appear to be coordinated in Gapping do not look very much like each other. In the case of ACC and RNR:

(2) a. I told the same joke to Robin on Friday and (to) Leslie on Sunday.
b. I gave Robin, and Leslie offered Terry, a pair of pliars.

it is possible to identify two coordinated substrings which are parallel up to the point where they combine with the rest of the sentence; the problem is only that expressions such as *(to) Leslie on Sunday* (in (2a)) and *I gave Robin* (in (2b)) are not constituents of the traditional kind. But in the case of Gapping, we seem to be coordinating a whole clause with a sequence of words which would be a clause if a copy of the verb in the first conjunct were introduced into the second conjunct. As they stand, however, *Leslie bought a CD* in (1) has a completely different status from *Robin a book*.

The material overtly missing from, but seemingly present in the interpretation of, the second conjunct can be quite a bit more extensive than just the matrix verb of the first; in (3a), a larger string *gave me* properly containing a finite verb undergoes Gapping, and in (3b), the Gapped material is an auxiliary + bare verb sequence:

(3) a. One gave me a book, and the other ∅ a CD.
b. Terry can go with me, and Pat ∅ with you.

The examples in (4) are still more complex, where (4a) shows that a chain of infinitives plus the main verb can be gapped; (4b-d) show that the gapped material can even be a discontinuous substring of the sentence:

(4) a. John wants to try to begin to write a novel, and Mary ∅ a play.
b. Robin put a dollar in the meter and Leslie ∅ three quarters ∅.
c. Some Republicans want Ford to run for the Presidency, and others ∅ Reagan ∅.
d. Too many Irish setters are named Kelly, ∅ German shepherds ∅ Fritz, and ∅ huskies ∅ Nanook.

These examples illustrate the core syntactic properties of Gapping that must be accounted for in any adequate analysis.[2]

(ii) For Robin to be convicted of fraud and her bootlicking minions fired is all I would ask for in this life.

[2]In addition, it has often been observed that there are typically just two remnants in the gapped conjunct. (Remnants are expressions that remain in non-initial conjuncts.) Thus, examples like the following are marginal at best:

(i) a.??Alan gave Sandy a book, and Peter Betsy a magazine.
b.??Alan told Harry that the sky was failing, and Sam Betsy that Chicken Little was right.

Sag (1976) however notes that if the post-verbal remnants contain PPs, the examples sound much better:

Gapping has indeed continued to pose a difficult challenge in both derivational and non-derivational variants of generative grammar. The syntactic asymmetry noted above is already highly problematic, but things are actually worse. A further, and even more vexing challenge for any analysis of Gapping comes from the scopal interactions with auxiliaries and quantifiers, exemplified by data such as the following (Siegel 1984, 1987; Oehrle 1987; McCawley 1993):

(5) a. Mrs. J can't live in Boston and Mr. J $\varnothing$ in LA.
   b. Mrs. J can't live in Boston or Mr. J $\varnothing$ in LA.
   c. No dog eats Whiskas or $\varnothing$ cat $\varnothing$ Alpo.

Examples of this type are generally ambiguous between two readings. For example, on its most natural reading, (5a) means that it's not possible for Mrs. J and Mr. J to live in the two different respective cities at the same time ($\neg\diamond(\varphi \wedge \psi)$), where the modal *can't* scopes over the conjunction. The sentence additionally has a reading denying *both* of the two possibilities ($\neg\diamond\varphi \wedge \neg\diamond\psi$), which is obtained by distributing the meaning of the modal to each conjunct. (5b) and (5c) are similarly ambiguous.[3]

The existence of the non-distributive, wide-scope reading of auxiliaries in Gapping, and particularly its default status in (5a) and similar examples, may appear rather surprising at first, since auxiliaries can't normally scope out of their local clauses to take scope in a higher clause (e.g. the modal *can't* can't scope over the matrix verb *thinks* in *Kevin thinks that Sandy can't rinse the sink*). Moreover, apart from Gapping, modals never outscope conjunction. Thus, *Mrs. J can't live in Boston and Mr. J lives in LA* does not have a reading analogous to (5a). The generalization here is that scopal operators, when they are gapped, can be interpreted *as if* they were not present in the first conjunct but instead were scoping over the whole coordinate structure (although not necessarily, since there is also the distributive reading). This 'deep' symmetry between the two conjuncts is a big hint that the phenomenon itself conceals a hidden symmetry.

We wish to stress at the outset that in the discussion below, we assume (along with Kuno (1976) and many subsequent authors) that the actual set of interpretations available for a particular Gapping sentence results from an interaction between what the combinatoric system of grammar generates, lexical properties of the expressions chosen, and general pragmatic knowledge. The important point is that the combinatoric component should make available both the distributive and non-distributive readings for both auxiliaries and quantifiers, leaving to other components of the grammar the relative accessibility of these

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(ii) a. Peter talked to his boss on Tuesday, and Betsy to her supervisor on Wednesday.
   b. John talked to his supervisor about his thesis, and Erich to the dean about departmental politics.

We (like other authors) do not attempt to explain why (i) and (ii) differ in acceptability, but assume that a processing basis is responsible for the difference.

[3] If the distributive reading of negation 'no dog eats Whiskas or no cat eats Alpo' seems difficult to get for (5c), consider the following, uttered in a 'no matter which' type context:

(i) No bus is available from Düsseldorf to Cologne, or train from Cologne to Frankfurt—in either case, we won't be able to get to Frankfurt in time.

respective interpretations (thus, one should not be misled by the fact that the distributive reading is difficult to get in some examples, especially without the right kind of contextual support).

The scope anomaly in Gapping, ignored in virtually all discussions of Gapping in the phrase structure theoretic literature (see our brief critique at the beginning of the next section), has been addressed extensively in the recent minimalist studies, starting from Johnson (2004) (originally written in 1996; cf. Johnson 2000, 2009; Lin 2000, 2002; Winkler 2005; Toosarvandani 2013). These proposals have in common the assumption that Gapping involves coordination at the low VP level (which is below the position where the modal auxiliary is base-generated), and that the subject of the first conjunct moves to some higher syntactic position while the subject of the second conjunct stays in its VP-internal position at surface structure. This approach thus attempts to derive the apparently anomalous scopal property of auxiliaries and quantifiers in examples like (5) from a posited syntactic asymmetry between the two conjuncts in Gapping, solving the two problems noted above (i.e. syntactic asymmetry and semantic scope anomaly) at once. Currently, this low VP coordination analysis is the only extant approach which links the two problems of Gapping and provides a uniform solution for them.[4]

The goal of this paper is two-fold. First, we present some new empirical arguments against the low VP coordination analysis of Gapping. Second, we propose an explicit alternative analysis of Gapping in a variant of categorial grammar which does not suffer from the problems that we point out for the low VP coordination analysis, while entertaining at least comparable (or better) empirical coverage as any previous account. The empirical arguments consist of both basic syntactic patterns of Gapping (involving largely neglected examples known since at least Sag (1976) as well as novel data reinforcing the point) and standard tests for constituency. These arguments both rely on uncontroversial assumptions about syntax, and we believe that they convincingly show that the structural asymmetry that the low VP coordination analysis crucially rests on in deriving the scope anomaly is highly problematic.

The analysis we propose is couched in a variant of categorial grammar (CG) called Hybrid Type-Logical Categorial Grammar (Kubota 2010, 2014, to appear; Kubota and Levine 2013), which builds on both the Lambek-inspired variants of CG (Lambek 1958; Morrill 1994; Moortgat 1997) and a more recent strand of research modelling word order via a lambda calculus for the prosodic component (Oehrle 1994; de Groote 2001; Muskens 2003). The flexible syntax-semantics interface of this framework enables an analysis of Gapping as like-category coordination at the combinatoric structure, and the mismatch between this concealed structure and the visible string is mediated by hypothetical reasoning involving lambda binding in the prosodic component. It thus avoids the undesirable structural asymmetry that the low VP coordination analysis posits between the two conjuncts, which is essentially the source of its mispredictions. Our like-category coordination analysis of Gapping is shown to interact with independently motivated analyses of scopal operators to immediately yield their apparently anomalous scopal properties in Gapping, offering, for the first time in the literature, a conceptually simple and empirically adequate solution for both of the two challenges noted above that Gapping poses for previous accounts.

[4]Except for Oehrle (1987) and Siegel (1987), whose analyses can, in a sense, be thought of as important precursors of this recent low VP coordination analysis, as well as of our own analysis presented below.

2 Gapping: the research background

As suggested in the preceding section, Gapping presents two major challenges to grammatical theories:

- determination of the structural relationship between the two conjuncts
- identification of how this relationship yields the interpretation of the second conjunct based on the interpretation of the first conjunct

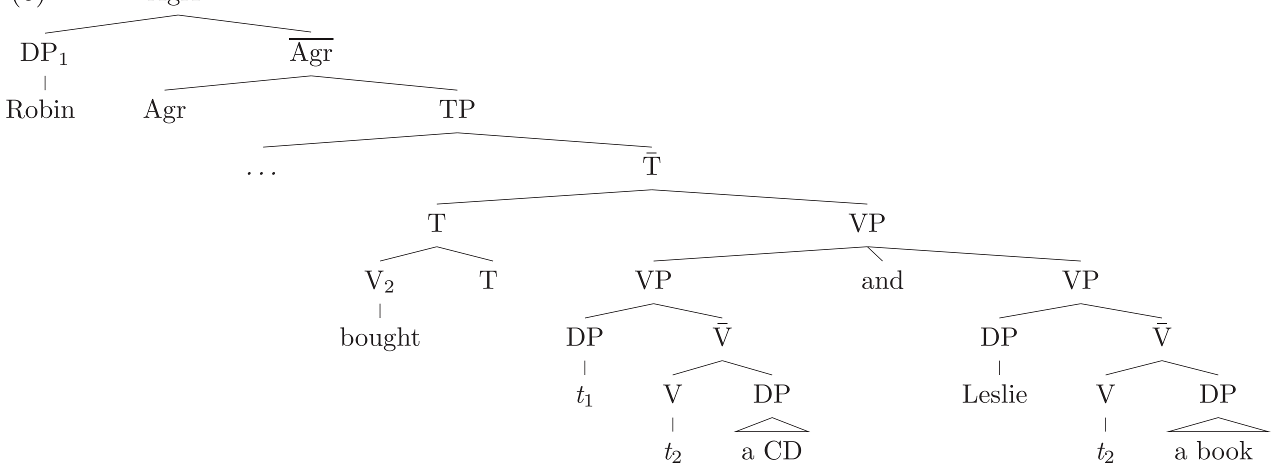
In this domain, phrase structure grammar (PSG) have proven conspicuously inadequate. To date, no phrase structure-theoretic proposal has provided an account of the interaction between Gapping and scopal operators displayed in (5). The earliest work on Gapping in a PSG paradigm, Sag et al. (1985), couched in GPSG, takes Gapped conjuncts to be unstructured strings of remnant constituents, and provides only vague speculations as to how an interpretation for the Gapped conjunct is to be constructed based on its putatively full-clause sister; a later PSG account, Abeillé et al. (2013) in Construction-based HPSG, provides almost essentially the same analysis as Sag et al. (1985), with a somewhat more explicit semantic interpretation procedure appealing to the Higher-Order Unification algorithm of Dalrymple et al. (1991). But neither of these approaches can provide an analysis for the scope anomaly of Gapping displayed in (5), in any reasonably straightforward manner at least. For this reason, we shall not be concerned with previous PSG work on Gapping, but focus instead on the transformational analytic thread beginning with Johnson (2004).

Transformational approaches certainly fare better with respect to the scope anomaly problem in Gapping. In fact, the family of low-VP coordination approaches (for references, see section 1) are designed to solve precisely this problem. These proposals differ in some details, but they all have in common the assumption that Gapping sentences are derived from underlying sentences involving coordination at the lower VP level. For expository ease, we take up Johnson's (2000) proposal in the ensuing discussion, but since all the problems we discuss below pertain to the low VP coordination assumption in his analysis, our critique is applicable to other approaches in this group as well.

2.1 Gapping as low VP coordination: details and motivation

The key innovation in Johnson's low VP coordination analysis is that, roughly speaking, what appears to be a coordination of a full clause with a partial clause missing its verb (and possibly other elements as well) is actually a coordination of two VPs—but where the second VP's subject is in situ in [Spec,VP] and the common verb of both is extracted via ATB movement to a position adjoining the T head whose complement is the conjoined VP. In addition to this more or less conventional movement, there is a second, non-ATB extraction which takes the subject of the first conjunct to the Spec position under the matrix AgrP, creating the illusion of a full clause on the left and a partial clause on the right. The actual structure is illustrated in (6).

(6)



Cases of Gapping which include more complex structures in the righthand conjunct (e.g. (4a)), are presumably handled by multiple leftward raisings which preserve the order of heads in the resulting structure. None of the works by Johnson (Johnson 2000, 2004, 2009) provides explicit details clarifying this issue, though Johnson (2009) offers some speculations about the mechanisms involved.[5]

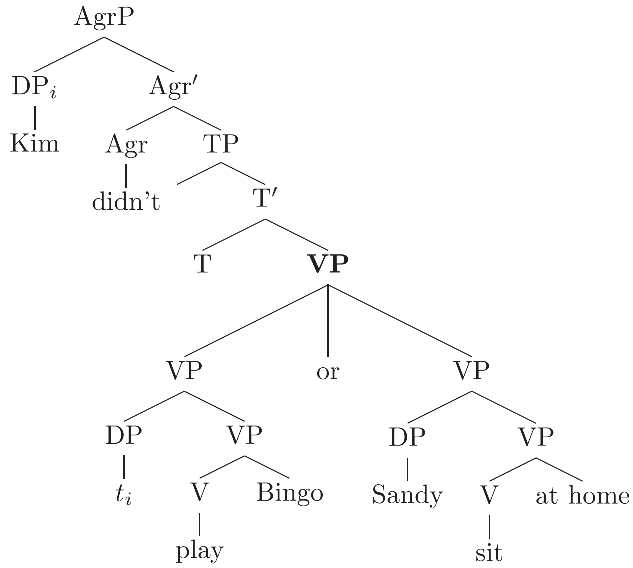
Johnson's analysis contains a number of controversial features, such as the non-ATB movement of the first conjunct subject and the treatment of both conjuncts as VPs rather than clauses (with the second seemingly defective in some way) or a clause and a string of constituents (as in Sag et al. (1985), Culicover and Jackendoff (2005), and Abeillé et al. (2013)). Our critique below in section 2.2 essentially consists in questioning the plausibility of this structural asymmetry between the status of the subjects of the two conjuncts. But these moves are crucial to Johnson's account of the interaction of Gapping with scopal operators, such as modal auxiliaries and negative determiners, where his goal is to provide a derivation of such sentences with nondistributive readings. Consider first the examples involving auxiliaries.

(7) a. Kim didn't play bingo or Sandy sit at home all evening.
b. Kim didn't play bingo or Sandy chess.

While (7a) and (7b) differ in that only the auxiliary is gapped in (7a) whereas both the auxiliary and the verb are gapped in (7b), the scopal facts are parallel. The key to an account of the auxiliary wide-scope reading for (7a) is to somehow separate the semantic action of the modal from its apparent linear position—an outcome which follows directly from Johnson's proposal to take the two conjuncts in these examples to be VPs, creating a structure above which the modal can appear, with consequent wide scope over the conjunction. The remaining requirement, that of making the modal appear to be embedded in the first conjunct, follows directly from the asymmetrical fronting of the first conjunct subject to [Spec,AgrP]. Thus, (7a) has the following structure:

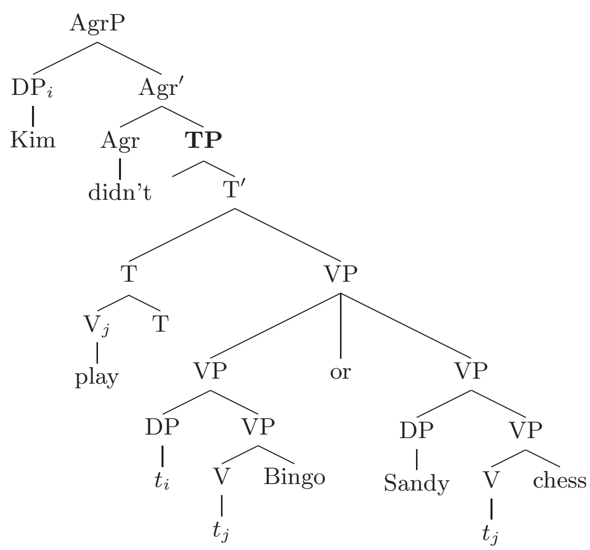
[5] We find the counterarguments to these speculations presented in Toosarvandani (2013) to be convincing, but will leave aside this issue, which does not bear directly on our own critique of the low VP coordination approaches in general, including Toosarvandani's (2013) own.

(8)



Examples like (7b) in which both the auxiliary and the verb are missing are licensed by moving the verb out of the two conjuncts in an ATB fashion (as in the basic Gapping example above in (6)).

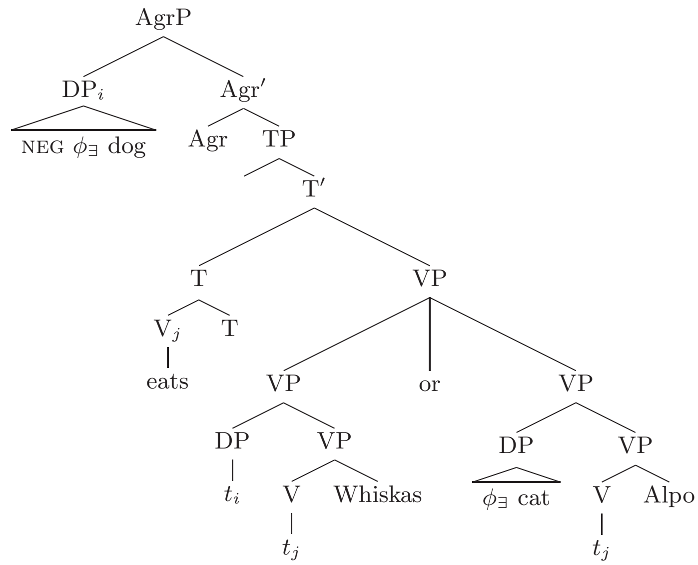
(9)



Finally, for cases involving negative determiners such as (10), Johnson adopts the split scope analysis (Jacobs 1980; Penka 2011) in which these determiners are decomposed into a higher sentential negation and a lower indefinite at LF, and proposes an analysis along the lines of (11):

(10) No dog eats Whiskas or cats Alpo.

(11)



The ATB movement of the verb is licensed in the same way as (9) above. The only extra complication involved in this example is the split scope of the subject negative quantifier. The subject in the two conjuncts both have a phonologically empty indefinite article $\phi_\exists$ as their determiners. This DP moves out of its VP internal position in the first conjunct (just as in other examples) and attaches to a higher adverbial negation so that this negation and the indefinite $\phi_\exists$ fuse at PF to be spelled out as the morpheme *no*. $\phi_\exists$ and the head noun are reconstructed to its base position at LF for the purpose of semantic interpretation. Thus, just as in the example above involving an auxiliary, the scopal relation between the quantifier and the coordinate structure is captured by assuming that the negation which is part of the negative quantifier originates syntactically *outside* the coordinate structure.

