Against ellipsis: Arguments for the direct licensing of ‘non-canonical’ coordinations

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Abstract

Categorial grammar is well-known for its elegant analysis of coordination enabled by the flexible notion of constituency it entertains. However, to date, no systematic study exists that examines whether this analysis has any obvious empirical advantage over alternative analyses of nonconstituent coordination available in phrase structure-based theories of syntax. This paper attempts precisely such a comparison. We compare the direct constituent coordination analysis of non-canonical coordinations (right-node raising, dependent cluster coordination and Gapping) in categorial grammar with an ellipsis-based analysis of the same phenomena in the recent HPSG literature. We provide a set of empirical evidence, consisting of cases in which non-canonical coordinations interact with scopal operators of various sorts, which systematically falsifies the predictions of the latter, ‘linearization-based’ ellipsis approach to coordination. We propose an alternative analysis in a variant of categorial grammar called Hybrid Type-Logical Categorial Grammar. The proposed framework 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 straightforwardly captures the interactions between non-canonical coordinations and scopal expressions, demonstrating the broader empirical payoff of the direct constituent coordination analysis of non-canonical coordinations pioneered by Steedman (1985), Dowty (1988) and Steedman (1990) hitherto not explicitly recognized in the literature.

Keywords: coordination, nonconstituent coordination, scope, categorial grammar, Hybrid Type-Logical Categorial Grammar

1 Introduction

Coordination has long been recognized as one of the more intractable realms of syntax. The initially attractive hypothesis of like category coordination (‘only constituents of the same category can coordinate’) is deemed untenable in view of examples such as the following:

(1) a. I gave Robin a book and Terry a pair of pliers.
b. I gave Robin, and Leslie offered Terry, a pair of pliers.
c. Leslie bought a CD, and Robin, a book.

In (1a) (dependent cluster coordination; DCC) and (1b) (right-node raising; RNR), strings like *Robin a book* and *I gave Robin*, which are standardly not taken to be constituents, are coordinated. In (1c) (Gapping), what appears to be a complete sentence is conjoined with an incomplete one, specifically, one in which the main verb is missing.

Examples like those in (1) are in fact extremely problematic in phrase structure-based approaches to syntax such as HPSG and LFG. Various attempts have been made in the literature to overcome this problem (see, e.g., Sag et al. 1985; Maxwell and Manning 1996; Mouret 2006). Currently, the most explicit and detailed approach to this problem takes the form of prosodic ellipsis. In this approach (Yatabe 2001; Crysmann 2003; Beavers and Sag 2004; Chaves 2007; Sag and Chaves 2008), advocated by several authors in the recent HPSG literature utilizing the so-called Linearization-Based architecture of HPSG, examples like those in (1) receive analyses roughly along the following lines:

(2) a. [$_S$ I gave Robin a book on Thursday] and [$_S$ ~~(I) gave~~ Leslie a book on Friday].
  b. [$_S$ I gave Robin ~~a pair of pliers~~] and [$_S$ Leslie offered Terry, a pair of pliers].
  c. [$_S$ Leslie bought a CD], and [$_S$ Robin ~~bought~~ a book].

The key claim, which is effectively the same as the old idea of CONJUNCTION REDUCTION from the transformational literature, is that the apparent nonconstituent coordination in these examples is in fact only apparent, and that these examples all involve full-fledged coordination in the 'underlying' combinatoric structure feeding into semantic interpretation. The surface form of the sentence is obtained by ellipsis of the relevant part of the sentence via identity in form to some string in the other conjunct.

In phrase structure-based approaches to syntax, this is arguably the simplest analysis of coordination. But there is an alternative analytic perspective, embodied in many (but not all) variants of categorial grammar (CG). In this alternative view, which effectively entails an abandonment (or at least a significant reconceptualization) of the standard notion of constituency in phrase structure-based theories, the noncanonical coordinations in (1) are literally analyzed as constituent coordination, by recognizing strings of words such as *I gave Robin* as (derived) full-fledged constituents. We call this the DIRECT COORDINATION analysis of noncanonical coordination.

The elegance by which this CG analysis of coordination characterizes the basic syntactic patterns of noncanonical coordination is well-known, especially in the literature of Combinatory Categorial Grammar (CCG; Steedman 1985; Dowty 1988). But curiosity enough, there is as yet no detailed explicit comparison of this approach with alternative ideas, such as the ellipsis-based approach noted above that is prominent in the recent HPSG literature. This paper attempts precisely such a comparison. The crucial data that enable us to tease apart the predictions of the ellipsis-based and direct coordination approaches come from interactions between coordination and scopal expressions such as quantifiers, symmetrical predicates (*same*, *different*, ...), 'respective' and summative predicates and modal auxiliaries. A simple example involving a quantifier and DCC illustrates the point:

(3) a. Terry gave no man a book on Friday or a record on Saturday.
  b. [$_S$ Terry gave no man a book on Friday] or [$_S$ (Terry) gave no man a record on Saturday].

Here, by far the more prominent reading of (3a) is one in which the negative quantifier outscopes disjunction, but the 'underlying source' for this sentence (according to the ellipsis-based approach) involving constituent coordination in (3b) completely lacks this reading.

To preview the conclusion we arrive at, in all examples of this type, we see the same pattern: in a configuration in which the scopal operator in question appears outside the coordinated expression in the overt string, an interpretation in which the operator scopes over the whole coordinate structure is always available in *both* ordinary constituent coordination and non-canonical coordination, regardless of the type of the operator. This parallel scoping pattern between constituent coordination and non-canonical coordination poses a significant problem for the ellipsis-based approach, since this approach predicts the exact opposite scoping pattern (i.e. one in which the operator takes scope within each conjunct separately) in the case of non-canonical coordination, given its fundamental premise (illustrated in (2)). The direct coordination analysis in CG, by contrast, predicts exactly the right empirical pattern, since in both constituent coordination and non-canonical coordination, the coordinate structure constitutes a full-fledged constituent to which a complete semantic interpretation is assigned, and the scopal operator directly scopes over the whole coordinate structure to induce the relevant wide-scope interpretation. From this, we conclude that, at least as far as coordination is concerned, the architecture of grammar embodied in CG that entertains a more flexible notion of constituency has a distinct advantage over phrase structure-based theories.

In addition to this comparison of phrase structure-based approaches and categorial approaches to coordination, the proposal we make in this paper has a substantial contribution to the literature of CG itself. As we discuss below, previous variants of CG can roughly be classified into two groups: variants which take the distinction between forward and backward slashes (to encode word order) to be primitive, such as CCG and the Lambek calculus, and a more recent family of approaches (pioneered by Oehrle (1994)) in which directionality is instead relegated to a separate prosodic component. As linguistic theories, each has advantages in different domains, but each has so far been motivated by relatively narrow ranges of empirical phenomena, and, for this reason, the data that we discuss in this paper involving interactions of coordination and scopal operator turn out to pose quite serious challenges to both of these variants of CG. The framework we propose in this paper, called HYBRID TYPE-LOGICAL CATEGORIAL GRAMMAR (Kubota 2010; Kubota and Levine 2012), is novel in that it overcomes this difficulty by integrating these two previous lines of research in CG. As we show below, this results in a system which straightforwardly accounts for the interaction between coordination and scopal phenomena in a fully general manner, revealing, for the first time in the literature, the true empirical payoff of the direct constituent coordination analysis of non-canonical coordination in CG.

2 The empirical domain: coordination and scope

Most of the evidence base for ellipsis-based treatments of noncanonical coordination involves prosodic deletion of semantically relatively simple material such as referring expressions. A more realistic assessment of such approaches should test them against instances of non-canonical coordination in which material with scopal interpretations is ellipsed. In this section we survey a sample of such cases, which jointly point to a major empirical generalization: (i) scopal elements which appear prosodically 'outside' coordinations of apparent nonconstituents (the result, in ellipsis-based analyses, of prosodic reduction operations on conjuncts) have both wide and narrow scope interpretations with respect to the conjunctions/disjunctions involved, whereas (ii) when separate tokens of such elements appear in each conjunct, they only scope narrowly within each conjunct. This fact proves a major contraindication to ellipsis-based treatments of these noncanonical coordinations (see Sect. 3), but follows straightforwardly as the null hypothesis in our CG analysis (Sect. 4).