2.2 Low VP coordination: contraindications

As should be clear from the above, low VP coordination and the asymmetrical non-ATB movement of the subject of the first conjunct out of its VP-internal position is crucial in this approach for mediating the apparent mismatch between the surface position of the scopal operators and their semantic scope. The central questions that arise at this point are (i) whether or not any clear independent motivations exist for this assumption, and (ii) whether the hypothesis does the work that is required of it.

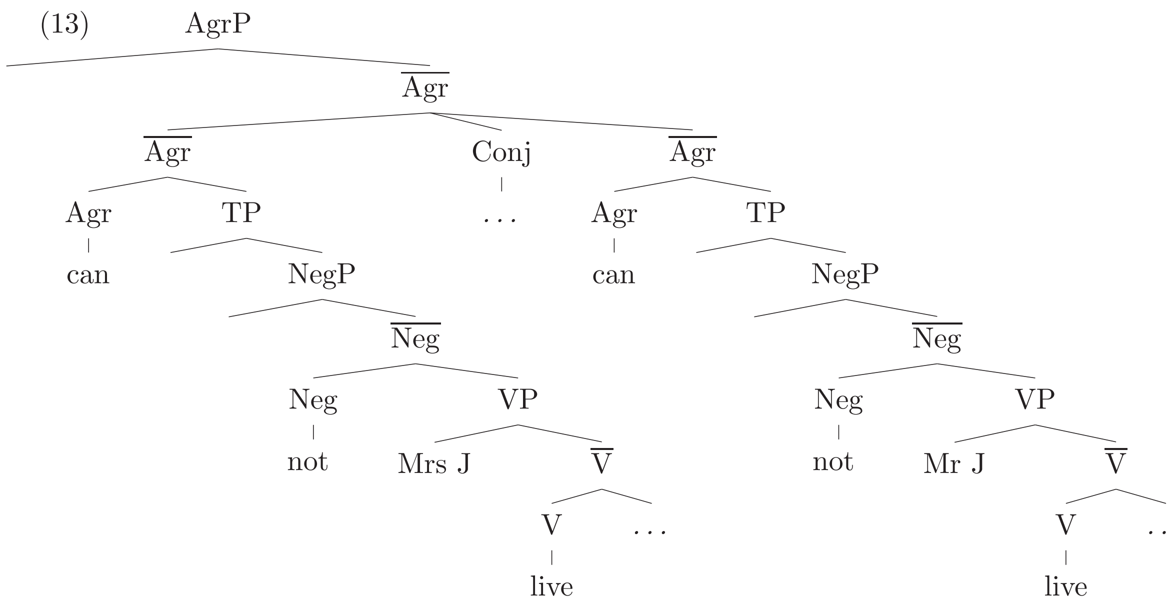
2.2.1 The problem of distributive readings

We begin with the latter question, where what is required of the low VP coordination analysis is, on the semantic side, to provide a configuration with a natural correspondence to the range of interpretations observed for Gapping sentences. The wide-scope interpretations of auxiliaries and negative determiners, as we have just seen, are straightforwardly accounted for in the low VP coordination analysis—but as noted in section 1, there is a distributive interpretation of the auxiliaries and determiners possible in Gapping as well, and it is nowhere made clear exactly how this interpretation is to be handled in the low VP coordination analysis.

Johnson himself, alluding to such data, says only that 'these cases might arise because gapping has removed the negation from the second conjunct' (Johnson 2009, 298, footnote 10), without further explication. Given his treatment of the basic cases of Gapping illustrated in (6), in which the shared meaning of a single main verb token between conjuncts is due to ATB movement of two identical underlying tokens of this verb, it appears that the same solution is intended to account for the missing auxiliary contributing the second conjunct negation. Thus, an example such as (12), which has a distributive reading, must be analyzed with a representation such as (13) at some stage in the derivation.

(12) Mrs. J cannot live in LA and Mr. J live in Boston.

(13)



Note that, crucially, to get the semantics right, each conjunct must, in addition to the verb *live*, contain a token of the modal *can* and the negation marker *not*. These three elements then need to undergo ATB movement so that only a single token of each appears in the surface string. But where the landing sites for these movements are supposed to be, and how the separate movements are made so that they yield the one way out of the 6 possible ordering among *can*, *not* and *live* that faithfully reproduces the hierarchical relationship (isomorphically reflected in linear order) among these elements in their original locations is never explained. Nonetheless, some hints are provided, for in discussing the parallelism between the word order in two conjuncts in Gapping, Johnson (2009, 315) appeals to an intricate set of conditions adopted from previous Minimalist literature (see, e.g., **??**). These mechanisms involve linearization of lexical items via restrictions on interspersed PF Spell-Outs and Merge operations, motived solely by the need to guarantee that the results of complex sequeces of movements wind up looking exactly like what we would find if no movement at all had taken place. It appears very likely that this same technology must be invoked to deal with the ordering problem among the auxiliary, negation and the main verb here. But such an account completely lacks independent motivation.

Far more problematic, as Johnson (2009, 298) himself acknowledges, are cases such as

(14), first noted by Repp (2006, 2009).[6]

(14) PETE wasn't called by VANESSA, but (rather) JOHN by JESSE

If neg contracted forms such as *wasn't* in (14) are entered as such in the lexicon, Repp's (2009, 31) characterization of the problem that (in the low VP coordination analysis) 'negation can either be interpreted above the coordination (= wide scope) or inside both conjuncts (= distributed scope) but it cannot scope over the first conjunct only' seems indeed indisputable. One might then make recourse to a possibility that negation and the auxiliary are separate lexical items underlyingly. There are two alternative configurations which would make this possible. One possibility (following a fairly standard assumption in the current Minimalist work) is to assume that negation has its own function projection NegP between VP and TP. On the other hand, in his discussion of split scope, Johnson (2000) explicitly entertains the possibility of negation being treated as an adjunct attaching freely to head categories. One might thus alternatively assume that negation is an adverbial category that right-adjoins to an auxiliary.

Whichever is the case, it should be clear that the $\neg A \wedge B$ reading for (14) requires an underlying conjunction of TPs (or of some larger functional projection), both of which contain *was* as the lexical head of that projection, but only the first of which contains negation, either as functional head of NegP or as the head of an AdvP attached to *was*. We thus have the schematic configuration prior to ATB movement of *was* to AgrP in (15a), and the final position of *was* after ATB movement in (15b):

(15) a. $[_{\mathrm{AgrP}} \ldots [_{\mathrm{TP}}[_{\mathrm{TP}}$ was ... not... VP] but (rather)$[_{\mathrm{TP}}$ was VP]
b. $[_{\mathrm{AgrP}} \ldots \mathrm{was}_1\ [_{\mathrm{TP}}[_{\mathrm{TP}}\ \mathrm{e}_1 \ldots$ not... VP] but (rather)$[_{\mathrm{TP}}\ \mathrm{e}_1$ VP]

Crucially, in either case, after its ATB movement, *was* is separated from *not* by its own trace. Thus, for the contraction of negation on the auxiliary to take place, a further movement must be assumed to allow *not* to move to a sister position of *was*:

(16) $[_{\mathrm{AgrP}} \ldots \underbrace{\mathrm{was}_1 + \mathrm{not}_2}_{\mathrm{wasn't}}\ [_{\mathrm{TP}}[_{\mathrm{TP}}\ \mathrm{e}_1 \ldots \mathrm{e}_2 \ldots \mathrm{VP}]$ but (rather)$[_{\mathrm{TP}}\ \mathrm{e}_1$ VP]

However, if we allow for this possibility, there is nothing in Johnson's framework, so far as we can tell, which dictates that *not* necessarily moves from the first conjunct exclusively. (17) thus appears to be an equally legal derivational sequence:

(17) $[_{\mathrm{AgrP}} \ldots \underbrace{\mathrm{was}_1 + \mathrm{not}_2}_{\mathrm{wasn't}}\ [_{\mathrm{TP}}[_{\mathrm{TP}}\ \mathrm{e}_1$ VP] but (rather)$[_{\mathrm{TP}}\ \mathrm{e}_1 \ldots \mathrm{e}_2 \ldots$ VP]

[6] Repp's (2006, 2009) own analysis—the only explicit proposal in the literature addressing this $\neg A \wedge B$ Gapping pattern—fails to predict the auxiliary wide-scope reading of sentences such as *John shouldn't eat steak and Mary just pizza*. The core idea of her proposal is that wide scope negation readings arise as instances of 'illocutionary negation', a kind of negation corresponding to a speech act. But since only the negation in this sentence would have this illocutionary force—as vs. *should*, which denotes a deontic operator with no illocutionary content—only the former could reasonably be assumed to scope over the whole conjunction, predicting, in effect, $\neg\Box A \wedge \neg\Box B$ as the meaning of the sentence (where the correct meaning makes a much stronger assertion: $\Box\neg(A \wedge B) \equiv \neg\Diamond(A \wedge B)$). Furthermore, Tomioka (2011) provides examples ((2) on p. 223) exhibiting auxiliary wide-scope interpretations within conditional and relative clauses, a phenomenon that is highly problematic for Repp's illocutionary negation-based account.

But this would assign the reading 'Pete was called by Vanessa, but John wasn't called by Jesse' to (14), which is obviously a wrong result.

It thus seems fair to conclude that both the ordinary distributive readings of auxiliaries and Repp's $\neg A \wedge B$ examples pose serious empirical problems for the low VP coordination approach.

2.2.2 The argument from island effects

We now turn to the first part of the question, namely, the existence of independent motivation for the low VP coordination analysis. Advocates of the low VP coordination approach in one or another version have attempted to offer such an argument by invoking alleged parallelisms between syntactic island effects in extraction and in Gapping. The unacceptability of the following examples from Johnson (2004), for example, is offered in an effort to establish the adherence of Gapping to island constraints (and hence the plausibility of the movement-based analysis).

(18) a. *John wondered what to cook today and Peter ~~wondered what to cook~~ tomorrow. (*Wh*-island Constraint)

b. *John must be a fool to have married Jane, and Bill ~~must be a fool to have married~~ Martha. (Adjunct Condition)

c. *I read out the order to fix the tortillas, and Mary ~~read out the order to fix~~ beans. (Complex NP Constraint)

d. *Stories about Frankenstein terrified John, and ~~stories about~~ Dracula ~~terrified~~ Peter. (Subject Condition)

This argument, however, is highly dubious. Note that examples such as the following (which are structurally parallel to those in (18)) seem well within the bounds of acceptability.[7]

(19) a. (Wife of a couple discussing who decides what to cook for which meal:)
Ok, how about this: I get to decide what to cook for LUNCH, and you, for DINner. (Wh-Island)

b. ONE twin calls me when he's in TEXAS, and the OTHER, in COLORADO. (Adjunct Condition)

c. One lab assistant needs informants who speak Japanese, and the other German. (Complex NP Constraint)

d. I don't think we need worry about John harassing us. Threats directed at ME would offend his WIFE, and at YOU, everyone else! (Subject Condition)

In view of the conflict between the (allegedly) unacceptable examples in (18) and the structually parallel good examples in (19), there are really only two alternatives: take the island

[7]Note also the following:

(i) a. ROBIN believes that everyone pays attention to you when you speak FRENCH, and LESIE, GERMAN. (Adjunct Condition, Culicover and Jackendoff (2005, 273))

b. Robin knows a lot of good reasons why DOGS are good pets, and LESLIE, CATS. (Complex NP Constraint, Culicover and Jackendoff (2005, 273)) violation cases in (18) to be the key diagnostic, in which case the examples in (19) are somehow perceived as acceptable although they are not generated by the grammar, or take the examples in (19) to be more representative and account for the unacceptability of (18) in terms of some extra-grammatical, processing-oriented principles. On the whole, the latter strategy provides by far the simpler explanation, since there is independent reason to think that similar processing-oriented principles are at work in other domains (most notably, in the typical extraction contexts; cf. Deane 1991; Kluender 1992, 1998; Kehler 2002; Hofmeister and Sag 2010). If one were to adopt the former view, the syntactic principle would account for the unacceptability of (18), but that is not enough; some independent processing-oriented principle explaining the amelioration found in (19) would need to be invoked as well. But if a pragmatic principle would need to be called for after all, recognizing a syntactic principle in addition seems totally redundant. Thus, by Occam's razor, a purely pragmatic account is more favorable here.

Note, moreover, a contrast such as the following:

(20) a. There were certain cars of which only [the windows __] were damaged in the explosion. (slightly modified from Ross (1967, 242))

b.??The windows of the van were cracked, and of the cars, shattered.

(20a), discussed in Ross (1967) as evidence *against* a general restriction on extraction from subjects, is perfectly good; clearly *the windows of which* cannot be an island for movement. But the Gapping example in (20b) sounds at least as bad as (18c). This kind of example strongly suggests the existence of issues involved in real-time interpretation of Gapping data which present particular difficulties that have no counterpart in filler/gap constructions. Our conclusions here coincide with those of Repp (2009, 13) that '[i]sland constraints do not seem to be the right sort of constraints: they are too strict for some cases and too lax for others'.

In sum, well-formed Gapping examples violating putative syntactic island constraints are available, whereas ill-formed Gapping examples can also be found for cases in which syntactic extraction is entirely acceptable. Given this, it seems reasonable to conclude that data such as (18), which are commonly invoked in the transformational literature, fails to adequately support the popular claim that the movement analysis of Gapping provides an explanation for patterns of acceptability that is not otherwise available.

2.2.3 Do Gapping conjuncts behave like VPs?

But we can go further than this, and reject the low VP coordination hypothesis outright. Robust empirical evidence imposes a heavy burden of proof on low-VP coordination analyses generally, strongly suggesting that they do not correctly characterize the basic syntactic structure of Gapping sentences. There are two lines of evidence against the low VP coordination analyses: on the one hand, the failure of constituency tests that VPs would be expected to satisfy, and on the other, a set of distributional patterns which strongly group Gapping conjuncts with clausal constituents as opposed to VPs.

Basic constituency tests. To see this, note that the non-ATB movement of the first conjunct subject creates a spurious surface VP (or TP)—the boldfaced constituents in (8) and (9)—asymmetrically containing the subject of the second conjunct. Thus, in (21) (which contains an auxiliary), the subject moves to a higher position, and the verb remains in either the T (in the case of auxiliary + verb gapping in (21a)) or V (in the case of auxiliary alone gapping in (21b)) head below, as in (22a) and (22b).

(21) No positron can occupy the INner shell and electron $\left\{\begin{array}{l}\text{a. } \varnothing \\ \text{b. sit in}\end{array}\right\}$ the OUTer shell of the same atom.

(22) a. [$_{\text{AgrP}}$ No positron$_i$ [$_{\text{Agr}'}$ can [$_{\text{TP}}$ occupy$_j$ [$_{\text{VP}}$ [$_{\text{VP}}$ t_i t_j the INner shell] and [$_{\text{VP}}$ $\phi_\exists$ electron t_j the OUTer shell]]]]]

b. [$_{\text{AgrP}}$ No positron$_i$ [$_{\text{Agr}'}$ can [$_{\text{TP}}$ [$_{\text{VP}}$ [$_{\text{VP}}$ t_i occupy the INner shell] and [$_{\text{VP}}$ $\phi_\exists$ electron sit in the OUTer shell]]]]]

It is not necessarily clear in advance exactly which category is targeted by phenomena like VP fronting that are standardly taken to diagnose complements of auxiliaries (in theory neutral terms), but given the structure assigned to the two versions of (21) in (22), regardless of whether these tests apply to VP or to TP, one or the other of the following examples in (23)–(25) should be predicted to be grammatical. The robust unacceptability of all of these examples falsifies this prediction very clearly.

(23) a. No positron can [$_{\text{TP}_i}$ occupy the INner shell and electron the OUTer shell of the same atom]. #Not only that, no neutron can do so$_i$. (*do so*)

b. No positron can [$_{\text{VP}_i}$ occupy the INner shell and electron sit in the OUTer shell of the same atom]. #Not only that, no neutron can do so$_i$.

(24) a. *[$_{\text{TP}_i}$ Occupy the INner shell and electron the OUTer shell of the same atom], no positron can t_i. (*VP fronting*)

b. *[$_{\text{VP}_i}$ Occupy the INner shell and electron sit in the OUTer shell of the same atom], no positron can t_i.

(25) a. *No positron can [$_{\text{TP}}$ occupy the INner shell and electron the OUTer shell of the same atom], or [$_{\text{TP}}$ occupy the inner shell of an atom with another positron]. (*coordination*)

b. *No positron can [$_{\text{VP}}$ occupy the INner shell and electron sit in the OUTer shell of the same atom], or [$_{\text{VP}}$ occupy the inner shell of an atom with another positron].

It is true that failing a constituency test does not necessarily disprove the constituenthood of the string in question, since the failure may arise for nonstructural reasons. Such accounts are of course alway possible, and in certain cases seem quite likely as the source of negative judgments. For example, in the case of (23), we might have used VP ellipsis as our test, rather than *do so* replacement, and the anomalous result (#*Not only that, no neutron can (either)*) might then have been taken to arise from the fact that focused material cannot undergo ellipsis, assuming Gapping remnants are focused. But so far as we can tell, there is no independent explanation—semantic, pragmatic, psycholinguistic or prosodic—for the badness of the examples in (23)–(25). There is, for example, no property of *do so* replacement analogous to that displayed by ellipsis which would allow a parallel argument to be made for (23). Thus, the examples in (23) (at least one or the other) should be well-formed on the low VP coordination analysis, and so should the others cited. The misprediction noted is essentially due to the fact that the low VP coordination approach analyzes Gapping via coordination at the VP level.[8]

Gapped conjuncts: VP vs. S. Moreover, just from the basic syntactic patterns of Gapping (not involving any interactions with other phenomena targeting 'VP' constituents), we see evidence against the low VP coordination analysis. The relevant data come from Gapping sentences involving various fronted elements.

(26) a. At our house we play poker, and at Betsy's house, bridge.
b. Yesterday we went to the movies, and last Thursday, to the circus. (Sag 1976, 265)

(27) a. To Robin Chris gave the book, and to Leslie, the magazine.
b. To Leslie I want to write a letter __, and to Robin, a short note __.
c. To Leslie I (had) thought that we'd write a letter __, and to Robin, a short note __.
d. Tweedledee, I intend to argue with __, and Tweedledum, to negotiate with __.
e. Robin, I'm quite disappointed in __, and Leslie, very angry at __.

(28) Which abstract should we send to NELS and which manuscript to LI?

Some of these facts were already known since Sag (1976), and indeed, Repp (2009, 34) briefly notes that examples similar to (26) and (28) are problematic for the low VP coordination analysis of Gapping offered in Winkler (2005). On the low VP coordination analysis, by assumption, the second conjunct contains only an untensed lower VP projection, but then, there are no landing sites for the fronted elements which are standardly taken to be somewhere above the T node.

[8]One might think that examples like (24) could be ruled out by assuming that reconstruction of the subject of the first conjunct to a VP-internal position (which one might motivate either from the CSC (Lin 2001) or perhaps just for the purpose of semantic interpretation) is blocked for fronted VPs. Such an assumption might in turn be taken to receive independent support from the fact that the object quantifier cannot scope over the subject quantifier in such an environment:

(i) See everyone, (I am sure) someone did. —— ($\exists > \forall$, $*\forall > \exists$; Huang 1993)

But the argument that (i) motivates this assumption is decisively undermined by contrasts such as that between (iia) and (iib).