2.1 Symmetrical, 'respective' and summative predicates and NCC

We start with the so-called symmetrical predicates and related expressions, since this class of phenomena illustrates the problem most clearly (as is well known in the literature). By symmetrical predicates, we mean expressions such as *the same*, *different* and *equal*, which, in one of their uses, establish some sort of (non-)identity between multiple entities to which some common description applies. These expressions interact with coordination to induce the ambiguity between the so-called 'internal reading' and the 'external reading'. This is illustrated in the following example:

(4) $\left\{\begin{array}{l}\text{The same waiter}\\ \text{Different waiters}\end{array}\right\}$ served Robin and poured the wine for Leslie.

When uttered in a context in which some waiter is already salient (for example, when (4) is preceded by *I had a very entertaining waiter when I went to that restaurant last week, and yesterday evening...*), *the same waiter* in (4) anaphorically refers to that individual already introduced in the discourse. This is called the external reading. But this sentence can be uttered in an 'out of the blue' context too, and in this case, it simply asserts that the individual who acted as Robin's server and the one who poured Leslie's wine were a single unique individual, and that that individual was indeed a waiter—the so-called internal reading (Carlson 1987). Importantly, when we 'reconstruct' an overt token of *the same waiter* in the second conjunct (*The same waiter served Robin and the same waiter poured wine for Leslie*), the sentence allows only the external reading.

The fact that the internal vs. external ambiguity is found in nonconstituent coordination (NCC) cases as well (as in the RNR example (5)) is an old observation (Abbott 1976; Jackendoff 1977), and it has been recognized in the literature of coordination as a particularly vexing issue since its discovery.

(5) Robin reviewed, and Leslie read, $\left\{\begin{array}{l}\text{the same book}\\ \text{different books}\end{array}\right\}$.

(6) I said $\left\{\begin{array}{l}\text{the same thing}\\ \text{different things}\end{array}\right\}$ to Robin on Thursday and (to) Leslie on Friday.

The internal reading is available in the examples (5) and (6), in which a single token of *the same N/different Ns* appears outside the coordinate structure, but not in their 'full' clausal coordination counterparts (as the reader can readily check themselves).

Parallel examples can be constructed for 'respective' readings and summative predicates. 'Respective' readings are typically encountered in connection with canonical coordinations, as in the following:

(7) a. John and Bill invited Mary and Sue (respectively).

b. Steve, Jane and Jim play jazz violin, teach downhill ski racing and design yacht hulls (respectively).

In such examples, the 'respective' relation is the bijective relationship between members of two separate coordinate expressions, corresponding to the relative order of the elements in each of the coordinations: in the case of (7), Steve with violin playing, Jane with ski instructing and Jim with yacht design.[1] By SUMMATIVE PREDICATES, we mean expressions like *a total of $150,000* in (8):

(8) Mary and Sue donated a total of $150,000 to animal rights groups and environmental protection organizations last year.

Here there is a reading in which Mary contributed a certain amount of money m and Sue an amount n such that $m + n$ came to $100,000 and was applied to the support of the two different kinds of organizations described.

(7) and (8) are standard instances of canonical coordination. Crucially, we find instances of both phenomena in NCC as well:

(9) a. I bought and sold a car on Thursday and a bike on Friday, respectively.

b. I lent *Syntactic Structures* and *Barriers* to Robin on Thursday and to Mary on Friday (respectively).

(10) a. I lent $1000 in total to Robin on Thursday and (to) Leslie on Friday.

b. John bought and sold a total of $10,000 worth of bonds from Robin on Thursday and to Leslie on Friday.

In (9a), for example, the apparent nonconstituent strings *a car on Thursday* and *a bike on Friday* are conjoined, with interpretation possibilities markedly different from those available to the conjunction of full-fledged constituents *bought and sold a car on Thursday* and *bought and sold a car on Friday*, etc. Similarly, (9b) corresponds to a very different meaning from the conjunction of full-fledged VPs *lent $1000 in total to Robin on Thursday* with *lent $1000 in total to Leslie on Friday.* (10b) presents a still more complex case, where both summative and 'respective' interpretations come into play and interact with each other, yielding a meaning which crucially depends on the conjunction of non-constituents.

In cases involving symmetrical and summative predicates, it is evident that the overt appearance of the relevant scopal operator in each conjunct yields a truth-conditionally quite different interpretation from the conjunction of the nonconstituents under a single token of the scopal operator. Thus, these NCC examples cannot be reduced to (underlying) coordination of full-fledged constituents. The issue is essentially the same with 'respective' readings, though, in this case, the point may be a bit harder to see since the semantic operator involved is a covert one, as we discuss below. Note especially that NCC examples pattern in the same way as surface constituent coordinations, rather than their supposed underlying sources (cf. (4) and (5)–(6), all of which exemplify the internal reading of *same/different*). This strongly suggests that the NCC examples above should be analyzed without the mediation of an underlying structure 'recovering' the elided material.

[1]This is distinct from (or more general than) the distributive readings of plural expressions. See the discussion in Sect. 3.2.2.

2.2 Quantifier scope and NCC

Though the implication of quantifier scope data for the analysis of coordination has often been noted in the literature (cf., e.g., Partee (1970), and the more recent Crysmann (2003) and Beavers and Sag (2004)), the descriptive generalization in this empirical domain has remained rather elusive. Our first objective in this section is clarifying this empirical question. Though our ultimate goal is to consider the theoretical implications of the relevant data, the empirical study itself should be of general interest, especially given the lack of a systematic investigation in this domain in the literature. We manipulate three parameters (all binary) that potentially affect the available interpretations: downward entailing (DE) vs. non-DE quantifiers,[2] conjunction vs. disjunction, and constituent coordination vs. NCC. In sentences in which quantifiers appear outside of coordinate structure, there are in principle two scopal relations between the quantifier and the coordinate structure: the quantifier either scopes over the whole coordinate structure (we call this the NON-DISTRIBUTIVE READING) or its meaning is distributed to each conjunct (DISTRIBUTIVE READING).

As we show below, the generalization that emerges is simple and straightforward:

(11) Both the distributive and non-distributive readings are available for both DE and non-DE quantifiers, regardless of the type of conjunction word (disjunction vs conjunction), and regardless of the type of coordination (constituent coordination vs. NCC).

In short, just as in the case of symmetrical, 'respective' and summative predicates, the operator (= quantifier) can be interpreted non-distributively when it appears outside the coordinate structure in the surface form of the sentence, regardless of whether the sentence involves ordinary coordination or NCC. This turns out to be crucial in the comparison of ellipsis-based and direct coordination analyses of NCC below.

There are, however, several (sometimes quite subtle) pragmatic factors that seem to affect the available interpretations in specific examples (in particular, the distributive reading turns out to be much harder to obtain than the non-distributive reading in many cases). We discuss these factors in what follows, in an attempt to further clarify the interactions of grammatical and non-grammatical factors involved in inducing the patterns that are apparently found in the data. Readers who are willing to accept the generalization in (11) can skip this section by quickly glancing over our key examples (15), (17) and (18) and making sure that the relevant readings are indeed available.

We start with non-DE quantifiers. The examples in (12) involve conjunction (with the a.-examples instantiating constituent coordination and the b.-examples NCC).