(ii) a. Some student (or other) wants to hear stories about every physicist. ($\exists > \forall$, $\forall > \exists$)
b. Stories about every physicist, some student (or other) wants to hear. ($\exists > \forall$, $*\forall > \exists$)

In (iib) there is no question of the existentially quantified subject reconstructing to a position within the fronted constituent, since it did not originate within that constituent to begin with. Yet just as in (i), we find that the wide scope available to the in situ universal is unavailable when the universal is part of a topicalized constituent. Hence the claim that subjects cannot reconstruct back into fronted VPs gets no support from the scopal facts about (i), and appealing to such a claim to explain the pattern in (24) must therefore be purely stipulative.

Note crucially that, unlike subjects (for which there is at least a theory-internal motivation for a pre-verbal base position by adopting the VP-internal subject hypothesis), the fronted elements in (26)–(28) do not originate in the conjunct-initial positions in the second conjunct. Thus, the only way to accomodate these examples is to posit an ad-hoc landing site just above the lower VP (Winkler (2005, 209) does ideed seem to be alluding to this possibility, without, however, noting its immediate consequence we discuss below). Positing such a landing site, however, is highly implausible, given the obvious impossiblity of topicalizing to this position in non-Gapping contexts, as robustly exemplified in (29) and (30).

(29) a. *I intend$_i$ [$_{\text{VP}}$ Tweedledee$_k$ [$_{\text{VP}}$ t$_i$ to negotiate with t$_k$]] (cf. (27d))

b. *I am Leslie very angry at __. (cf. (27e))

(30) a. *I want [to Robin]$_i$ to write a letter t$_i$. (cf. (27b))

b. *I thought [to Robin]$_i$ that we would write a letter t$_i$ (cf. (27c))

c. *I had [to Robin]$_i$ thought that we would write a letter $_i$ (cf. (27c))

Tweedledum is fronted in the second conjunct in (27d). The claim that the second conjunct is a VP thus entails that there is a position within a VP which can host a topicalized constituent. But then, this landing site should be available in non-Gapping clauses as well. However, this prediction fails, as attested by the ill-formedness of (29a). Similar arguments go with other examples. To rule out examples like (29) and (30), one would then need to invoke some constraint prohibiting the (future) fronted element to stay in the lower VP adjunction site if the subject moves out of its VP internal position. But such a complex interdependency between movement operations is not only theoretically dubious but also lacks any independent empirical motivation.

The evidence just outlined from topicalization against the low VP coordination analysis uses a particular syntactic behavior characteristic of clauses but not of VPs as a diagnostic probe. A second argument of the same kind can be made based on a property characteristic of VPs as opposed to clauses: the distribution of the adverb *merely* is a case in point. As shown in (31), *merely* is a strictly VP adjunct; it cannot adjoin to S.

(31) a. Robin $\left\{\begin{array}{l}\text{merely said}\\ \text{said merely}\end{array}\right\}$ that our footnotes were too long.

b. *Merely, Robin said that our footnotes were too long.

On this basis, we predict that *merely* should be eligible to appear preceding the putative VP which the second conjunct consists of in Johnson's analysis. But this prediction is not borne out.

(32) Robin commented only that our margins were too small, and $\left\{\begin{array}{l}\text{a. Leslie merely}\\ \text{b.*merely Leslie}\end{array}\right\}$ that our footnotes were too long.

The badness of (32b) follows directly from the fact, exemplified in (31b), that *merely* is strictly a VP modifier, if we assume that the Gapped conjunct is clausal. But it is completely unexpected if we take the Gapped conjunct to be a VP.

We thus have two diagnostics which independently sort VPs from Ss converging on the identification of the Gapped conjunct as a VP, not an S. Ordinary methodological considerations therefore suggest that, like the data in (23)–(25), these facts impose a very heavy buden of proof onto the low VP coordination analysis.

Does determiner Gapping depend on 'normal' Gapping? Finally, as should be clear from the above exposition, in Johnson's analysis determiners can be gapped from the second conjunct only if the verb (or at least the auxiliary) is also gapped, instantiating the low VP coordination structure. This is meant to capture the (alleged) generalization from McCawley (1993) that the former is dependent on the latter:

(33) a. *Too many Irish setters are named Kelly, and ∅ German shepherds are named Fritz.
b. *Your daughter is 16 and ∅ son is 17-1/2. (McCawley 1993)

However, this empirical observation does not seem to be entirely correct. Note that, if the remaining VP in the second conjunct is short enough, determiner-alone gapping sentences are actually acceptable:

(34) a. Some dog barked and ∅ donkey brayed last night.
b. No dog barked or ∅ donkey brayed last night.

Note in particular that (34b) exhibits the same scope anomaly as examples like (5c). Given the predicted dependency of determiner gapping on ordinary Gapping, there does not seem to be any straightforward way of accounting for the parallel scopal behavior of negative quantifiers in these two types of cases in Johnson's approach.

Gapping thus continues to pose a serious challenge to all syntactic frameworks, and it seems fair to say that there is currently no successful analysis of the apparently anomalous scopal properties of auxiliaries and quantifiers that is free from major empirical problems. On the whole, the low VP coordination analysis is the best story that has been produced in previous work on Gapping, but the empirical evidence we have discussed above seems to show conclusively that the particular way in which it links the two puzzles of Gapping is not on the right track.

3 An analysis of Gapping in Hybrid Type-Logical Categorial Grammar

In this section, we propose an analysis of Gapping in a variant of categorial grammar (CG) called Hybrid Type-Logical Categorial Grammar (Hybrid TLCG) (Kubota 2010, 2014, to appear; Kubota and Levine 2013). Hybrid TLCG is essentially an extension of the Lambek calculus (Lambek 1958) with one additional, non-directional mode of implication. The original Lambek calculus is known to be unsuitable for dealing with order-insensitive phenomena such as extraction and quantification (cf., e.g., Muskens 2003; see also section 3.1.2 below). Hybrid TLCG overcomes this difficulty by incorporating the idea, initially developed in a separate strand of research in CG (Oehrle 1994; de Groote 2001; Muskens 2003), that detaching word order from the combinatoric component by utilizing λ-binding in the prosodic component enables a simple and elegant solution to this problem. Unlike previous authors in this tradition, we retain the directional slashes from the Lambek calculus, since they are indispensable for a proper analysis of nonconstituent coordination (see Muskens (2001) and Kubota (2010, section 3.2.1) for the difficulty that these 'non-directional' CGs face in this respect). As discussed in detail in ***[reference omitted for refereeing]***, this architecture results in a flexible syntax-semantics interfere that is suitable for handling a number of complex interactions between (non-Gapping type) coordination and various scopal expressions. The present paper extends this line of research by providing an explicit and detailed analysis of Gapping which systematically accounts for both its (apparent) syntactic and semantic anomalies. We argue that a complete analysis of Gapping requires precisely the kind of hybrid implication architecture (equipped with both directional and non-directional modes of implication) that Hybrid TLCG embodies.

Our analysis builds heavily on previous studies on Gapping in the CG literature, but extends their empirical coverage significantly. Implementational details aside, previous literature on Gapping in CG all agree on the fundamental hypothesis about the 'underling' syntactic structure of Gapping: Gapping instantiates like-category constituent coordination, despite the surface asymmetry between the initial and non-initial conjuncts. We take this hypothesis to be basically correct. However, previous analyses of Gapping in CG are all significantly limited in their empirical coverage. As we see it, the problem is that these previous analyses are couched in variants of CG that are suitable for handling only one or the other of the two problems that Gapping poses (i.e. describing the syntactic patterns and explaining the scope anomaly), thus leaving the analysis incomplete in the other respect (see ***[reference omitted for refereeing]*** for a more detailed critique of the major previous approaches to Gapping in the CG literature). For example, Steedman's (1990) analysis in CCG is the first analysis of Gapping as like category coordination, and it captures the basic syntactic patterns of Gapping quite successfully. However, since CCG is basically a 'directional' variant of CG with only forward and backward slashes, it is not equipped with a mechanism that can handle the complex scopal properties of auxiliaries and quantifiers. By contrast, Oehrle (1987) and Siegel (1987) shed considerable light on this scope anomaly by casting their analyses in frameworks that are essentially the precursors of the contemporary 'non-directional' CGs. By relegating word order from the combinatoric component, such frameworks are indeed suitable for capturing scope-related phenomena, but this comes at the cost that keeping track of linear order becomes notoriously difficult, resulting in an incomplete analysis of the basic syntactic patterns of Gapping. Our own analysis resembles most closely Morrill et al.'s (2011) (which is a refinement of Hendriks (1995)) in treating Gapping essentially as coordination of sentences with medial gaps. However, neither Hendriks (1995) nor Morrill et al. (2011) extend thier analyses to the scope anomaly puzzle. (To be fair, the core of our empirical results, so far as we can tell, seem to straightforwardly carry over to Morrill et al.'s (2011) system.) We think that the main reason that the discovery of a TLCG solution for this problem did not become available until present is that previous variants of TLCG employ very complex mechanisms for handling discontinuous constituency in Gapping and the syntax-semantics mismatch of scopal expressions, which obscured the insight of the underlying analysis. Our setup improves over these approaches in this respect, in treating (following Oehrle (1994)) discontinuity simply by λ-binding in phonology, thereby making the underlying analytic intuition considerably more transparent.

3.1 Overview of Hybrid TLCG

Here we provide a brief introduction to Hybrid TLCG. We believe that what is contained below provides everything necessary to follow our analysis of Gapping, but due to space considerations, the presentation is kept to a minimum; for a more leisurely presentation of the same material, see ***[reference omitted for refereeing]***. Readers conversant in TLCG, on the other hand, may want to skip this section, look over the complete set of rules reproduced in Appendix A.1 (taking note of the last paragraph of section 3.1.1), check on the discussion in section 3.1.3, and then directly jump to section 3.2.

3.1.1 Hypothetical reasoning with directional slashes

Following Oehrle (1994) and Morrill (1994), we adopt the labelled deduction presentation of the calculus. Linguistic expressions are written as tuples $\langle \phi, \sigma, \kappa \rangle$ of phonological form (ϕ), semantic translation (σ), and syntactic category (κ), as in the following sample lexicon:

(35) a. john; $\mathbf{j}$; NP
b. mary; $\mathbf{m}$; NP
c. walks; $\mathbf{walk}$; NP\S
d. loves; $\mathbf{love}$; (NP\S)/NP

Complex syntactic categories are built from the atomic categories including S, NP and N with the connectives / and \ (to which | will be later added) recursively. The distinction between / and \ pertains to the directionality (reflected in surface word order) in which functor (or, functional) expressions look for their arguments. We adopt the Lambek-style notation of slashes, meaning that $A\backslash B$ designates a functor looking for an argument A to its left. (Thus, the transitive verb category is written as (NP\S)/NP, rather than (S\NP)/NP as in CCG.) We omit parentheses for a sequence of the same type of slash, assuming that / and | are left associative, and \ right associative. Thus, S/NP/NP, NP\NP\S and S|NP|NP are abbreviations of (S/NP)/NP, NP\(NP\S) and (S|NP)|NP, respectively.

In TLCG, derivations of linguistic expressions are thought of as proofs. Thus, syntactic rules are inference rules of the deductive system, and for each of the syntactic connectives (which should be thought of as directional counterparts of the implication connective in ordinary logic), there are inference rules of Introduction and Elimination. We first introduce the Elimination rules /E and \E (which are the rules of modus ponens $B \to A, B \vdash A$).

(36) a. Forward Slash Elimination

$$\frac{\mathsf{a};\ \mathcal{F};\ A/B \quad \mathsf{b};\ \mathcal{G};\ B}{\mathsf{a} \circ \mathsf{b};\ \mathcal{F}(\mathcal{G});\ A}\ /\mathrm{E}$$

b. Backward Slash Elimination

$$\frac{\mathsf{b};\ \mathcal{G};\ B \quad \mathsf{a};\ \mathcal{F};\ B\backslash A}{\mathsf{b} \circ \mathsf{a};\ \mathcal{F}(\mathcal{G});\ A}\ \backslash\mathrm{E}$$

The connective $\circ$ in the prosodic component designates string concatenation and is associative in both directions (i.e. $(\varphi_1 \circ \varphi_2) \circ \varphi_3 \equiv \varphi_1 \circ (\varphi_2 \circ \varphi_3)$). This makes the system equivalent to the associative Lambek calculus $\mathbf{L}$ once we add the Introduction rules for / and \. We return to this point below.

The Elimination rules in TLCG roughly correspond to rules of subcategorization cancellation in other theories (Merge in Minimalist syntax and Head-Complement rules in HPSG).

Thus, by using these rules, we can combine a transitive verb (of category (NP\S)/NP) with the two arguments that it is looking for to build a sentence.

(37)
$$\dfrac{\textsf{john}; \mathbf{j}; \mathrm{NP} \qquad \dfrac{\textsf{loves}; \mathbf{love}; (\mathrm{NP}\backslash\mathrm{S})/\mathrm{NP} \quad \textsf{mary}; \mathbf{m}; \mathrm{NP}}{\textsf{loves} \circ \textsf{mary}; \mathbf{love}(\mathbf{m}); \mathrm{NP}\backslash\mathrm{S}}/\mathrm{E}}{\textsf{john} \circ \textsf{loves} \circ \textsf{mary}; \mathbf{love}(\mathbf{m})(\mathbf{j}); \mathrm{S}}\backslash\mathrm{E}$$

Note that, by applying the rules in (36), the right surface word order is obtained which is paired with the right meaning. The prosodic effect of these rules is string concatenation (sensitive to the directionality encoded in the slash) and their semantic effect is function application.

An important difference between other syntactic theories and TLCG is that TLCG takes the analogy between language and logic quite literally. Thus, in addition to the Elimination rules there are also Introduction rules for the two connectives / and \, which are essentially rules of implication introduction (or HYPOTHETICAL REASONING), where the form of the reasoning involves drawing the conclusion $A \to B$ given a proof of B by hypothetically assuming A.[9]

(38) a. FORWARD SLASH INTRODUCTION

$$\begin{array}{c} \vdots \quad \vdots \quad \underline{[\varphi; x; A]^n} \quad \vdots \quad \vdots \\ \vdots \quad \vdots \quad\; \vdots \quad \vdots \;\quad \vdots \quad \vdots \\ \hline \dfrac{\textsf{b} \circ \varphi; \mathcal{F}; B}{\textsf{b}; \lambda x.\mathcal{F}; B/A}/\mathrm{I}^n \end{array}$$

b. BACKWARD SLASH INTRODUCTION

$$\begin{array}{c} \vdots \quad \vdots \quad \underline{[\varphi; x; A]^n} \quad \vdots \quad \vdots \\ \vdots \quad \vdots \quad\; \vdots \quad \vdots \;\quad \vdots \quad \vdots \\ \hline \dfrac{\varphi \circ \textsf{b}; \mathcal{F}; B}{\textsf{b}; \lambda x.\mathcal{F}; A\backslash B}\backslash\mathrm{I}^n \end{array}$$

Since these rules are more abstract and complex than the Elimination rules, we first illustrate their workings in linguistic application and then make some remarks on the relevant conceptual and technical points. For linguistic application, the significance of the /I and \I rules is that they enable reanalyzing any substring of a sentence as a constituent looking for some missing material to become a full-fledged sentence. This enables analyzing the string *John loves* in the following RNR sentence as a full-fledged constituent of type S/NP:

(39) John loves, but Bill hates, Mary.

The derivation goes as in (40).

[9] To aid the reader's understanding we'd like to point out here that the Introduction rules, especially the one for the non-directional slash | that we introduce below, loosely correspond to Move in Minimalism. There are, however, two important caveats. First, conceptually, the Introduction rules in TLCG are inference rules in the deductive system, which means that they, together with the Elimination rules, *define* the properties of the connectives /, \and |, just as the rules in natural deduction formulations of standard logics (such as propositional logic) define the (proof-theoretic) properties of conjunction, implication and other connectives. For this reason, the 'grammar rules' in TLCG have very different statuses from 'corresponding' rules in other theories. Second, and relatedly, there is also a (by no means trivial) empirical difference as well, which the metaphorical allusion to Merge and Move might obscure: since these rules are not rules for structure building and structure manipulation, having the Introduction and Elimination rules in TLCG as inference rules has a different consequence than having Merge and Move in a derivational setup, a point which we return to below.

(40)

$$\textcircled{2}\to\ \dfrac{\textcircled{1}\to\ \dfrac{\textsf{john};\ \mathbf{j};\ \mathrm{NP} \qquad \dfrac{[\varphi; x; \mathrm{NP}]^1 \quad \textsf{loves};\ \mathbf{love};\ (\mathrm{NP}\backslash\mathrm{S})/\mathrm{NP}}{\textsf{loves}\circ\varphi;\ \mathbf{love}(x);\ \mathrm{NP}\backslash\mathrm{S}}/\mathrm{E}}{\textsf{john}\circ\textsf{loves}\circ\varphi;\ \mathbf{love}(x)(\mathbf{j});\ \mathrm{S}}\backslash\mathrm{E}}{\textsf{john}\circ\textsf{loves};\ \lambda x.\mathbf{love}(x)(\mathbf{j});\ \mathrm{S}/\mathrm{NP}}/\mathrm{I}^1$$

By hypothetically assuming an NP in the direct object position, we can infer that there is a complete sentence (①). The next step (②), which is an instance of /I, is the crucial step. What is going on at this step can informally be paraphrased as follows: since the phonology of the hypothesized NP φ appears on the right periphery of the input phonology, we know that, without this NP (whose presence we merely hypothetically entertained), all we have is something that would become a complete sentence *if* there were an NP to its right, namely S/NP. Note that the lambda abstraction on the corresponding variable in semantics assigns the right meaning for the derived S/NP constituent (a function that returns a proposition when the meaning of the missing object is supplied).