(12) a. $\left\{\begin{array}{c}\text{Some minstrel}\\ \text{Every minstrel}\\ \text{Six minstrels}\\ \text{Most minstrels}\end{array}\right\}$ sang and danced. (non-DE, CC, $\wedge$)

[2] Note here that only the right argument of the quantificational determiner is relevant, since we are interested in the properties of quantificational NPs as a whole. Readers who are confused with our terminology should replace our 'downward entailing' with 'right downward entailing/monotone decreasing'.

b. I gave $\left\{\begin{array}{c}\text{a minstrel}\\ \text{every minstrel}\\ \text{six minstrels}\\ \text{most minstrels}\end{array}\right\}$ presents on Thursday and food and wine on Saturday.

(non-DE, NCC, $\wedge$)

Parallel examples with disjunction can be readily constructed (by just replacing *and* with *or* in (12)), but with such examples, it is hard, or sometimes even impossible, to discern the relevant ambiguity, due to the logical equivalence or entailment relations that hold between the two readings ($\exists x P(x) \vee \exists y Q(y) \equiv \exists x[P(x) \vee Q(x)], \forall x P(x) \vee \forall y Q(y) \models \forall x[P(x) \vee Q(x)]$, etc.). Thus, we focus on conjunction here, and assume (by Occam's razor) that the same result carries over to disjunction. With conjunction, the two readings are clearly distinct. For example, the distributive reading for (12a) with *some* should be compatible with a situation in which different minstrels sang and danced, and with *six minstrels*, it should entail a total of maximally 12 (rather than 6) minstrels to be involved. In examples like those above, the distributive reading might seem to be harder to obtain, but this is most likely a pragmatic blocking effect (that is, saying explicitly *Some minstrels sang and some minstrels danced* disambiguates the relevant reading—note here again that repeating the scopal operator in both conjuncts has only the distributive reading, a pattern parallel to the case of symmetrical predicates, etc., from the previous section). In fact, this pragmatic effect can be overridden quite readily with a judicious choice of lexical content:

(13) a. $\left\{\begin{array}{c}\text{A mob boss was}\\ \text{Three mob bosses were}\end{array}\right\}$ assassinated in Boston earlier last month and executed for murder in New York this weekend.

b. I gave $\left\{\begin{array}{c}\text{an exam}\\ \text{three assignments}\end{array}\right\}$ to my advanced calculus seminar on Monday and my basket-weaving class on Thursday.

We thus take it that non-DE quantifiers induce scope ambiguity in coordination in general.

Turning to DE quantifiers such as *no*, *few* and *hardly any*, we see an (apparently) quite different pattern. Ordinary constituent coordination with a DE quantifier in the subject position appears to strongly resist the distributive reading:

(14) a. $\left\{\begin{array}{c}\text{No man}\\ \text{Few men}\\ \text{Hardly any man}\end{array}\right\}$ sang and danced. (DE, CC, $\wedge$)

b. $\left\{\begin{array}{c}\text{No man}\\ \text{Few men}\\ \text{Hardly any man}\end{array}\right\}$ sang or danced. (DE, CC, $\vee$)

However, there is reason to believe that the unavailability of the distributive reading here is not syntactic, for either conjunction or disjunction. We consider the disjunction case first, since the overall pattern is somewhat simpler with disjunction than with conjunction. Consider first the following example:

(15) Your family won't have any trouble getting past the border, as long as no one (either) is caught with a gun, or has left their gun license at home. (DE, CC, $\vee$)

Suppose (15) is uttered by a lawyer advising a family who are crossing the border into a country in which gun ownership is legal, but where guns are regarded as a family possession/responsibility. In this context, (15) is unexceptional in the distributive reading which essentially says that as long as either of the two conditions (no one getting caught; no one leaving their license at home) is satisfied, one is free to cross the border; in other words, for the sentence to be true, it doesn't have to be the case that both conditions are satisfied.[3,4]

Parallel patterns hold for NCC. Cases such as (16) are parallel to (14b) in seemingly resisting the distributive reading robustly:

(16) Terry gave $\left\{\begin{array}{c}\text{no man}\\ \text{few men}\\ \text{hardly any men}\end{array}\right\}$ a book on Friday or a record on Saturday. (DE, NCC, $\vee$)

But again, just a bit of pragmatic manipulation changes the situation dramatically. Suppose the speaker is planning to travel to Berlin, and that the success of the trip is contingent on train transport being available *both* at Düsseldorf and Cologne. Then the following sentence easily allows for the distributive reading:[5]

(17) Deutchebahn is routing no trains to (either) Düsseldorf on Thursday or to Cologne on Friday, but in either case, we won't be able to get to Berlin this week. (DE, NCC, $\vee$)

Thus, careful preparation of the pragmatic ground makes the distributive reading of DE quantifiers surprisingly accessible. This demonstrates that the preference for the non-distributive reading in 'out of the blue' contexts is largely an artifact of assumptions about the discourse background.

Conjunction with DE quantifiers presents an apparently somewhat more complex pattern, since constituent coordination and NCC don't initially seem to behave in a completely parallel fashion. Let us examine constituent coordination first. Examples such as (14a) above seem to rule out a distributive reading for negation. However, as noted by Szabolcsi and Haddican (2004), conjunction under negation in fact allows for the distributive reading much more readily than one might initially be led to believe (note, for example, their examples involving 'stereotypical conjunction', such as *Mary didn't take math and physics* (cf. **Mary didn't take math and hockey*)). The following example illustrates this point:[6]

[3]The distributive reading in addition involves a distinctive prosody, with a marked stress on *caught* and high intonation from that word to the end of the intonation phrase, followed by a slight but distinct pause, ending with moderately emphatic stress on *home*. This sort of specialized intonation is in itself hardly surprising; a distinct prosody is also typically required to enforce distributive readings arising from negated modals in Gapping sentences (see, e.g, Oehrle (1987); Kubota and Levine (2013b)).

[4]The crucial factor that facilitates the distributive reading in this example seems to be the possibility of construing the conjuncts as instantiating what Kehler (2002) refers to as a *Resemblance* relation. When this relation holds between two clauses, the respective propositions they express are manifestations of some common and more general relation that is relevant in the larger discourse. In (15), what is common to the two conjuncts (under the distributive reading) is that they both alone count as sufficient conditions for passing the border without trouble, which is precisely the issue under discussion in the larger context.

[5]Here, the two clauses have a parallel status to the larger discourse (instantiating a Resemblance relation) in that both count equally as a factor that results ('*in either case*') in the eventual failure of the trip.

[6]Here again, what crucially supports the distributive reading seems to be the discourse relation. As Szabolcsi and Haddican (2004) note, one factor that facilitates the distributive reading for conjunction under negation is a 'violation of expectation' type discourse relation, supported by a parallel expectation for

(18) Nobody wants to help spammers and be taken advantage of by hackers, but the reality is, if you don't install the appropriate security software, you are vulnerable to both types of danger. (DE,CC, $\wedge$)

Thus, the constituent coordination case for conjunction is very much like disjunction under negation in that contextual manipulation makes available an apparently unavailable distributive reading.

We see a seemingly different (and initially somewhat surprising) pattern in the NCC case. In NCC examples like (19), it seems that the more easily available interpretation is actually the distributive reading:

(19) I intend to say nothing to Robin on Thursday and to Leslie on Friday. (DE, NCC, $\wedge$)

But in fact, the non-distributive reading is available too, if two nonstructural conditions are satisfied as in the following example (20): on the prosodic side, a marked stress on both *no* and *and*, and on the semantic/pragmatic side, a referentially more specific nominal head, in contrast to the minimally informative *nothing* of (19).[7]

(20) I told NO joke to Robin on Thursday AND to Leslie on Friday. (DE, NCC, $\wedge$)

As Szabolcsi and Haddican (2004, 226) note, a stress on *and* is actually required for the non-distributive reading in NP coordination cases as well:

(21) Mary didn't take hockey AND algebra.

Thus, the initial difficulty of obtaining the non-distributive reading for NCC like (19) is most likely due to the semantic/prosodic factors noted above (note that stressing *and* is not among the most natural prosodies for NCC sentences unlike in NP coordination like (21)).