In the CG analysis of RNR (see, e.g., Morrill (1994); the original analytic insight goes back to Steedman (1985)) such nonconstituents are directly coordinated as constituents and then combined with the RNR'ed expression.[10]

(41)

$$\dfrac{\dfrac{\begin{matrix}\vdots\quad\vdots\\ \textsf{john}\circ\textsf{loves};\\ \lambda x.\mathbf{love}(x)(\mathbf{j}); \mathrm{S}/\mathrm{NP}\end{matrix} \qquad \dfrac{\begin{matrix}\textsf{and};\\ \lambda\mathcal{W}\lambda\mathcal{V}.\mathcal{V}\sqcap\mathcal{W};\\ (X\backslash X)/X\end{matrix} \qquad \begin{matrix}\vdots\quad\vdots\\ \textsf{bill}\circ\textsf{hates};\\ \lambda x.\mathbf{hate}(x)(\mathbf{b}); \mathrm{S}/\mathrm{NP}\end{matrix}}{\begin{matrix}\textsf{and}\circ\textsf{bill}\circ\textsf{hates};\\ \lambda\mathcal{V}.\mathcal{V}\sqcap\lambda x.\mathbf{hate}(x)(\mathbf{b}); (\mathrm{S}/\mathrm{NP})\backslash(\mathrm{S}/\mathrm{NP})\end{matrix}}/\mathrm{E}}{\textsf{john}\circ\textsf{loves}\circ\textsf{and}\circ\textsf{bill}\circ\textsf{hates};\ \lambda x.\mathbf{love}(x)(\mathbf{j})\sqcap\lambda x.\mathbf{hate}(x)(\mathbf{b});\ \mathrm{S}/\mathrm{NP}}\backslash\mathrm{E} \qquad \begin{matrix}\textsf{mary};\\ \mathbf{m}; \mathrm{NP}\end{matrix}}{\textsf{john}\circ\textsf{loves}\circ\textsf{and}\circ\textsf{bill}\circ\textsf{hates}\circ\textsf{mary};\ \mathbf{love}(\mathbf{m})(\mathbf{j})\wedge\mathbf{hate}(\mathbf{m})(\mathbf{b});\ \mathrm{S}}/\mathrm{E}$$

Note in particular that the right meaning is compositionally assigned to the whole sentence via the standard generalized conjunction meaning for *and* (Partee and Rooth 1983). This analysis of RNR immediately generalizes to another case of nonconstituent coordination, namely, ACC (see Morrill 1994; Carpenter 1997).

We now return to some formal details. As should be clear from the above illustration, Introduction rules are rules for hypothetical reasoning. The brackets around a premise (a leaf of the proof tree) indicates that the premise is a hypothetical one, and the index on the bracket keeps track of where that hypothesis is withdrawn in the whole proof (thus, the corresponding application of /I or \I carries the same index; see Morrill (1994); Carpenter (1997)). As emphasized by Dowty (2007, 88), this is just a bookkeeping device which can be eliminated by adopting a different notation (called 'sequent style', where all the hypotheses yet to be withdrawn are kept track of at each point in the derivation explicitly by writing them all to the left of the symbol $\vdash$; see, for example, Mihaliček and Pollard (2012) for a formulation of a variant of TLCG closely related to the present one adopting this format). Thus, this should not be confused with the use of indices and variables in derivational theories, which are indispensable representational objects. As noted above, $\circ$ is string concatenation in our system. (This could be elaborated in various ways; see,

[10]Here and elsewhere, calligraphic letters ($\mathcal{U}, \mathcal{V}, \mathcal{W}, \ldots$) are invariably used for polymorphic variables; copperplate letters ($\mathscr{P}, \mathscr{Q}, \ldots$) are reserved for higher-order variables (with fixed types).

e.g., Muskens 2007; Mihaliček 2012; Kubota 2014.) Thus, the fragment up to this point is essentially equivalent to the (associative) Lambek calculus **L** (Lambek 1958).

To our knowledge, Morrill (1994) was the first to recast the Lambek calculus in this labelled deduction format. Importantly, in this formulation of the Lambek calculus (and its extension that we introduce below), the phonological term labelling (rather than the left-to-right order of the premises in the whole proof tree) keeps track of the linear order that affects the inferences involving / and \. For example, the applicability of the /I rule (38a) is conditioned on the phonology of the hypothesis φ appearing at the right periphery of the phonology of the input expression, *not* on the place that the hypothesis itself appears in the preceding proof tree, as should be clear from the proof in (40). This also means that the order of the two premises in the Elimination rules does not play any role. In what follows, we often write premises in an order reflecting the actual word order, but this should be taken only as an aide to enhance the readability of derivations.

3.1.2 Extending the system with a non-directional mode of implication

Hypothetical reasoning is thus a very powerful (yet systematic) tool, but with forward and backward slashes, it is only good for analyzing expressions missing some material at the (right or left) periphery. This is especially problematic for the analysis of Gapping, where the missing material in the second conjunct is medial, rather than at the periphery. Indeed, the need for a non-directional mode of implication is not limited to Gapping, but is found in both ‘overt’ and ‘covert’ types of movement phenomena (here and elsewhere we use the term ‘movement’ purely for descriptive purposes). Oehrle (1994) was the first to note that, with a non-directional mode of implication, which is associated with λ-binding in the prosodic component, we can deal with hypothetical reasoning more generally, with missing materials in sentence-medial positions.

For this purpose, we extend our calculus with the |I and |E rules for the VERTICAL SLASH:

(42) a. VERTICAL SLASH INTRODUCTION

$$\cfrac{\begin{array}{c} \vdots \quad \vdots \quad \underline{[\varphi; x; A]^n} \quad \vdots \quad \vdots \\ \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \\ \hline b; \mathcal{F}; B \end{array}}{\lambda\varphi.b;\ \lambda x.\mathcal{F};\ B|A}\,|\mathrm{I}^n$$

b. VERTICAL SLASH ELIMINATION

$$\dfrac{a;\ \mathcal{F};\ A|B \quad b;\ \mathcal{G};\ B}{a(b);\ \mathcal{F}(\mathcal{G});\ A}\,|\mathrm{E}$$

Unlike the /I and \I rules, in the |I rule, the missing position of A within $B|A$ (as with /, we write the argument to the right) is explicitly kept track of by means of λ-binding in phonology. This means that, following Oehrle (1994) and much current work in non-directional CG, we admit functional expressions in the phonological component. Such functional phonologies are applied to their arguments via the |E rule, whose phonological effect is function application. Note the close parallel between the semantic and phonological operations in these rules.

Hypothetical reasoning with | enables modelling what (roughly) corresponds to covert movement in derivational frameworks (but note that what corresponds to QR is modelled here by a ‘lowering’ operation, where the quantifier string is prosodically embedded in the gap position of its semantic argument). This is illustrated in (43) for the $\forall > \exists$ reading for the sentence *Someone talked to everyone yesterday*:

(43)

$$\dfrac{\begin{matrix}\textsf{talked} \circ \textsf{to};\\ \mathbf{talk\text{-}to};\\ (\mathrm{NP}\backslash\mathrm{S})/\mathrm{NP}\end{matrix} \qquad \begin{bmatrix}\varphi_1;\\ x;\\ \mathrm{NP}\end{bmatrix}^1}{\begin{matrix}\textsf{talked} \circ \textsf{to} \circ \varphi_1;\\ \mathbf{talk\text{-}to}(x); \mathrm{NP}\backslash\mathrm{S}\end{matrix}}\,/\mathrm{E}$$

$$\dfrac{\begin{bmatrix}\varphi_2;\\ y;\\ \mathrm{NP}\end{bmatrix}^2 \qquad \begin{matrix}\textsf{talked} \circ \textsf{to} \circ \varphi_1;\\ \mathbf{talk\text{-}to}(x); \mathrm{NP}\backslash\mathrm{S}\end{matrix}}{\varphi_2 \circ \textsf{talked} \circ \textsf{to} \circ \varphi_1;\ \mathbf{talk\text{-}to}(x)(y);\ \mathrm{S}}\,\backslash\mathrm{E}$$

$$\dfrac{\varphi_2 \circ \textsf{talked} \circ \textsf{to} \circ \varphi_1;\ \mathbf{talk\text{-}to}(x)(y);\ \mathrm{S} \qquad \begin{matrix}\textsf{yesterday};\\ \mathbf{yest}; \mathrm{S}\backslash\mathrm{S}\end{matrix}}{\begin{matrix}\varphi_2 \circ \textsf{talked} \circ \textsf{to} \circ \varphi_1 \circ \textsf{yesterday};\\ \mathbf{yest}(\mathbf{talk\text{-}to}(x)(y)); \mathrm{S}\end{matrix}}\,\backslash\mathrm{E}$$

$$① \rightarrow \dfrac{\begin{matrix}\varphi_2 \circ \textsf{talked} \circ \textsf{to} \circ \varphi_1 \circ \textsf{yesterday};\\ \mathbf{yest}(\mathbf{talk\text{-}to}(x)(y)); \mathrm{S}\end{matrix}}{\begin{matrix}\lambda\varphi_2.\varphi_2 \circ \textsf{talked} \circ \textsf{to} \circ \varphi_1 \circ \textsf{yesterday};\\ \lambda y.\mathbf{yest}(\mathbf{talk\text{-}to}(x)(y)); \mathrm{S}|\mathrm{NP}\end{matrix}}\,|\mathrm{I}^2$$

$$② \rightarrow \dfrac{\begin{matrix}\lambda\sigma.\sigma(\textsf{someone});\\ \exists_{\mathbf{person}};\\ \mathrm{S}|(\mathrm{S}|\mathrm{NP})\end{matrix} \qquad \begin{matrix}\lambda\varphi_2.\varphi_2 \circ \textsf{talked} \circ \textsf{to} \circ \varphi_1 \circ \textsf{yesterday};\\ \lambda y.\mathbf{yest}(\mathbf{talk\text{-}to}(x)(y)); \mathrm{S}|\mathrm{NP}\end{matrix}}{\begin{matrix}\textsf{someone} \circ \textsf{talked} \circ \textsf{to} \circ \varphi_1 \circ \textsf{yesterday};\\ \exists_{\mathbf{person}}(\lambda y.\mathbf{yest}(\mathbf{talk\text{-}to}(x)(y))); \mathrm{S}\end{matrix}}\,|\mathrm{E}$$

$$\dfrac{\begin{matrix}\textsf{someone} \circ \textsf{talked} \circ \textsf{to} \circ \varphi_1 \circ \textsf{yesterday};\\ \exists_{\mathbf{person}}(\lambda y.\mathbf{yest}(\mathbf{talk\text{-}to}(x)(y))); \mathrm{S}\end{matrix}}{\begin{matrix}\lambda\varphi_1.\textsf{someone} \circ \textsf{talked} \circ \textsf{to} \circ \varphi_1 \circ \textsf{yesterday};\\ \lambda x.\exists_{\mathbf{person}}(\lambda y.\mathbf{yest}(\mathbf{talk\text{-}to}(x)(y))); \mathrm{S}|\mathrm{NP}\end{matrix}}\,|\mathrm{I}^1$$

$$\dfrac{\begin{matrix}\lambda\sigma.\sigma(\textsf{everyone});\\ \forall_{\mathbf{person}};\\ \mathrm{S}|(\mathrm{S}|\mathrm{NP})\end{matrix} \qquad \begin{matrix}\lambda\varphi_1.\textsf{someone} \circ \textsf{talked} \circ \textsf{to} \circ \varphi_1 \circ \textsf{yesterday};\\ \lambda x.\exists_{\mathbf{person}}(\lambda y.\mathbf{yest}(\mathbf{talk\text{-}to}(x)(y))); \mathrm{S}|\mathrm{NP}\end{matrix}}{\begin{matrix}\textsf{someone} \circ \textsf{talked} \circ \textsf{to} \circ \textsf{everyone} \circ \textsf{yesterday};\\ \forall_{\mathbf{person}}(\lambda x.\exists_{\mathbf{person}}(\lambda y.\mathbf{yest}(\mathbf{talk\text{-}to}(x)(y)))); \mathrm{S}\end{matrix}}\,|\mathrm{E}$$

A quantifier has the ordinary GQ meaning ($\exists_{\mathbf{person}}$ and $\forall_{\mathbf{person}}$ abbreviate $\lambda P.\exists x[\mathbf{person}(x) \wedge P(x)]$ and $\lambda P.\forall x[\mathbf{person}(x) \rightarrow P(x)]$, respectively), but its phonology is a function of type $(\mathbf{st} \rightarrow \mathbf{st}) \rightarrow \mathbf{st}$ (for higher-order phonological variables we use $\sigma_1, \sigma_2, \ldots$ (type $\mathbf{st} \rightarrow \mathbf{st}$, $\mathbf{st} \rightarrow (\mathbf{st} \rightarrow \mathbf{st})$, etc.) and $\tau_1, \tau_2, \ldots$ (type $(\mathbf{st} \rightarrow \mathbf{st}) \rightarrow \mathbf{st}$, etc.)). Thus, by abstracting over the position in which the quantifier 'lowers into' in an S, we have an expression of type S|NP (phonologically $\mathbf{st} \rightarrow \mathbf{st}$) (①), which can be given as an argument to the quantifier. Then, by function application via |E (②), the subject quantifier *someone* semantically scopes over the sentence and lowers its phonology to the 'gap' position kept track of by λ-binding in phonology. The scopal relation between multiple quantifiers depends on the order of application of this hypothetical reasoning. We get the inverse scope reading ($\forall > \exists$) in this derivation since the subject quantifier is combined with the sentence first.

Note that this formalization of quantifying-in by Oehrle (1994) illuminates the tight correlation between the semantic and phonological effects of quantification much more transparently than Montague's (1973) original syncategorematic treatment, by modelling both the semantic and phonological effects via λ-binding reflecting the properties of order-insensitive reasoning in the underlying logic. This approach to quantification has a significant empirical advantage over quantifying-in (and its analogs) as well, in that it extends straightforwardly to the treatment of more complex scopal operators such as symmetrical predicates (Pollard and Smith 2012) and the degree question operator *how many/how much* (Pollard and Snyder 2013). We show below that it enables a lexical treatment of the so-called 'split scope' phenomenon of negative quantifiers too.

Further empirical motivation for the non-directional mode of implication comes from the analysis of 'overt' movement phenomena. As discussed by Muskens (2003), the use of | enables a simple and attractive solution for a long-standing problem in the literature of TLCG on the treatment of extraction. Like quantifiers, gaps corresponding to extracted elements can occur at sentence-medial positions. Thus, treating extraction in terms of directional slashes does not work, and various mechanisms have been proposed in the TLCG literature to overcome this problem, but they all involve significant complications in the mapping between syntax and surface morpho-phonology. Muskens's proposal is unique in that it solves this problem by directly representing the phonology of gapped sentences via a higher-order functional phonological term, exploiting the order-insensitive nature of the vertical slash $|$.

The key idea of Muskens's (2003) approach to extraction involves analyzing (incomplete) sentences with gaps like *Kim gave* __ *to Chris* in the topicalization sentence in (44) as a sentence missing some expression somewhere inside, with hypothetical reasoning for $|$, as in the derivation in (45).

(44) Bagels$_i$, Kim gave t_i to Chris.

(45)

$$
\dfrac{\begin{matrix}\mathsf{bagels};\\ \mathbf{b};\mathrm{NP}\end{matrix} \quad ②\!\rightarrow \dfrac{\begin{matrix}\lambda\sigma\lambda\varphi.\varphi\circ\sigma(\varepsilon);\\ \lambda\mathcal{F}.\mathcal{F};\\ (\mathrm{S}|X)|(\mathrm{S}|X)\end{matrix} \quad ①\!\rightarrow \dfrac{\dfrac{\begin{matrix}\mathsf{kim};\\ \mathbf{k};\mathrm{NP}\end{matrix} \quad \dfrac{\dfrac{\begin{matrix}\mathsf{gave};\\ \mathbf{gave};\\ \mathrm{VP/PP/NP}\end{matrix} \quad \begin{bmatrix}\varphi;\\ x;\\ \mathrm{NP}\end{bmatrix}^1}{\mathsf{gave}\circ\varphi;\ \mathbf{gave}(x);\ \mathrm{VP/PP}}/\mathrm{E} \quad \begin{matrix}\mathsf{to}\circ\mathsf{chris};\\ \mathbf{c};\mathrm{PP}\end{matrix}}{\mathsf{gave}\circ\varphi\circ\mathsf{to}\circ\mathsf{chris};\ \mathbf{gave}(x)(\mathbf{c});\ \mathrm{VP}}/\mathrm{E}}{\mathsf{kim}\circ\mathsf{gave}\circ\varphi\circ\mathsf{to}\circ\mathsf{chris};\ \mathbf{gave}(x)(\mathbf{c})(\mathbf{k});\ \mathrm{S}}\backslash\mathrm{E}}{\lambda\varphi.\mathsf{kim}\circ\mathsf{gave}\circ\varphi\circ\mathsf{to}\circ\mathsf{chris};\ \lambda x.\mathbf{gave}(x)(\mathbf{c})(\mathbf{k});\ \mathrm{S|NP}}|\mathrm{I}^1}{\lambda\varphi.\varphi\circ\mathsf{kim}\circ\mathsf{gave}\circ\mathsf{to}\circ\mathsf{chris};\ \lambda x.\mathbf{gave}(x)(\mathbf{c})(\mathbf{k});\ \mathrm{S|NP}}|\mathrm{E}}{\mathsf{bagels}\circ\mathsf{kim}\circ\mathsf{gave}\circ\mathsf{to}\circ\mathsf{chris};\ \mathbf{gave}(\mathbf{b})(\mathbf{c})(\mathbf{k});\ \mathrm{S}}|\mathrm{E}
$$

In (45), an NP is hypothesized in the direct object position of the verb, and by withdrawing this hypothesis after the whole sentence is built (①), the gap position is explicitly represented by the variable φ bound by the λ-operator. (Note also that this gapped sentence is assigned the right meaning, by the corresponding λ-binding in the semantics.) Since hypothetical reasoning for the vertical slash can be carried out regardless of the position of the variable in the surface string, this approach can treat filler-gap dependency in a fully general manner wherever the gap appears within the sentence.

Since the gap can appear anywhere in the sentence, the analysis of extraction here predicts that there are no syntactic island constraints. We take this to be a desirable result. As noted in the previous section, there is now considerable evidence that the so-called island effects that have traditionally received syntactic accounts can more profitably be explained in terms of various pragmatic and processing-oriented factors (see references cited above).

The difference between 'covert' and 'overt' movement is that, in the latter, the filler that corresponds to the gap appears *outside* of the gapped sentence. The 'displacement' of the filler in topicalization is mediated by the following phonologically empty topicalization operator:

(46) $\lambda\sigma\lambda\varphi.\varphi\circ\sigma(\varepsilon);\ \lambda\mathcal{F}.\mathcal{F};\ (\mathrm{S}|X)|(\mathrm{S}|X)$

(46) is an identity function both syntactically and semantically, but it changes the phonology of its argument in such a way that an empty string ε is embedded in the original gap site and the host sentence now looks for the filler immediately to the left of itself (as in ② in (45)). This approach generalizes straightforwardly to other types of extraction. In

particular, Mihaliček and Pollard (2012) demonstrate that it enables a simple treatment of cross-linguistic differences in the syntax-semantics interface of *wh*-questions.

3.1.3 Taking stock: Empirical and conceptual consequences of introducing hypothetical reasoning for |

We have seen above that hypothetical reasoning with | enables a simple and explicit modelling of both 'overt' and 'covert' types of movement operations. A natural question that arises at this point is whether the present system is just a notational variant of the more widely entertained derivational architecture of grammar (albeit one that is formally more explicit) or is something more than that. We would like to dwell on this question a bit here, since it directly pertains to the question of how the analysis of Gapping we present below differs from the movement-based alternative we have discussed above.