To summarize the findings in this section, both the distributive and non-distributive readings are in principle available for both DE and non-DE quantifiers, regardless of the type of the conjunction word (disjunction vs. conjunction) and regardless of the type of coordination (constituent coordination vs. NCC).

2.3 Wide-scope modal and negation in Gapping

Finally, Gapping presents an apparently puzzling pattern when they interact with scopal operators such as modal auxiliaries and negation. These data were noted by Siegel (1984) and Oehrle (1987) (the latter attributes the observation to Oehrle (1971)).

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contrasted entities, which then ends up being denied by the negation of the two conjuncts (cf. their minimal pair in (43) and (44) (Szabolcsi and Haddican 2004, 235)). In (18), this common contextual expectation is to keep one's computer secure from external attack, and the sentence asserts of two types of threat that have an equal status in counting as potential violations of this expectation. This parallel violation of expectation again establishes a Resemblance relation between the two conjuncts, supporting the distributive reading.

[7] Pragmatic factors are likely to play a role here too. Not telling a single joke to two different people has a kind of real world plausibility (for example, the two people in question might have completely incompatible senses of humor, so that at least one of them will probably hate the joke, regardless of what it is). But a general determination that, regardless of what one might say, one is not going to say it to *both* Robin and Leslie on different respective days seems quite odd and far more difficult to find a natural context for.

(22) a. Kim didn't play bingo or Sandy sit at home all evening.
b. John can't eat steak and Mary just spam—it's totally unfair.

The most natural reading for these sentences (with default intonation) is one in which the auxiliary scopes over the whole coordinate structure. For (22a), this reading corresponds to the paraphrase 'It's not the case that Kim played bingo or (that) Sandy sat at home all evening', which (via De Morgan's law) is equivalent to the conjunction of two negations. There is, in addition, a reading that can be paraphrased by 'reconstructing' the gapped material in the second conjunct, though getting this distributive reading requires a special prosody, with an exaggerated intonation break following *Sandy*.[8]

Crucially, examples like the following in which the elided material is 'reconstructed' in the gap sites do not have the modal/negation wide-scope interpretations that the Gapping examples in (22) do.

(23) a. Kim didn't play bingo or Sandy didn't sit at home all evening.
b. John can't eat steak and Mary can't just spam.

Just as with the scopal facts with other operators in NCC, the set of interpretations available for the Gapping examples and their supposed non-elliptical sources (under an ellipsis-based analysis) do not coincide here. These facts are initially quite surprising, and indeed pose serious challenges to ellipsis-based analyses of Gapping as we discuss in the next section. We show in Sect. 4 that this scopal pattern falls out from an analysis of Gapping in categorial grammar which takes it as an instance of like-category coordination.

3 The PSG approaches to NCC

3.1 Linearization-Based Ellipsis

The coordination facts noted in the preceding section constitute perhaps the strongest challenge to the assumption characteristic of phrase-structure-based frameworks (such as HPSG and LFG) that the combinatoric units of natural language sentences are hierarchically organized objects defined by context-free PS rules. None of the conjuncts in the data in (1) satisfy the 'gold standard' probes—displacement and pronoun replaceability—which have over the past half-century come be seen as the primary diagnostics of constituency.

Within phrase structure-based theories, by far the most formally well developed approach to this problem is what we will call the LINEARIZATION-BASED ELLIPSIS (LBE) approach to coordination, discussed and developed in Yatabe (2001), Crysmann (2003), Beavers and

[8] See Kubota and Levine (2014b) for a discussion of the role of discourse relations in inducing the distributive reading in Gapping examples. For example, in the following example, the 'same consequence no matter which' type implication seems to establish a parallel relation between the two conjuncts in terms of the larger discourse structure, facilitating the distributive interpretation:

(i) A: Is there any type of food that somebody doesn't eat?
B: (Either) Sandy doesn't eat meat or Kim fish, but it doesn't matter since we're going to prepare vegetarian food.