There are some observations that seem to be relevant for clarifying the similarities and differences between hypothetical reasoning with | and the notion of movement in derivational approaches. Note, first of all, that in our setup, 'overt' and 'covert' movement differ essentially with respect to what happens to the phonology of the 'gap'-containing expression. 'Covert' movement is modelled by an operator with a functional phonology whose string component is embedded in the 'gap' position of its semantic argument. By contrast, for 'overt' movement, we have an operator that fills in an empty string to the gap. But note that nothing in the formal setup says that these are the only two things that one can do with linguistic signs containing gap positions. This is perhaps a subtle, but, we think, crucial difference between our approach and the derivational architecture of grammar. In the latter, where movement is conceived of as inherently ordered structure-building/manipulation operations, these two options would indeed seem to exhaust the set of logical possibilities: if you move constituents before computing word order (i.e. before SpellOut), then what you have is an instance of overt movement, whereas if you move constituents after computing word order, then what you have is an instance of covert movement. But in our calculus, the two types of 'movement' are not ordered with respect to one another. Rather, they are just two types of inference that are both simultaneously available at any step of the proof. (It is precisely for this reason that the analogies to 'overt' and 'covert' movement that we have informally introduced above should be taken only as a rough and crude metaphor.)

This, then, opens up an interesting analytic possibility: in our system, it is possible to do 'overt' movement and 'covert' movement *at the same time*, as it were, or, to put it differently, do something that cannot be broken down into a successive application of separate overt and covert movements. In this connection, the following remark by an anonymous reviewer gets at the key difference between Hybrid TLCG and derivational frameworks:

> [In Hybrid TLCG, with the use of functional phonologies] it becomes possible to state a conjunction rule for gapping that combines likes. If I'm not mistaken, in a derivational framework like Minimalism, such signs cannot be created, since it does not countenance the idea of prosodic variables that can later be filled in. Traces of movement are semantic placeholders, but not phonological ones.

The analysis of Gapping we present below crucially exploits this property of the system: the coordination operator takes two pieces of phonology both missing some material inside themselves. It fills in the gap of the second conjunct with an empty string (as in 'overt' movement) and fills in the gap of the first conjunct with the phonology of the missing verb (as in 'covert' movement). As this reviewer notes, there is no movement-based analog of a complex operation on functional phonologies like this, since there is no genuine analog of linguistic signs with functional phonologies in derivational approaches. As will become clear below, when what is missing is just the verb, this analysis just distributes the verb meaning to each conjunct, but in more complex cases where (part of) what is missing is a scopal operator, it *predicts* the availability of the wide scope reading for the relevant operator, based on an independently motivated form-meaning mismatch encoded in the lexical entries of such operators.

3.2 Gapping as hypothetical reasoning

Our analysis of Gapping exploits the order-insensitive nature of the vertical slash $|$. As discussed above, with $|$, expressions containing medial gaps can be modelled straightforwardly via hypothetical reasoning. This enables us to analyze expressions like *Robin* __ *Bill* (a sentence missing the main verb) in Gapping as directly conjoinable constituents. Specifically, as illustrated in the following (partial) derivation, such expressions are derived as constituents of syntactic category (or type) S|((NP\S)/NP) (i.e. an S missing a transitive verb (NP\S)/NP in the middle), with a functional phonology of type $\mathsf{st} \to \mathsf{st}$ (where the prosodic variable φ_1 of type st (string) bound by the lambda operator explicitly keeps track of the position of the gap in the string). The derivation is parallel to the topicalization derivation in (45) from the previous section, except that the missing category is (NP\S)/NP rather than NP.

(47)
$$\dfrac{\mathsf{robin};\ \mathbf{r};\ \mathrm{NP} \quad \dfrac{[\varphi_1;\ P;\ (\mathrm{NP}\backslash\mathrm{S})/\mathrm{NP}]^1 \quad \mathsf{bill};\ \mathbf{b};\ \mathrm{NP}}{\varphi_1 \circ \mathsf{bill};\ P(\mathbf{b});\ \mathrm{NP}\backslash\mathrm{S}}/\mathrm{E}}{\dfrac{\mathsf{robin} \circ \varphi_1 \circ \mathsf{bill};\ P(\mathbf{b})(\mathbf{r});\ \mathrm{S}}{\lambda\varphi_1.\mathsf{robin} \circ \varphi_1 \circ \mathsf{bill};\ \lambda P.P(\mathbf{b})(\mathbf{r});\ \mathrm{S}|((\mathrm{NP}\backslash\mathrm{S})/\mathrm{NP})}|\mathrm{I}^1}\backslash\mathrm{E}$$

Note that the matching index 1 on the hypothesis and the last inference step $|\mathrm{I}^1$ indicates that the transitive verb hypothesis is withdrawn at this step. Because of this, the derived category is S|((NP\S)/NP), in accordance with what the rule dictates. Note also that the phonology and semantics of the derived expression is obtained by strictly following what is specified in the rule, that is, binding the variable corresponding to the hypothesis by a lambda operator.

The following Gapping-specific lexical entry for conjunction is responsible for coordinating such expressions with functional phonologies of type $\mathsf{st} \to \mathsf{st}$:

(48) $\lambda\sigma_2\lambda\sigma_1\lambda\varphi.[\sigma_1(\varphi) \circ \mathsf{and} \circ \sigma_2(\varepsilon)];\ \lambda\mathcal{W}\lambda\mathcal{V}.\mathcal{V} \sqcap \mathcal{W};\ (\mathrm{S}|X)|(\mathrm{S}|X)|(\mathrm{S}|X)$

(where ε is the empty string and $X = \begin{Bmatrix} Y_0\backslash\mathrm{S} \\ \mathrm{S}/Y_0 \end{Bmatrix} /Y_1/\ldots/Y_n$ with $n \geq 1$)

The side condition on X here is meant to capture the generalization that the gapped expression is of a verbal category (with at least two unsaturated arguments). In most cases, the last argument is an NP sought via \, thus instantiating $Y_0\backslash\mathrm{S}$ as NP\S. (But see the topicalization interaction case in Appendix A.2.1 for the need for the S/Y_0 case.) Gapping is associated with distinct properties both prosodically and pragmatically (cf. the Parallelism requirement (Kehler 2002) for the latter). Our lexical treatment provides a basis for encoding such constructional idiosyncrasies in the special conjunction entry dedicated to Gapping. The lexical entry in (48) may appear to be more complicated and stipulative than we believe it actually is. We return to this point at the end of this section.

Syntactically, (48) coordinates two sentences missing the main verb (i.e. S|((NP\S)/NP) in the case at hand) to produce a larger expression of the same type, instantiating the general like-category coordination schema; correspondingly, the semantics is that of generalized conjunction, again conforming to the general treatment of coordination. The only slight complication is in the phonology. The output phonology is of the same type $\mathsf{st} \to \mathsf{st}$ as the input phonologies, but instead of binding the variables in each conjunct by the same λ-operator, the gap in the second conjunct is filled by an empty string ε, capturing the idiosyncrasy of Gapping (where the verb is not pronounced in the second conjunct) via a lexical specification, without invoking any extra rule or prosodically empty operator.

With this conjunction lexical entry, (1) can be derived as in (49) (in what follows, we abbreviate (NP\S)/NP and NP\S as TV and VP, respectively):

(49)

$$\dfrac{\dfrac{\begin{array}{l}\vdots\ \ \vdots\\ \lambda\varphi_1.\mathsf{leslie}\circ\varphi_1\circ\mathsf{sandy};\\ \lambda Q.Q(\mathbf{s})(\mathbf{l});\\ \mathrm{S}|\mathrm{TV}\end{array}\quad \dfrac{\begin{array}{l}\lambda\sigma_2\lambda\sigma_1\lambda\varphi.\sigma_1(\varphi)\circ\\ \mathsf{and}\circ\sigma_2(\varepsilon);\\ \lambda\mathcal{W}\lambda\mathcal{V}.\mathcal{V}\sqcap\mathcal{W};\\ (\mathrm{S}|X)|(\mathrm{S}|X)|(\mathrm{S}|X)\end{array}\quad \begin{array}{l}\vdots\ \ \vdots\\ \lambda\varphi_1.\mathsf{robin}\circ\varphi_1\circ\mathsf{bill};\\ \lambda P.P(\mathbf{b})(\mathbf{r});\\ \mathrm{S}|\mathrm{TV}\end{array}}{\begin{array}{c}\lambda\sigma_1\lambda\varphi.\sigma_1(\varphi)\circ\mathsf{and}\circ\mathsf{robin}\circ\varepsilon\circ\mathsf{bill};\\ \lambda\mathcal{V}.\mathcal{V}\sqcap\lambda P.P(\mathbf{b})(\mathbf{r});(\mathrm{S}|\mathrm{TV})|(\mathrm{S}|\mathrm{TV})\end{array}}|\mathrm{E}}{\begin{array}{c}\lambda\varphi[\mathsf{leslie}\circ\varphi\circ\mathsf{sandy}\circ\mathsf{and}\circ\mathsf{robin}\circ\varepsilon\circ\mathsf{bill}];\\ \lambda Q.Q(\mathbf{s})(\mathbf{l})\sqcap\lambda P.P(\mathbf{b})(\mathbf{r});\mathrm{S}|\mathrm{TV}\end{array}}|\mathrm{E}\quad \begin{array}{l}\mathsf{met};\\ \mathbf{met};\\ \mathrm{TV}\end{array}}{\begin{array}{c}\mathsf{leslie}\circ\mathsf{met}\circ\mathsf{sandy}\circ\mathsf{and}\circ\mathsf{robin}\circ\varepsilon\circ\mathsf{bill};\\ \mathbf{met}(\mathbf{s})(\mathbf{l})\wedge\mathbf{met}(\mathbf{b})(\mathbf{r});\mathrm{S}\end{array}}|\mathrm{E}$$

In this analysis, two conjoined gapped sentences together form a tectogrammatical constituent (i.e. a unit in the combinatoric structure), which the verb 'lowers into' phonologically. The right surface string is obtained for the whole sentence by giving the two type $\mathsf{st} \to \mathsf{st}$ functional phonologies of the conjuncts as arguments to the conjunction and then by applying the resultant $\mathsf{st} \to \mathsf{st}$ function to the string of the verb, via three successive applications of |E. Note that the fact that the verb appears to the right of the coordinate structure in the derivation does not have any significance for the surface word order (thus, this should not be thought to reflect the status of the verb as being 'extraposed' or 'right-node raised'). The surface order is computed based on what is specified in the rules, in particular, here, the |E rule, according to which the phonology of the derived expression is the result of applying the phonology of the functor to that of its argument.

Note also that the right meaning for the sentence is obtained by letting the verb bind the gap positions in the two conjuncts after the coordinate structure is built via generalized conjunction (if the reduction of the semantic translation at the last step isn't obvious, note Partee and Rooth's (1983, 364) fact (6b) $[\phi \sqcap \psi](\alpha) = \phi(\alpha) \sqcap \psi(\alpha)$, which follows from their definition of generalized conjunction), instead of positing a phonetically empty copy of the verb in the gapped conjunct. This turns out to be crucial in assigning the right interpretations for the more complex cases involving scopal expressions like auxiliaries and quantifiers.

As should be clear at this point, the role of both directional and non-directional implication is crucial in our analysis: the gapped sentence with syntactic type S|TV explicitly keeps track of the position of the medial gap via λ-binding in phonology; on the other hand, directional slashes are crucially employed in the specification of the gapped material (NP\S)/NP, which is reflected in the linear order in which its arguments appear in the string part of the gapped sentence. Thus, we exploit the hybrid implication architecture of Hybrid TLCG here; keeping track of the right word order becomes a virtually intractable problem in non-directional variants of CG such as Abstract Categorial Grammar (de Groote 2001) and Lambda Grammar (Muskens 2003).

The analysis of Gapping presented above straightforwardly interacts with the analysis of topicalization from section 3.1.2 to yield an analysis of the topicalization/Gapping interaction example (27a) from section 2. See Appendix A.2.1 for a complete derivation.

Before moving on to the more complex cases involving auxiliaries and determiners, we would like to clarify what our analysis above exactly amounts to. With the lexical entry (48) and the general availability of hypothetical reasoning, our analysis entails that *any* substring of the sentence that is a rightward looking (except for the last argument) functor rooted in S can undergo Gapping and that Gapping is restricted to non-initial conjuncts. As for the latter point, one might question our lexical treatment here since there are attempts to derive this property from basic word order, building on Ross's (1970) classical conjecture. However, the most successful such attempt by Steedman (1990) remains problematic due to the highly controversial status of the key combinatory rule ('Decompose') for deriving Gapping in English (see ***[reference omitted for refereeing]*** for some discussion), and for this reason we remain skeptical about such attempts. Moreover, in most other accounts of Gapping, including the low VP coordination analysis, this, or a related aspect remains a stipulation. (On the latter, the question is why the subject of the second conjunct cannot undergo the non-ATB movement.)

The former question, namely, why Gapping is restricted to verbal categories, is currently a big open question for any theoretical account of Gapping.[11] We conjecture here that this may perhaps be understood as a grammaticalization of a functional constraint on the kinds of meanings typically expressed by Gapping sentences. As noted by many authors (see, e.g., Kuno (1976) for an early reference), Gapping invokes a contrast between parallel 'pairs' of items. The relation holding between the elements of each pair is expressed by whatever material is contained in the initial conjunct that is missing in the non-initial conjunct(s). There is a sense in which the verb expresses the most central relation in the propositions expressed by each of the contrasted clauses. It then does not seem entirely implausible to speculate that, for this functionally motivated reason, there is a grammatical constraint that Gapping is restricted to verbs. Cases of auxiliary-alone gapping such as (7) and determiner-

[11] The brace notation in (48) might give the misleading impression that the condition on the missing category is stated purely disjunctively. Current work in progress by Chris Worth suggests that it may be possible to embed our directional mode of implication within a non-directional CG (such as ACG) via subtyping making use of Higher-Order Logic. We envisage that in this more formally sophisticated implementation of our framework, it will be possible to treat the two directional slashes as subtypes of a single more general type, and that the disjunction in (48) can be collapsed to a single more general condition, capturing the underlying analytic intuition more transparently.

alone gapping such as (34) may then be thought of as an extension of this pattern (where the missing relation is higher-order than in the case of plain verbs).

3.3 Scopal interactions with auxiliaries

The above analysis of the basic syntax of Gapping automatically interacts with an independently motivated analyses of auxiliaries and quantifiers that take into account their scope-taking properties to predict their behaviors in Gapping examples.

The key assumption that enables a straightforward analysis of the scopal interactions between auxiliary and Gapping is that auxiliaries are scope-taking expressions just like quantifiers. Specifically, we assume that morpho-phonologically auxiliaries have the distributional properties of a VP modifier of category VP/VP, but semantically, modals and negation are sentential operators μ which take some proposition φ as an argument and return another proposition $\mu(\varphi)$. In the present approach, this syntax-semantics mismatch can be straightforwardly captured by assigning lexical entries of the following form to auxiliaries:

(50) $\lambda\sigma.\sigma(\mathsf{must}); \lambda\mathscr{F}.\Box\mathscr{F}(\mathsf{id}_{et}); \mathrm{S}|(\mathrm{S}|(\mathrm{VP}/\mathrm{VP}))$
(where $\mathsf{id}_{et} =_{def} \lambda P_{et}.P$)

This lexical entry says that the auxiliary verb *must* binds a VP/VP (i.e. forward-looking VP modifier) gap in a sentence to return a fully saturated S. The VP modifier gap is vacuously bound by supplying an identify function id_{et} in its place, and the real semantic contribution of the auxiliary comes from the modal operator that takes as its scope the entire proposition obtained by binding this VP modifier gap of the gapped sentence.

The following derivation for the sentence *Someone must be present (at the meeting)* illustrates this scopal analysis of auxiliaries.[12] This derivation illustrates that the present analysis enables licensing the **must** $>$ $\exists$ reading for the sentence without assuming that the modal subcategorizes for the subject in the GQ-type.

[12] As it is, the analysis of auxiliaries here overgenerates. To capture the clause-boundedness of the scope of auxiliaries, we follow Siegel (1987) and assume that auxiliaries lower into untensed sentences to produce tensed sentences. This can be achieved by positing a binary feature [tns±] for the category S and modifying the lexical entries for auxiliaries along the following lines:

(i) $\lambda\sigma.\sigma(\mathsf{must}); \lambda\mathscr{F}.\Box\mathscr{F}(\mathsf{id}_{et}); \mathrm{S}_{[\mathrm{tns}+]}|(\mathrm{S}_{[\mathrm{tns}-]}|\mathrm{VP}_{[\mathrm{tns}-]}/\mathrm{VP}_{[\mathrm{tns}-]})$

This prevents auxiliaries from lowering into tensed sentences in a long-distance fashion. With (i), the clause that the auxiliary lowers into has to be specified as [tns−] originally, but such an untensed sentence cannot combine with a higher verb subcategorizing for a sentential complement ($\mathrm{S}_{[\mathrm{tns}+]}$) unless an auxiliary combines with it to change the value of the tns feature from − to +. Thus, auxiliaries are bound to take scope immediately above the local clause, modulo cases involving coordination of untensed sentences, which give rise to the auxiliary wide-scope Gapping sentences, as we show below. The assumption that such Gapping sentences involve coordination of untensed clauses might explain why they allow accusative (instead of nominative) pronouns as subjects of the non-initial conjuncts, as in *You can't eat steak and me just pizza*.

Note also that the internal VP/VP is specified as $\mathrm{VP}_{[\mathrm{tns}-]}/\mathrm{VP}_{[\mathrm{tns}-]}$, not as $\mathrm{VP}_{[\mathrm{tns}+]}/\mathrm{VP}_{[\mathrm{tns}-]}$. This allows us to derive (as desired) the $\mathrm{VP}_{[\mathrm{tns}+]}/\mathrm{VP}_{[\mathrm{tns}-]}$ type derived auxiliary entry in the same procedure as shown in (70) in Appendix A.2.3.

(51)

$$
②\!\rightarrow \dfrac{
\begin{array}{l}\lambda\sigma.\sigma(\mathsf{must});\\ \lambda\mathscr{F}.\Box\mathscr{F}(\mathsf{id}_{et});\\ \mathrm{S}|(\mathrm{S}|(\mathrm{VP/VP}))\end{array}
\quad
①\!\rightarrow \dfrac{
\dfrac{
\begin{array}{l}\lambda\sigma.\sigma(\mathsf{someone});\\ \exists_{\mathbf{person}};\\ \mathrm{S}|(\mathrm{S}|\mathrm{NP})\end{array}
\quad
\dfrac{
\dfrac{
\begin{bmatrix}\varphi_2;\\ x;\\ \mathrm{NP}\end{bmatrix}^2
\quad
\dfrac{
\begin{bmatrix}\varphi_1;\\ f;\\ \mathrm{VP/VP}\end{bmatrix}^1
\quad
\begin{array}{l}\mathsf{be}\circ\mathsf{present};\\ \mathbf{present};\\ \mathrm{VP}\end{array}
}{
\begin{array}{c}\varphi_1\circ\mathsf{be}\circ\mathsf{present};\\ f(\mathbf{present});\mathrm{VP}\end{array}
}\;/\mathrm{E}
}{
\begin{array}{c}\varphi_2\circ\varphi_1\circ\mathsf{be}\circ\mathsf{present};\\ f(\mathbf{present})(x);\mathrm{S}\end{array}
}\;\backslash\mathrm{E}
}{
\begin{array}{c}\lambda\varphi_2.\varphi_2\circ\varphi_1\circ\mathsf{be}\circ\mathsf{present};\\ \lambda x.f(\mathbf{present})(x);\mathrm{S}|\mathrm{NP}\end{array}
}\;|\mathrm{I}^2
}{
\begin{array}{c}\mathsf{someone}\circ\varphi_1\circ\mathsf{be}\circ\mathsf{present};\\ \exists_{\mathbf{person}}(\lambda x.f(\mathbf{present})(x));\mathrm{S}\end{array}
}\;|\mathrm{E}
}{
\begin{array}{c}\lambda\varphi_1.\mathsf{someone}\circ\varphi_1\circ\mathsf{be}\circ\mathsf{present};\\ \lambda f.\exists_{\mathbf{person}}(\lambda x.f(\mathbf{present})(x));\mathrm{S}|(\mathrm{VP/VP})\end{array}
}\;|\mathrm{I}^1
}{
\mathsf{someone}\circ\mathsf{must}\circ\mathsf{be}\circ\mathsf{present};\ \Box\exists_{\mathbf{person}}(\lambda x.\mathbf{present}(x));\ \mathrm{S}
}\;|\mathrm{E}
$$

Just as in the quantifier example above, a hypothetical VP/VP expression is posited and this hypothesis is withdrawn once the whole sentence is built (①). This has the effect that the corresponding semantic and phonological variables are bound. The resultant type S|(VP/VP) expression is of the right type to be given as an argument to the auxiliary. The two are then combined by function application via |E (②) and the phonology of the auxiliary fills in the gap position of its argument. The semantic effect is somewhat more complex (and this might be thought of as a limiting case of 'split scope' that we discuss below for negative quantifiers, where the lower meaning component is an identity function). An identify function is first filled in to the gap position of the sentence, which yields the proposition $\exists_{\mathbf{person}}(\lambda x.\mathbf{present}(x))$. And then the modal operator $\Box$ (which is the 'real' semantic contribution of the auxiliary) scopes over this proposition to derive the translation of the whole sentence. As will become clear below, this higher-order treatment of auxiliaries turns out to be crucial in assigning the right meaning to the auxiliary gapping examples. Note also here that, since the quantifier is introduced in the derivation below the modal auxiliary, we obtain the **must** $>$ $\exists$ reading.

We are now ready to illustrate how the auxiliary wide-scope, non-distributive readings are obtained for Gapping sentences. We start with a variant in which only the auxiliary is gapped (52a) (the derivation for which is a bit simpler), and then move on to the case in which the whole auxiliary + verb sequence is gapped (52b).

(52) a. John can't eat steak and Mary eat pizza.
b. John can't eat steak and Mary pizza.

The overall structure of the derivation for the auxiliary wide-scope reading is the same as in the simpler Gapping analysis in (49) above: we coordinate two expressions which are in effect clauses missing VP/VP functors, forming a larger expression of the same category:

(53)

$$\dfrac{\dfrac{\dfrac{\begin{array}{c}\mathsf{john};\\ \mathbf{j};\mathbf{NP}\end{array}\quad \dfrac{\left[\begin{array}{l}\varphi_1;\\ f;\mathrm{VP/VP}\end{array}\right]^1 \quad \begin{array}{l}\mathsf{eat}\circ\mathsf{steak};\\ \mathbf{eat}(\mathbf{s});\mathbf{VP}\end{array}}{\begin{array}{l}\varphi_1\circ\mathsf{eat}\circ\mathsf{steak};\\ f(\mathbf{eat}(\mathbf{s}));\mathbf{VP}\end{array}}{/\mathrm{E}}}{\begin{array}{l}\mathsf{john}\circ\varphi_1\circ\mathsf{eat}\circ\mathsf{steak};\\ f(\mathbf{eat}(\mathbf{s}))(\mathbf{j});\mathbf{S}\end{array}}{\backslash\mathrm{E}}}{\begin{array}{l}\lambda\varphi_1.\mathsf{john}\circ\varphi_1\circ\mathsf{eat}\circ\mathsf{steak};\\ \lambda f.f(\mathbf{eat}(\mathbf{s}))(\mathbf{j});\mathrm{S}|(\mathrm{VP/VP})\end{array}}{|\mathrm{I}^1} \quad \dfrac{\begin{array}{l}\lambda\sigma_2\lambda\sigma_1\lambda\varphi.\sigma_1(\varphi)\circ\\ \mathsf{and}\circ\sigma_2(\varepsilon);\\ \lambda\mathcal{F}_2\lambda\mathcal{F}_1.\mathcal{F}_1\sqcap\mathcal{F}_2;\\ (\mathrm{S}|X)|(\mathrm{S}|X)|(\mathrm{S}|X)\end{array} \quad \begin{array}{l}\vdots\quad\vdots\\ \lambda\varphi_2.\mathsf{mary}\circ\varphi_2\circ\\ \mathsf{eat}\circ\mathsf{pizza};\\ \lambda g.g(\mathbf{eat}(\mathbf{p}))(\mathbf{m});\\ \mathrm{S}|(\mathrm{VP/VP})\end{array}}{\begin{array}{l}\lambda\sigma_1\lambda\varphi_0.\sigma_1(\varphi_0)\circ\mathsf{and}\circ\\ \mathsf{mary}\circ\varepsilon\circ\mathsf{eat}\circ\mathsf{pizza};\\ \lambda\mathcal{F}_1.\mathcal{F}_1\sqcap\lambda g.g(\mathbf{eat}(\mathbf{p}))(\mathbf{m});\\ (\mathrm{S}|(\mathrm{VP/VP}))|(\mathrm{S}|(\mathrm{VP/VP}))\end{array}}{|\mathrm{E}}}{\begin{array}{l}\lambda\varphi_0.\mathsf{john}\circ\varphi_0\circ\mathsf{eat}\circ\mathsf{steak}\circ\mathsf{and}\circ\mathsf{mary}\circ\varepsilon\circ\mathsf{eat}\circ\mathsf{pizza};\\ \lambda f.f(\mathbf{eat}(\mathbf{s}))(\mathbf{j})\sqcap\lambda g.g(\mathbf{eat}(\mathbf{p}))(\mathbf{m});\mathrm{S}|(\mathrm{VP/VP})\end{array}}{|\mathrm{E}}$$

This coordinated 'gapped' constituent is then given as an argument to the auxiliary to complete the derivation, just in the same way as in the previous simpler example involving an auxiliary.

(54)

$$\dfrac{\begin{array}{l}\lambda\sigma_0.\sigma_0(\mathsf{can't});\\ \lambda\mathscr{F}.\neg\Diamond\mathscr{F}(\mathsf{id}_{et});\mathrm{S}|(\mathrm{S}|(\mathrm{VP/VP}))\end{array} \quad \begin{array}{l}\qquad\qquad\vdots\quad\vdots\\ \lambda\varphi_0.\mathsf{john}\circ\varphi_0\circ\mathsf{eat}\circ\mathsf{steak}\circ\mathsf{and}\circ\mathsf{mary}\circ\varepsilon\circ\mathsf{eat}\circ\mathsf{pizza};\\ \lambda f.f(\mathbf{eat}(\mathbf{s}))(\mathbf{j})\sqcap\lambda g.g(\mathbf{eat}(\mathbf{p}))(\mathbf{m});\mathrm{S}|(\mathrm{VP/VP})\end{array}}{\mathsf{john}\circ\mathsf{can't}\circ\mathsf{eat}\circ\mathsf{steak}\circ\mathsf{and}\circ\mathsf{mary}\circ\varepsilon\circ\mathsf{eat}\circ\mathsf{pizza};\ \neg\Diamond[\mathbf{eat}(\mathbf{s})(\mathbf{j})\wedge\mathbf{eat}(\mathbf{p})(\mathbf{m})];\ \mathrm{S}}{|\mathrm{E}}$$

Note crucially that the auxiliary is a higher-order functor and what gets distributed to each conjunct is an identity function, not the modal meaning itself. More specifically, the reduction of the semantic term at the last step is unpacked in (55):

(55)
$$\begin{aligned}&\lambda\mathscr{F}[\neg\Diamond\mathscr{F}(\mathsf{id}_{et})](\lambda f.f(\mathbf{eat}(\mathbf{s}))(\mathbf{j})\sqcap\lambda g.g(\mathbf{eat}(\mathbf{p}))(\mathbf{m}))\\ &=\neg\Diamond[[\lambda f.f(\mathbf{eat}(\mathbf{s}))(\mathbf{j})\sqcap\lambda g.g(\mathbf{eat}(\mathbf{p}))(\mathbf{m})](\mathsf{id}_{et})]\\ &=\neg\Diamond[[\lambda f.f(\mathbf{eat}(\mathbf{s}))(\mathbf{j})](\mathsf{id}_{et})\sqcap[\lambda g.g(\mathbf{eat}(\mathbf{p}))(\mathbf{m})](\mathsf{id}_{et})]\\ &=\neg\Diamond[\mathbf{eat}(\mathbf{s})(\mathbf{j})\sqcap\mathbf{eat}(\mathbf{p})(\mathbf{m})]\\ &=\neg\Diamond[\mathbf{eat}(\mathbf{s})(\mathbf{j})\wedge\mathbf{eat}(\mathbf{p})(\mathbf{m})]\end{aligned}$$

Thus, we get an interpretation in which the modal scopes over the conjunction, as desired. Note also that the right surface string is obtained in which the auxiliary is pronounced only once in the first conjunct, as per the lexical specification of the Gapping-type conjunction.

The analysis of the full-gapping example like (52b) is somewhat more complex, but the way the wide-scope reading is predicted for the auxiliary is essentially the same. The technical complication lies in the fact that both the verb and the auxiliary strings need to be lowered to the first conjunct. We reproduce below the sign in which the verb is already lowered to the first conjunct (see Appendix A.2.2 for the derivation):

(56) $\lambda\varphi_0.\mathsf{john}\circ\varphi_0\circ\mathsf{eat}\circ\mathsf{steak}\circ\mathsf{and}\circ\mathsf{mary}\circ\varepsilon\circ\mathsf{pizza};\ \lambda f.[f(\mathbf{eat}(\mathbf{s}))(\mathbf{j})\wedge f(\mathbf{eat}(\mathbf{p}))(\mathbf{m})];$ $\mathrm{S}|(\mathrm{VP/VP})$

Then by giving this linguistic sign as an argument to the auxiliary the derivation completes and we obtain the same auxiliary wide-scope reading as in (53).

(57)

$$\dfrac{\begin{array}{l}\lambda\sigma_0.\sigma_0(\mathsf{can't});\\ \lambda\mathscr{F}.\neg\Diamond\mathscr{F}(\mathsf{id}_{et});\mathrm{S}|(\mathrm{S}|(\mathrm{VP/VP}))\end{array} \quad \begin{array}{l}\qquad\qquad\vdots\quad\vdots\\ \lambda\varphi_0.\mathsf{john}\circ\varphi_0\circ\mathsf{eat}\circ\mathsf{steak}\circ\mathsf{and}\circ\mathsf{mary}\circ\varepsilon\circ\mathsf{pizza};\\ \lambda f.[f(\mathbf{eat}(\mathbf{s}))(\mathbf{j})\wedge f(\mathbf{eat}(\mathbf{p}))(\mathbf{m})];\mathrm{S}|(\mathrm{VP/VP})\end{array}}{\mathsf{john}\circ\mathsf{can't}\circ\mathsf{eat}\circ\mathsf{steak}\circ\mathsf{and}\circ\mathsf{mary}\circ\varepsilon\circ\mathsf{pizza};\ \neg\Diamond[\mathbf{eat}(\mathbf{s})(\mathbf{j})\wedge\mathbf{eat}(\mathbf{p})(\mathbf{m})];\ \mathrm{S}}{|\mathrm{E}}$$

Essentially, in the present account, the wide-scope option for the auxiliary in examples like (52a) and (52b) trivially follows from the fact that the (combinatoric) syntax of Gapping involves *directly* coordinating sentences with missing elements and supplying the missing element at a later point in the derivation.

The present analysis predicts the availability of distributive readings for Gapping sentences with auxiliaries as well. Importantly (and interestingly), as shown in (70) in Appendix A.2.3, in the present approach, a VP/VP entry for the auxiliary (identical to the familiar entry for auxiliaries in non-transformational approaches like G/HPSG and earlier versions of CG) that has a simple string phonology can be derived as a theorem from the more basic type assigned in the lexicon above in the category S|(S|(VP/VP)) (thus, the former does not need to be separately stipulated in the lexicon). Then, by giving this derived auxiliary as an argument to the same S|(VP/VP) constituent used in (57), we obtain the distributive reading for the auxiliary. See Appendix A.2.3 for a full derivation.[13]

3.4 Scopal interactions with negative quantifiers

We have seen above that the apparent scope anomaly in Gapping sentences with auxiliaries is in fact a *predicted* consequence of the most straightforward analysis of Gapping embodying the idea of like-category coordination in the present framework. In short, the unexpected wide scope interpretation for auxiliaries follows from the fact that the auxiliary is introduced in the derivation after the whole coordinate structure is built. This analysis extends directly to the case of negative quantifiers in examples like (5c). Here too, the apparently anomalous scope relations between quantifiers and coordination immediately falls out from the fact that the quantificational determiner is gapped and appears only in the first conjunct on the surface string. Though conceptually the analysis is a straightforward extension, since quantifiers (and negative quantifiers in particular) are more complex types of scopal expressions than auxiliaries, the technical details are somewhat demanding. For this reason, we choose to outline the key points of the analysis in broad terms in what follows and relegate the technical details to Appendix B.

Following Johnson (2000), we take the split scope property of negative quantifiers to be the key driving force of their apparently anomalous scope in determiner gapping. Thus, we first need an analysis of 'split scope', where negative quantifiers like *no*, *few* and *hardly any* are decomposed into sentential negation and an existential quantifier (or an indefinite) that scopes below the negation (Jacobs 1980; Penka 2011). So far as we are aware, the question of how to model split scope has not been addressed in the previous literature of CG. It turns out that a fully lexical analysis of split scope is available in the present framework.[14] Specifically, we assume that the quantificational determiners forming negative quantifiers

[13] One might wonder at this point whether the present approach can derive the $\neg A \wedge B$ reading of examples like (14) from the previous section. This can be derived by taking (14) to instantiate a case of discontinuous Gapping where the missing elements in the second conjunct are the auxiliary *was* and the passive infinitive *called* (rather than the whole string *wasn't called*). Then, by assuming that the contraction of negation on the auxiliary is a surface morpho-phonological process, the string in (14) can be matched with the intended interpretation.

[14] For a recent alternative analysis of split scope, see Abels and Martí (2010). The key component of Abels and Martí's analysis consists in treating negative quantifiers (and related expressions) as quantifiers over choice functions (of type $((et \to e) \to t) \to t$). We believe that this approach is also compatible with the syntax-semantics interface of determiner gapping in our analysis.

are lexically type-raised higher-order determiners of type S|(S|Det), where Det abbreviates the syntactic type of ordinary determiners S|(S|NP)|N. By assigning negative determiners in this type, it becomes possible to specify the scope of the higher negation and the lower existential separately in the lexical meaning of the negative determiner:

(58) $[\![\text{no}]\!] = \lambda \mathscr{P}_{(et \to et \to t) \to t}.\neg \mathscr{P}(\exists)$

That is, the lexically type-raised determiner feeds an ordinary positive quantifier meaning to its argument, thus saturating its determiner-type variable position, and additionally contributes negation which scopes over the whole sentence.

The full lexical entry for the negative determiner is then formulated as follows:

(59) $\lambda \rho.\rho(\lambda \varphi \lambda \sigma.\sigma(\mathsf{no} \circ \varphi))$; $\lambda \mathscr{P}.\neg \mathscr{P}(\exists)$; S|(S|Det)
(where Det abbreviates S|(S|NP)|N)

In Appendix B we unpack the higher-order phonology of this entry and illustrate how it enables an analysis of split scope.

Determiner gapping can then be treated as a case of multiple gapping involving both the verb and the determiner. The only complication here is that the 'gap' corresponding to the determiner is of a higher-order type phonologically, so an identity element of this higher-order phonological type needs to be fed to the second conjunct. This is done by the following lexical entry for the conjunction word, which generalizes the Gapping-type conjunction entry to the S|Det|TV type:

(60) $\lambda \rho_2 \lambda \rho_1 \lambda \varphi \lambda \sigma.\rho_1(\varphi)(\sigma) \circ \mathsf{and} \circ \rho_2(\varepsilon)(\varepsilon_{\mathsf{d}})$; $\sqcap$; $\mathbf{GC}$(S|Det|TV)
(where $\mathbf{GC}(A) =_{def} A|A|A$ for any syntactic type A)

Sentences containing both a verb gap and a determiner gap are obtained via hypothetical reasoning in the usual way (as in (78) in Appendix B):

(61) $\lambda \varphi_1 \lambda \tau.\tau(\mathsf{dog})(\lambda \varphi_2.\varphi_2 \circ \varphi_1 \circ \mathsf{whiskas})$; $\lambda P \lambda \mathscr{F}.\mathscr{F}(\mathbf{dog})(\lambda x.P(\mathbf{w})(x))$; S|Det|TV

Then, conjunction of two such expressions via (77) yields the following sign ((79) in Appendix B):

(62) $\lambda \varphi_1 \lambda \tau.\tau(\mathsf{dog})(\lambda \varphi_2.\varphi_2 \circ \varphi_1 \circ \mathsf{whiskas}) \circ \mathsf{or} \circ \mathsf{cat} \circ \mathsf{alpo}$;
$\lambda P \lambda \mathscr{F}.\mathscr{F}(\mathbf{dog})(\lambda x.P(\mathbf{w})(x)) \sqcup \lambda P \lambda \mathscr{F}.\mathscr{F}(\mathbf{cat})(\lambda x.P(\mathbf{a})(x))$; S|Det|TV

Note in particular that the right string is obtained for the second conjunct. This part is illustrated in (80) in Appendix B.

Finally, the missing verb and determiner are successively lowered to the first conjunct to yield the following sign ((81) in Appendix B):

(63) $\mathsf{no} \circ \mathsf{dog} \circ \mathsf{eats} \circ \mathsf{whiskas} \circ \mathsf{or} \circ \mathsf{cat} \circ \mathsf{alpo}$; $\neg[\exists_{\mathbf{dog}}(\lambda x.\mathbf{eat}(\mathbf{w})(x)) \vee \exists_{\mathbf{cat}}(\lambda x.\mathbf{eat}(\mathbf{a})(x))]$; S

Crucially, just as in the analysis from the previous section, since the negative determiner scopes over the whole coordinated gapped sentence in the combinatoric structure, the right semantic scope between the two operators is predicted. Thus, here again, the apparently anomalous scope relation between the negative quantifier and disjunction is a predicted consequence of the 'gapped' status of the former. The syntactic analysis of gapping requires the determiner to syntactically scope over the whole coordinate structure, and the semantic scope between the two transparently reflects this underlying structural relationship.

Finally, just like a lower-order auxiliary entry of type VP/VP can be derived from the lexically specified higher-order entry of type S|(S|VP/VP), the higher-order entry for the negative determiner can be lowered to the ordinary determiner type Det (= S|(S|NP)|N) via hypothetical reasoning in the present framework. The derivation is given in (82) in Appendix B, and the syntax and semantics of this derived entry is just the familiar GQ type quantifier entry for the word *no*:

(64) $\lambda\varphi\lambda\sigma.\sigma(\mathsf{no} \circ \varphi)$; $\lambda P.\lambda Q.\neg\exists(P)(Q)$; S|(S|NP)|N

With this derived entry for *no*, the distributive reading for the negative quantifier in examples like (5c) (or (i) in footnote 3) can be derived straightforwardly. The derivation will be identical in form to the one for the non-distributive reading for the negative quantifier up to the point where the verb is lowered into the first conjunct (which can be obtained by feeding a TV as an argument to (62)), and differs only in the last step, where we simply let the derived S|Det to take the lowered Det type determiner derived in (82) as an argument.

4 Conclusion

Gapping poses perhaps the greatest challenge to syntactic theories of all kinds. The two problems that it presents, namely, the syntactic asymmetry between the two conjuncts and the semantic scope anomaly exhibited by scopal operators, have resisted successful treatments in the previous literature, both in generative syntax and in CG. Our analysis attempts to make sense of this complex empirical property of Gapping in a variant of CG whose robust empirical applicability is established independently ***[reference omitted for refereeing]***. The central feature of the framework we adopt is that it captures the flexible yet systematic properties of the syntax-semantics interface of natural language by employing both the directional and non-directional modes of implication developed in separate strands of research in the previous CG literature. Given that a fully successful analysis of Gapping becomes available only in such a framework, we seem to be led to the conclusion that the kind of hybrid implication architecture embodied in the proposed framework—however one implements it technically—is indispensable, and that it reflects some deep property of the logic of natural language syntax, where both the directional and non-directional modes of inference, as well as their flexible interactions, play central roles. In fact, the availability of the Gapping construction itself is almost a predicted consequence of such an architecture of grammar: other types of non-canonical coordination display hypothetical reasoning with the directional slashes, with the missing material either on the right (Right-Node Raising) or on the left (Argument Cluster Coordination); Gapping just represents the other possibility, where the missing material is medial, but then, hypothetical reasoning with the non-directional mode of implication is exactly the right way to handle it. We take it to be highly illuminating that this analytic possibility, which suggests itself as a natural solution for the surface asymmetry problem (independently of any other considerations) in this type of approach, automatically provides a solution for the other, apparently much more intractable problem of scope anomaly that the phenomenon exhibits.

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A Deductive rules and ancillary derivations

A.1 Rules of Hybrid TLCG

(65)

Connective	**Introduction**	**Elimination**
$/$	$\dfrac{\dfrac{\begin{array}{ccc}\vdots\ \vdots & \underline{[\varphi;\ x;\ A]^n} & \vdots\ \vdots \\ \vdots\ \vdots & \vdots\ \vdots & \vdots\ \vdots\end{array}}{\mathsf{b} \circ \varphi;\ \mathcal{F};\ B}}{\mathsf{b};\ \lambda x.\mathcal{F};\ B/A}\,/\mathrm{I}^n$	$\dfrac{\mathsf{a};\ \mathcal{F};\ A/B \quad \mathsf{b};\ \mathcal{G};\ B}{\mathsf{a} \circ \mathsf{b};\ \mathcal{F}(\mathcal{G});\ A}\,/\mathrm{E}$
$\backslash$	$\dfrac{\dfrac{\begin{array}{ccc}\vdots\ \vdots & \underline{[\varphi;\ x;\ A]^n} & \vdots\ \vdots \\ \vdots\ \vdots & \vdots\ \vdots & \vdots\ \vdots\end{array}}{\varphi \circ \mathsf{b};\ \mathcal{F};\ B}}{\mathsf{b};\ \lambda x.\mathcal{F};\ A\backslash B}\,\backslash\mathrm{I}^n$	$\dfrac{\mathsf{b};\ \mathcal{G};\ B \quad \mathsf{a};\ \mathcal{F};\ B\backslash A}{\mathsf{b} \circ \mathsf{a};\ \mathcal{F}(\mathcal{G});\ A}\,\backslash\mathrm{E}$
$\vert$	$\dfrac{\dfrac{\begin{array}{ccc}\vdots\ \vdots & \underline{[\varphi;\ x;\ A]^n} & \vdots\ \vdots \\ \vdots\ \vdots & \vdots\ \vdots & \vdots\ \vdots\end{array}}{\mathsf{b};\ \mathcal{F};\ B}}{\lambda\varphi.\mathsf{b};\ \lambda x.\mathcal{F};\ B\vert A}\,\vert\mathrm{I}^n$	$\dfrac{\mathsf{a};\ \mathcal{F};\ A\vert B \quad \mathsf{b};\ \mathcal{G};\ B}{\mathsf{a}(\mathsf{b});\ \mathcal{F}(\mathcal{G});\ A}\,\vert\mathrm{E}$

A.2 Derivations

A.2.1 Interaction of topicalization and Gapping

First, the gapped string *Chris gave* can be derived via hypothetical reasoning in the usual manner:

(66)

$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\mathsf{gave};\ \mathbf{give};\ \mathrm{VP/PP/NP} \quad [\varphi_6; w; \mathrm{NP}]^1}{\mathsf{gave} \circ \varphi_6;\ \mathbf{give}(w);\ \mathrm{VP/PP}}/\mathrm{E} \quad [\varphi_7; u; \mathrm{PP}]^2}{\mathsf{gave} \circ \varphi_6 \circ \varphi_7;\ \mathbf{give}(w)(u);\ \mathrm{VP}}/\mathrm{E} \quad \mathsf{chris};\ \mathbf{c};\ \mathrm{NP}}{\mathsf{chris} \circ \mathsf{gave} \circ \varphi_6 \circ \varphi_7;\ \mathbf{give}(w)(u)(\mathbf{c});\ \mathrm{S}}\backslash\mathrm{E}}{\mathsf{chris} \circ \mathsf{gave} \circ \varphi_6;\ \lambda u.\mathbf{give}(w)(u)(\mathbf{c});\ \mathrm{S/PP}}/\mathrm{I}^2}{\mathsf{chris} \circ \mathsf{gave};\ \lambda w \lambda u.\mathbf{give}(w)(u)(\mathbf{c});\ \mathrm{S/PP/NP}}/\mathrm{I}^1$$

Then the two conjuncts to be coordinated are derived by binding a gap of type S/PP/NP in a topicalized sentence (note that two hypothetical reasonings are involved here, one for Gapping and the other for topicalization):

(67)

$$\dfrac{\dfrac{\dfrac{\dfrac{\begin{bmatrix}\varphi_1; \\ x; \mathrm{PP}\end{bmatrix}^1 \quad \dfrac{\begin{bmatrix}\varphi_0; \\ P; \mathrm{S/PP/NP}\end{bmatrix}^2 \quad \begin{matrix}\mathsf{the} \circ \mathsf{book}; \\ \mathbf{b}; \mathrm{NP}\end{matrix}}{\varphi_0 \circ \mathsf{the} \circ \mathsf{book};\ P(\mathbf{b});\ \mathrm{S/PP}}/\mathrm{E}}{\varphi_0 \circ \mathsf{the} \circ \mathsf{book} \circ \varphi_1;\ P(\mathbf{b})(x);\ \mathrm{S}}/\mathrm{E}}{\begin{matrix}\lambda\varphi_1.\varphi_0 \circ \mathsf{the} \circ \mathsf{book} \circ \varphi_1; \\ \lambda x.P(\mathbf{b})(x); \mathrm{S|PP}\end{matrix}}|\mathrm{I}^1 \quad \begin{matrix}\lambda\sigma_1\lambda\varphi_3.\varphi_3 \circ \sigma_1(\varepsilon); \\ \lambda\mathcal{G}.\mathcal{G}; (\mathrm{S}|X)|(\mathrm{S}|X)\end{matrix}}{\lambda\varphi_3.\varphi_3 \circ \varphi_0 \circ \mathsf{the} \circ \mathsf{book};\ \lambda x.P(\mathbf{b})(x);\ \mathrm{S|PP}}|\mathrm{E} \quad \begin{matrix}\mathsf{to} \circ \mathsf{robin}; \\ \mathbf{r}; \mathrm{PP}\end{matrix}}{\dfrac{\mathsf{to} \circ \mathsf{robin} \circ \varphi_0 \circ \mathsf{the} \circ \mathsf{book};\ P(\mathbf{b})(\mathbf{r});\ \mathrm{S}}{\lambda\varphi_0.\mathsf{to} \circ \mathsf{robin} \circ \varphi_0 \circ \mathsf{the} \circ \mathsf{book};\ \lambda P.P(\mathbf{b})(\mathbf{r});\ \mathrm{S|(S/PP/NP)}}|\mathrm{I}^2}|\mathrm{E}$$

The derivation completes by conjoining two expressions of type S|(S/PP/NP) and lowering the type S/PP/NP gapped expression to the first conjunct:

(68)

$$\dfrac{\dfrac{\dfrac{\begin{matrix}\vdots \\ \lambda\varphi_0.\mathsf{to} \circ \mathsf{leslie} \circ \\ \varphi_0 \circ \mathsf{the} \circ \mathsf{cd}; \\ \lambda P.P(\mathbf{cd})(\mathbf{l}); \\ \mathrm{S|(S/PP/NP)}\end{matrix} \quad \begin{matrix}\vdots \\ \lambda\sigma_2\lambda\sigma_1\lambda\varphi_5.\sigma_1(\varphi_5) \circ \\ \mathsf{and} \circ \sigma_2(\varepsilon); \\ \lambda\mathcal{W}\lambda\mathcal{V}.\mathcal{V} \sqcap \mathcal{W}; (\mathrm{S}|X)|(\mathrm{S}|X)|(\mathrm{S}|X)\end{matrix}}{\begin{matrix}\lambda\sigma_2\lambda\sigma_1\lambda\varphi_5.\sigma_1(\varphi_5) \circ \\ \mathsf{and} \circ \mathsf{to} \circ \mathsf{leslie} \circ \varepsilon \circ \mathsf{the} \circ \mathsf{cd} \circ \varepsilon; \\ \lambda\mathcal{V}.\mathcal{V} \sqcap \lambda P.P(\mathbf{cd})(\mathbf{l}); \\ \mathrm{(S|(S/PP/NP))|(S|(S/PP/NP))}\end{matrix}}|\mathrm{E} \quad \begin{matrix}\vdots \\ \lambda\varphi_0.\mathsf{to} \circ \mathsf{robin} \circ \\ \varphi_0 \circ \mathsf{the} \circ \mathsf{book}; \\ \lambda P.P(\mathbf{b})(\mathbf{r}); \\ \mathrm{S|(S/PP/NP)}\end{matrix}}{\begin{matrix}\lambda\varphi_5.\mathsf{to} \circ \mathsf{robin} \circ \varphi_5 \circ \mathsf{the} \circ \mathsf{book} \circ \mathsf{and} \circ \mathsf{to} \circ \mathsf{leslie} \circ \varepsilon \circ \mathsf{the} \circ \mathsf{cd} \circ \varepsilon; \\ \lambda P.P(\mathbf{b})(\mathbf{r}) \sqcap \lambda P.P(\mathbf{cd})(\mathbf{l}); \mathrm{S|(S/PP/NP)}\end{matrix}}|\mathrm{E} \quad \begin{matrix}\vdots \\ \mathsf{chris} \circ \mathsf{gave}; \\ \lambda w \lambda u.\mathbf{give}(w)(u)(\mathbf{c}); \\ \mathrm{S/PP/NP}\end{matrix}}{\begin{matrix}\mathsf{to} \circ \mathsf{robin} \circ \mathsf{chris} \circ \mathsf{gave} \circ \mathsf{the} \circ \mathsf{book} \circ \mathsf{and} \circ \mathsf{to} \circ \mathsf{leslie} \circ \mathsf{the} \circ \mathsf{cd}; \\ \mathbf{give}(\mathbf{b})(\mathbf{r})(\mathbf{c}) \wedge \mathbf{give}(\mathbf{cd})(\mathbf{l})(\mathbf{c}); \mathrm{S}\end{matrix}}|\mathrm{E}$$

A.2.2 Intermediate derivation for auxiliary + verb gapping

We first lower a TV-type constituent (consisting of the verb itself and an unbound variable representing the gap position for the auxiliary) to a gapped sentence of type S|TV. Then, by binding the VP/VP gap for the auxiliary with |, an S|(VP/VP) expression is derived which can then be given as an argument to the auxiliary (as in (57) in the main text).

(69)

$$
\dfrac{
\dfrac{
\begin{bmatrix}\varphi_0;\\ f;\mathrm{VP/VP}\end{bmatrix}^0
\quad
\dfrac{\begin{array}{l}\mathsf{eat};\\ \mathbf{eat};\mathrm{VP/NP}\end{array}\quad \begin{bmatrix}\varphi_1;\\ x;\mathrm{NP}\end{bmatrix}^1}{\mathsf{eat}\circ\varphi_1;\ \mathbf{eat}(x);\ \mathrm{VP}}\,/\mathrm{E}
}{
\dfrac{\varphi_0\circ\mathsf{eat}\circ\varphi_1;\ f(\mathbf{eat}(x));\ \mathrm{VP}}{\varphi_0\circ\mathsf{eat};\ \lambda x.f(\mathbf{eat}(x));\ \mathrm{VP/NP}}\,/\mathrm{I}^1
}\,/\mathrm{E}
\quad
\begin{array}{l}\vdots\quad\vdots\\ \lambda\varphi_2.\mathsf{john}\circ\varphi_2\circ\mathsf{steak}\circ\\ \mathsf{and}\circ\mathsf{mary}\circ\varepsilon\circ\mathsf{pizza};\\ \lambda Q.[Q(\mathbf{s})(\mathbf{j})]\sqcap\lambda P.[P(\mathbf{p})(\mathbf{m})];\\ \mathrm{S}|(\mathrm{VP/NP})\end{array}
}{
\dfrac{\mathsf{john}\circ\varphi_0\circ\mathsf{eat}\circ\mathsf{steak}\circ\mathsf{and}\circ\mathsf{mary}\circ\varepsilon\circ\mathsf{pizza};\ f(\mathbf{eat}(\mathbf{s}))(\mathbf{j})\wedge f(\mathbf{eat}(\mathbf{p}))(\mathbf{m});\ \mathrm{S}}{\begin{array}{l}\lambda\varphi_0.\mathsf{john}\circ\varphi_0\circ\mathsf{eat}\circ\mathsf{steak}\circ\mathsf{and}\circ\mathsf{mary}\circ\varepsilon\circ\mathsf{pizza};\\ \lambda f.[f(\mathbf{eat}(\mathbf{s}))(\mathbf{j})\wedge f(\mathbf{eat}(\mathbf{p}))(\mathbf{m})];\mathrm{S}|(\mathrm{VP/VP})\end{array}}\,|\mathrm{I}^0
}\,|\mathrm{E}
$$

A.2.3 Distributive reading for auxiliary gapping

We first show how a VP/VP entry for an auxiliary is obtained from the lexically assigned higher-order entry of type S|(S|(VP/VP)).

(70)

$$
\dfrac{
\begin{array}{l}\lambda\sigma.\sigma(\mathsf{can't});\\ \lambda\mathscr{F}.\neg\Diamond\mathscr{F}(\mathsf{id}_{et});\mathrm{S}|(\mathrm{S}|(\mathrm{VP/VP}))\end{array}
\quad
\dfrac{
\dfrac{[\varphi_1;x;\mathrm{NP}]^1\quad \dfrac{[\varphi_2;g;\mathrm{VP/VP}]^2\quad[\varphi_3;f;\mathrm{VP}]^3}{\varphi_2\circ\varphi_3;\ g(f);\ \mathrm{VP}}\,/\mathrm{E}}{\varphi_1\circ\varphi_2\circ\varphi_3;\ g(f)(x);\ \mathrm{S}}\,\backslash\mathrm{E}
}{
\begin{array}{l}\lambda\varphi_2.\varphi_1\circ\varphi_2\circ\varphi_3;\\ \lambda g.g(f)(x);\mathrm{S}|(\mathrm{VP/VP})\end{array}
}\,|\mathrm{I}^2
}{
\dfrac{\dfrac{\varphi_1\circ\mathsf{can't}\circ\varphi_3;\ \neg\Diamond f(x);\ \mathrm{S}}{\mathsf{can't}\circ\varphi_3;\ \lambda x.\neg\Diamond f(x);\ \mathrm{VP}}\,\backslash\mathrm{I}^1}{\mathsf{can't};\ \lambda f\lambda x.\neg\Diamond f(x);\ \mathrm{VP/VP}}\,/\mathrm{I}^3
}\,|\mathrm{E}
$$

By using this entry, the distributive reading for examples like (52b) can be derived straightforwardly, as in (71).

(71)

$$
\dfrac{
\begin{array}{l}\vdots\quad\vdots\\ \mathsf{can't};\\ \lambda f\lambda x.\neg\Diamond f(x);\mathrm{VP/VP}\end{array}
\quad
\begin{array}{l}\vdots\quad\vdots\\ \lambda\varphi.[\mathsf{john}\circ\varphi\circ\mathsf{eat}\circ\mathsf{steak}\circ\mathsf{and}\circ\mathsf{mary}\circ\varepsilon\circ\mathsf{pizza}];\\ \lambda h.[h(\mathbf{eat}(\mathbf{s}))(\mathbf{j})\wedge h(\mathbf{eat}(\mathbf{p}))(\mathbf{m})];\mathrm{S}|(\mathrm{VP/VP})\end{array}
}{
\mathsf{john}\circ\mathsf{can't}\circ\mathsf{eat}\circ\mathsf{steak}\circ\mathsf{and}\circ\mathsf{mary}\circ\varepsilon\circ\mathsf{pizza};\ \neg\Diamond\mathbf{eat}(\mathbf{s})(\mathbf{j})\wedge\neg\Diamond\mathbf{eat}(\mathbf{p})(\mathbf{m});\ \mathrm{S}
}\,|\mathrm{E}
$$

B Full formal analysis of determiner gapping

We assign the following type of lexical entry for negative determiners (= (59)):

(72) $\lambda\rho_2\lambda\rho_1\lambda\varphi\lambda\sigma.\rho_1(\varphi)(\sigma)\circ\mathsf{and}\circ\rho_2(\varepsilon)(\varepsilon_{\mathsf{d}});\ \sqcap;\ \mathbf{GC}(\mathrm{S|Det|TV})$

where $\mathbf{GC}(A) =_{def} A|A|A$ for any syntactic type A

We can intuitively make sense of the phonological term assigned to this entry as follows. Since ordinary quantificational determiners are of type $\mathbf{st}\to((\mathbf{st}\to\mathbf{st})\to\mathbf{st})$, the prosodic type of this type-raised determiner is $((\mathbf{st}\to((\mathbf{st}\to\mathbf{st})\to\mathbf{st}))\to\mathbf{st})\to\mathbf{st}$. The right form of this higher-order phonology of a type-raised determiner can be inferred from the phonological term that is assigned to a syntactically type-raised ordinary determiner. This is shown in the following derivation, where a determiner whose phonology is built from the string c is type-raised to the syntactic category S|(S|Det), with the corresponding higher-order phonology:

(73)

$$
\dfrac{\dfrac{\lambda\varphi\lambda\sigma.\sigma(\mathsf{c}\circ\varphi);\ \gamma;\ \mathrm{Det}\quad[\rho;\mathscr{P};\mathrm{S|Det}]^1}{\rho(\lambda\varphi\lambda\sigma.\sigma(\mathsf{c}\circ\varphi));\ \mathscr{P}(\gamma);\ \mathrm{S}}\,|\mathrm{E}}{\lambda\rho.\rho(\lambda\varphi\lambda\sigma.\sigma(\mathsf{c}\circ\varphi));\ \lambda\mathscr{P}.\mathscr{P}(\gamma);\ \mathrm{S}|(\mathrm{S|Det})}\,|\mathrm{I}^1
$$

By replacing the string c with no, we obtain the phonological term in the lexical entry in (72).

We illustrate how this entry is used in the derivation for a simple sentence containing a negative quantifier.

(74)
$$\dfrac{\begin{matrix}\lambda\rho.\rho(\lambda\varphi\lambda\sigma.\sigma(\mathsf{no}\circ\varphi));\\ \lambda\mathscr{P}.\neg\mathscr{P}(\exists); \mathrm{S}|(\mathrm{S}|\mathrm{Det})\end{matrix} \quad \dfrac{\dfrac{\dfrac{[\tau;\mathscr{F};\mathrm{Det}]^1 \quad \mathsf{fish};\ \mathbf{fish};\ \mathrm{N}}{\tau(\mathsf{fish});\ \mathscr{F}(\mathbf{fish});\ \mathrm{S}|(\mathrm{S}|\mathrm{NP})}|\mathrm{E} \quad \begin{matrix}\vdots \quad \vdots\\ \lambda\varphi.\varphi\circ\mathsf{walks};\\ \mathbf{walk}; \mathrm{S}|\mathrm{NP}\end{matrix}}{\tau(\mathsf{fish})(\lambda\varphi.\varphi\circ\mathsf{walks});\ \mathscr{F}(\mathbf{fish})(\mathbf{walk});\ \mathrm{S}}|\mathrm{E}}{\lambda\tau.\tau(\mathsf{fish})(\lambda\varphi.\varphi\circ\mathsf{walks});\ \lambda\mathscr{F}.\mathscr{F}(\mathbf{fish})(\mathbf{walk});\ \mathrm{S}|\mathrm{Det}}|\mathrm{I}^1}{\mathsf{no}\circ\mathsf{fish}\circ\mathsf{walks};\ \neg\exists_{\mathbf{fish}}\mathbf{walk};\ \mathrm{S}}|\mathrm{E}$$

Since the negative determiner is lexically assigned a raised, higher-order type, an ordinary determiner is first hypothesized in the subject position and later gets bound by the negative determiner via hypothetical reasoning with $|$. Note in particular that the right surface string is obtained by applying the higher-order functional phonology of the negative determiner to its argument of type S|Det (an expression missing a determiner).

With this lexical entry for the determiner *no*, split scope of examples like the following is straightforward.

(75) The company need fire no employee.

As shown in the derivation in (76), by hypothesizing a determiner in the sentence below the modal verb *need* and binding that hypothesis by a negative determiner above the modal, the desired $\neg > \mathbf{need} > \exists$ reading is obtained.

(76)
$$\dfrac{\begin{matrix}\lambda\rho.\rho(\lambda\varphi\lambda\sigma.\\ \sigma(\mathsf{no}\circ\varphi));\\ \lambda\mathscr{P}.\neg\mathscr{P}(\exists);\\ \mathrm{S}|(\mathrm{S}|\mathrm{Det})\end{matrix} \quad \dfrac{\dfrac{\begin{matrix}\lambda\sigma.\sigma(\mathsf{need});\\ \lambda\mathscr{G}.\Box_{\mathbf{need}}\mathscr{G}(\mathsf{id}_{et});\\ \mathrm{S}|(\mathrm{S}|(\mathrm{VP}/\mathrm{VP}))\end{matrix} \quad \dfrac{\dfrac{\dfrac{\begin{bmatrix}\tau;\\ \mathscr{F};\\ \mathrm{Det}\end{bmatrix}^3 \quad \begin{matrix}\mathsf{employee};\\ \mathbf{emp}; \mathrm{N}\end{matrix}}{\begin{matrix}\tau(\mathsf{employee});\\ \mathscr{F}(\mathbf{emp});\\ \mathrm{S}|(\mathrm{S}|\mathrm{NP})\end{matrix}}|\mathrm{E} \quad \dfrac{\dfrac{\begin{matrix}\mathsf{the}\circ\\ \mathsf{company};\\ \iota(\mathbf{c}); \mathrm{NP}\end{matrix} \quad \dfrac{\begin{bmatrix}\varphi_2;\\ y;\\ \mathrm{VP}/\mathrm{VP}\end{bmatrix}^2 \quad \dfrac{\begin{matrix}\mathsf{fire};\\ \mathbf{fire};\\ \mathrm{VP}/\mathrm{NP}\end{matrix} \quad \begin{bmatrix}\varphi_1;\\ x;\\ \mathrm{NP}\end{bmatrix}^1}{\mathsf{fire}\circ\varphi_1;\ \mathbf{fire}(x);\ \mathrm{VP}}/\mathrm{E}}{\varphi_2\circ\mathsf{fire}\circ\varphi_1;\ f(\mathbf{fire}(x));\ \mathrm{VP}}/\mathrm{E}}{\begin{matrix}\mathsf{the}\circ\mathsf{company}\circ\varphi_2\circ\mathsf{fire}\circ\varphi_1;\\ f(\mathbf{fire}(x))(\iota(\mathbf{c})); \mathrm{S}\end{matrix}}\backslash\mathrm{E}}{\begin{matrix}\lambda\varphi_1.\mathsf{the}\circ\mathsf{company}\circ\varphi_2\circ\mathsf{fire}\circ\varphi_1;\\ \lambda x.f(\mathbf{fire}(x))(\iota(\mathbf{c})); \mathrm{S}|\mathrm{NP}\end{matrix}}|\mathrm{I}^1}{\begin{matrix}\tau(\mathsf{employee})(\lambda\varphi_1.\mathsf{the}\circ\mathsf{company}\circ\varphi_2\circ\mathsf{fire}\circ\varphi_1);\\ \mathscr{F}(\mathbf{emp})(\lambda x.f(\mathbf{fire}(x))(\iota(\mathbf{c}))); \mathrm{S}\end{matrix}}|\mathrm{E}}{\begin{matrix}\lambda\varphi_2.\tau(\mathsf{employee})(\lambda\varphi_1.\mathsf{the}\circ\mathsf{company}\circ\varphi_2\circ\mathsf{fire}\circ\varphi_1);\\ \lambda f.\mathscr{F}(\mathbf{emp})(\lambda x.f(\mathbf{fire}(x))(\iota(\mathbf{c}))); \mathrm{S}|(\mathrm{VP}/\mathrm{VP})\end{matrix}}|\mathrm{I}^2}{\begin{matrix}\tau(\mathsf{employee})(\lambda\varphi_1.\mathsf{the}\circ\mathsf{company}\circ\mathsf{need}\circ\mathsf{fire}\circ\varphi_1);\\ \Box_{\mathbf{need}}\mathscr{F}(\mathbf{emp})(\lambda x.\mathbf{fire}(x)(\iota(\mathbf{c}))); \mathrm{S}\end{matrix}}|\mathrm{E}}{\begin{matrix}\lambda\tau.\tau(\mathsf{employee})(\lambda\varphi_1.\mathsf{the}\circ\mathsf{company}\circ\mathsf{need}\circ\mathsf{fire}\circ\varphi_1);\\ \lambda\mathscr{F}.\Box_{\mathbf{need}}\mathscr{F}(\mathbf{emp})(\lambda x.\mathbf{fire}(x)(\iota(\mathbf{c}))); \mathrm{S}|\mathrm{Det}\end{matrix}}|\mathrm{I}^3}{\begin{matrix}\mathsf{the}\circ\mathsf{company}\circ\mathsf{need}\circ\mathsf{fire}\circ\mathsf{no}\circ\mathsf{employee};\\ \neg\Box_{\mathbf{need}}\exists_{\mathbf{emp}}(\lambda x.\mathbf{fire}(x)(\iota(\mathbf{c}))); \mathrm{S}\end{matrix}}|\mathrm{E}$$

The lexical entry for the conjunction word for determiner gapping can be written as in (77), generalizing the Gapping-type conjunction entry to the S|Det|TV type:

(77) $\lambda\rho_2\lambda\rho_1\lambda\varphi\lambda\sigma.\rho_1(\varphi)(\sigma)\circ\mathsf{and}\circ\rho_2(\varepsilon)(\varepsilon_{\mathsf{d}});\ \sqcap;\ \mathbf{GC}(\mathrm{S}|\mathrm{Det}|\mathrm{TV})$
where $\mathbf{GC}(A) =_{def} A|A|A$ for any syntactic type A and $\varepsilon_{\mathsf{d}} =_{def} \lambda\varphi\lambda\sigma.\sigma(\varepsilon\circ\varphi) = \lambda\varphi\lambda\sigma.\sigma(\varphi)$

Expressions that are of the right type to be coordinated by this conjunction category can be derived via hypothetical reasoning in the usual way:

(78)

$$\dfrac{\dfrac{\dfrac{\dfrac{[\tau;\mathscr{F};\mathrm{Det}]^3 \quad \mathsf{dog};\,\mathbf{dog};\,\mathrm{N}}{\tau(\mathsf{dog});\,\mathscr{F}(\mathbf{dog});\,\mathrm{S}|(\mathrm{S}|\mathrm{NP})}{|}\mathrm{E} \qquad \dfrac{\dfrac{[\varphi_2;x;\mathrm{NP}]^2 \quad \dfrac{[\varphi_1;P;\mathrm{TV}]^1 \quad \mathsf{whiskas};\,\mathbf{w};\,\mathrm{NP}}{\varphi_1\circ\mathsf{whiskas};\,P(\mathbf{w});\,\mathrm{VP}}/\mathrm{E}}{\varphi_2\circ\varphi_1\circ\mathsf{whiskas};\,P(\mathbf{w})(x);\,\mathrm{S}}\backslash\mathrm{E}}{\lambda\varphi_2.\varphi_2\circ\varphi_1\circ\mathsf{whiskas};\,\lambda x.P(\mathbf{w})(x);\,\mathrm{S}|\mathrm{NP}}{|}\mathrm{I}^2}{\tau(\mathsf{dog})(\lambda\varphi_2.\varphi_2\circ\varphi_1\circ\mathsf{whiskas});\,\mathscr{F}(\mathbf{dog})(\lambda x.P(\mathbf{w})(x));\,\mathrm{S}}{|}\mathrm{E}}{\lambda\tau.\tau(\mathsf{dog})(\lambda\varphi_2.\varphi_2\circ\varphi_1\circ\mathsf{whiskas});\,\lambda\mathscr{F}.\mathscr{F}(\mathbf{dog})(\lambda x.P(\mathbf{w})(x));\,\mathrm{S}|\mathrm{Det}}{|}\mathrm{I}^3}{\lambda\varphi_1\lambda\tau.\tau(\mathsf{dog})(\lambda\varphi_2.\varphi_2\circ\varphi_1\circ\mathsf{whiskas});\,\lambda P\lambda\mathscr{F}.\mathscr{F}(\mathbf{dog})(\lambda x.P(\mathbf{w})(x));\,\mathrm{S}|\mathrm{Det}|\mathrm{TV}}{|}\mathrm{I}^1$$

This is then conjoined with another expression of the same type via the determiner-gapping conjunction in (77) to yield the following coordinated S|Det|TV:

(79)

$$\dfrac{\begin{array}{l}\lambda\varphi_1\lambda\tau.\\ \tau(\mathsf{dog})(\lambda\varphi_2.\varphi_2\circ\varphi_1\circ\mathsf{whiskas});\\ \lambda P\lambda\mathscr{F}.\mathscr{F}(\mathbf{dog})(\lambda x.P(\mathbf{w})(x));\\ \mathrm{S}|\mathrm{Det}|\mathrm{TV}\end{array} \quad \dfrac{\begin{array}{l}\lambda\rho_2\lambda\rho_1\lambda\varphi\lambda\tau.\rho_1(\varphi)(\tau)\circ\\ \mathsf{or}\circ\rho_2(\varepsilon)(\varepsilon_{\mathsf{d}});\\ \sqcup;\mathbf{GC}(\mathrm{S}|\mathrm{Det}|\mathrm{TV})\end{array} \quad \begin{array}{l}\lambda\varphi_1\lambda\tau.\\ \tau(\mathsf{cat})(\lambda\varphi_2.\varphi_2\circ\varphi_1\circ\mathsf{alpo});\\ \lambda P\lambda\mathscr{F}.\mathscr{F}(\mathbf{cat})(\lambda x.P(\mathbf{a})(x));\\ \mathrm{S}|\mathrm{Det}|\mathrm{TV}\end{array}}{\begin{array}{l}\lambda\rho_1\lambda\varphi\lambda\tau.\rho_1(\varphi)(\tau)\circ\mathsf{or}\circ\mathsf{cat}\circ\mathsf{alpo};\\ \lambda\mathcal{W}.\mathcal{W}\sqcup\lambda P\lambda\mathscr{F}.\mathscr{F}(\mathbf{cat})(\lambda x.P(\mathbf{a})(x));\\ (\mathrm{S}|\mathrm{TV}|\mathrm{Det})|(\mathrm{S}|\mathrm{TV}|\mathrm{Det})\end{array}}{|}\mathrm{E}}{\begin{array}{l}\lambda\varphi_1\lambda\tau.\tau(\mathsf{dog})(\lambda\varphi_2.\varphi_2\circ\varphi_1\circ\mathsf{whiskas})\circ\mathsf{or}\circ\mathsf{cat}\circ\mathsf{alpo};\\ \lambda P\lambda\mathscr{F}.\mathscr{F}(\mathbf{dog})(\lambda x.P(\mathbf{w})(x))\sqcup\lambda P\lambda\mathscr{F}.\mathscr{F}(\mathbf{cat})(\lambda x.P(\mathbf{a})(x));\mathrm{S}|\mathrm{Det}|\mathrm{TV}\end{array}}{|}\mathrm{E}$$

Note in particular that the right string *cat Alpo* is obtained for the second conjunct. This is a straightforward result of a couple of β-reduction steps:

(80) $\lambda\varphi\lambda\tau[\tau(\mathsf{cat})(\lambda\varphi'.\varphi'\circ\varphi\circ\mathsf{alpo})](\varepsilon)(\varepsilon_{\mathsf{d}})$
$= \lambda\varphi\lambda\sigma[\sigma(\varphi)](\mathsf{cat})(\lambda\varphi_2.\varphi_2\circ\varepsilon\circ\mathsf{alpo}) = \lambda\varphi_2[\varphi_2\circ\varepsilon\circ\mathsf{alpo}](\mathsf{cat})$
$= \mathsf{cat}\circ\varepsilon\circ\mathsf{alpo} = \mathsf{cat}\circ\mathsf{alpo}$

The rest of the derivation just involves combining the main verb and the negative determiner with this S|Det|TV expression:

(81)

$$\dfrac{\begin{array}{l}\lambda\rho.\rho(\lambda\varphi\lambda\sigma.\\ \sigma(\mathsf{no}\circ\varphi));\\ \lambda\mathscr{P}.\neg\mathscr{P}(\exists);\\ \mathrm{S}|(\mathrm{S}|\mathrm{Det})\end{array} \quad \dfrac{\begin{array}{l}\mathsf{eats};\\ \mathbf{eat};\\ \mathrm{TV}\end{array} \quad \begin{array}{l}\vdots \quad \vdots\\ \lambda\varphi_1\lambda\tau.\tau(\mathsf{dog})(\lambda\varphi_2.\varphi_2\circ\varphi_1\circ\mathsf{whiskas})\circ\mathsf{or}\circ\mathsf{cat}\circ\mathsf{alpo};\\ \lambda P\lambda\mathscr{F}.\mathscr{F}(\mathbf{dog})(\lambda x.P(\mathbf{w})(x))\sqcup\\ \lambda P\lambda\mathscr{F}.\mathscr{F}(\mathbf{cat})(\lambda x.P(\mathbf{a})(x));\mathrm{S}|\mathrm{Det}|\mathrm{TV}\end{array}}{\begin{array}{l}\lambda\tau.\tau(\mathsf{dog})(\lambda\varphi_2.\varphi_2\circ\mathsf{eats}\circ\mathsf{whiskas})\circ\mathsf{or}\circ\mathsf{cat}\circ\mathsf{alpo};\\ \lambda\mathscr{F}.\mathscr{F}(\mathbf{dog})(\lambda x.\mathbf{eat}(\mathbf{w})(x))\sqcup\lambda\mathscr{F}.\mathscr{F}(\mathbf{cat})(\lambda x.\mathbf{eat}(\mathbf{a})(x));\mathrm{S}|\mathrm{Det}\end{array}}{|}\mathrm{E}}{\begin{array}{l}\mathsf{no}\circ\mathsf{dog}\circ\mathsf{eats}\circ\mathsf{whiskas}\circ\mathsf{or}\circ\mathsf{cat}\circ\mathsf{alpo};\\ \neg[\exists_{\mathbf{dog}}(\lambda x.\mathbf{eat}(\mathbf{w})(x))\vee\exists_{\mathbf{cat}}(\lambda x.\mathbf{eat}(\mathbf{a})(x))];\mathrm{S}\end{array}}{|}\mathrm{E}$$

The GQ-type entry for the negative quantifier, used in the distributive reading of the negative quantifier in determiner gapping, is obtained from the lexically specified higher-order entry as follows:

(82)

$$\dfrac{\dfrac{\dfrac{\begin{array}{l}\lambda\rho.\rho(\lambda\varphi\lambda\sigma.\sigma(\mathsf{no}\circ\varphi));\\ \lambda\mathscr{Q}.\neg\mathscr{Q}(\exists);\mathrm{S}|(\mathrm{S}|\mathrm{Det})\end{array} \quad \dfrac{\dfrac{\dfrac{[\tau;\mathscr{P};\mathrm{Det}]^1 \quad [\varphi;P;\mathrm{N}]^2}{\tau(\varphi);\,\mathscr{P}(P);\,\mathrm{S}|(\mathrm{S}|\mathrm{NP})}{|}\mathrm{E} \quad [\sigma;Q;\mathrm{S}|\mathrm{NP}]^3}{\tau(\varphi)(\sigma);\,\mathscr{P}(P)(Q);\,\mathrm{S}}{|}\mathrm{E}}{\lambda\tau.\tau(\varphi)(\sigma);\,\lambda\mathscr{P}.\mathscr{P}(P)(Q);\,\mathrm{S}|\mathrm{Det}}{|}\mathrm{I}^1}{\sigma(\mathsf{no}\circ\varphi);\,\neg\exists(P)(Q);\,\mathrm{S}}{|}\mathrm{E}}{\lambda\sigma.\sigma(\mathsf{no}\circ\varphi);\,\lambda Q.\neg\exists(P)(Q);\,\mathrm{S}|(\mathrm{S}|\mathrm{NP})}{|}\mathrm{I}^3}{\lambda\varphi\lambda\sigma.\sigma(\mathsf{no}\circ\varphi);\,\lambda P.\lambda Q.\neg\exists(P)(Q);\,\mathrm{S}|(\mathrm{S}|\mathrm{NP})|\mathrm{N}}{|}\mathrm{I}^2$$