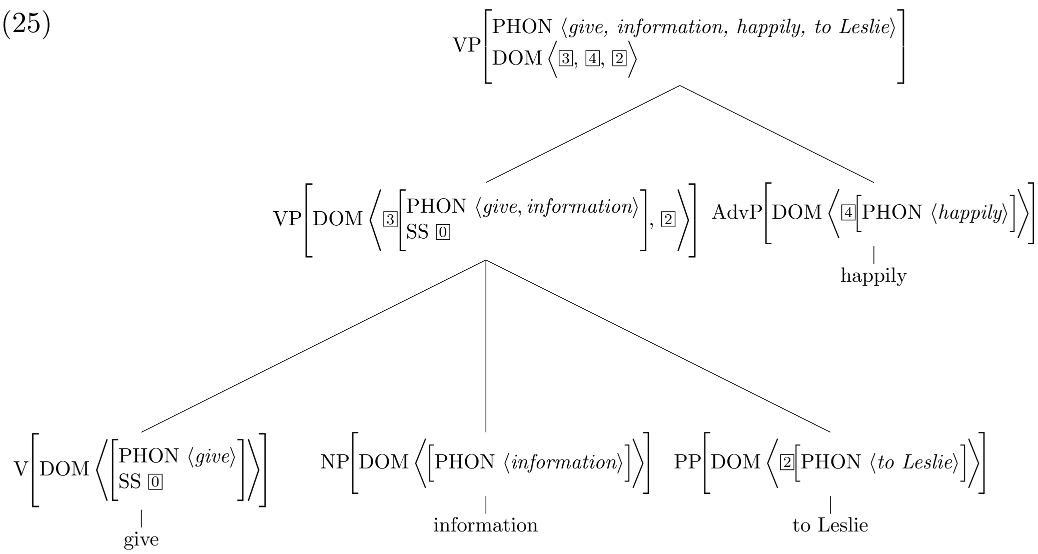
Sag (2004), Chaves (2007), and Sag and Chaves (2008). The central claim of this approach is that apparently non-standard coordinations such as those in (1) all reduce to constituent coordination under prosodic ellipsis.[9] The analysis is technically implemented in a variant of HPSG that relaxes the mapping between the combinatoric structure and the surface string known as Linearization-Based HPSG (Reape 1996; Kathol 1995).[10]

The gist of the Linearization-Based framework involves associating a single combinatoric structure feeding into semantic interpretation with multiple possibilities of surface phonological realization. English exhibits flexibility of word order that this approach is designed to handle to a much more limited degree than languages like German and Japanese, but even in English, it considerably simplifies the analysis of phenomena such as adverb placement:

(24) a. Robin *happily* will give information to Leslie.
b. Robin will *happily* give information to Leslie.
c. Robin will give information *happily* to Leslie.
d. Robin will give information to Leslie *happily*.

In the linearization-based approach, variation in word order exhibited in (24) can be accounted for by formulating constraints on mapping from syntax to phonology such that a single combinatoric structure of the form in (25) is associated with a set of phonological realizations corresponding to the strings in (24).

(25)



[9]Some alternatives to the LBE strategy for dealing with coordination are pursued in Maxwell and Manning (1996), Mouret (2006) and Abeillé et al. (2014), in which noncanonical coordinated strings are taken to reflect actual constituents directly licensed by the grammar. Such approaches consistently fail to provide satisfactory semantic analyses, as acknowledged in Mouret (2006).

[10]This approach has precedent in the 'pheno/tectogrammar' distinction advocated in Curry (1961), and pursued in the context of CG in Dowty (1996b). The core of this proposal is a dramatic separation of prosodic representations, including word order, from syntactic combinatorics, so that, for example, words that are dependents of different subcategorizing heads may nonetheless be adjacent to each other in the surface string, while words that are dependents of the same head be separated from each other by elements subcategorized by a different head. This broad idea has been adopted in the literatures of both HPSG and CG. See Mihaliček (2012) and Kubota (2010, 2014), for a recent application of this technique in the latter.

Unlike phrase structure trees, the tree in (25) does not represent word order as a left-to-right yield of the terminal nodes. The surface pronunciation is instead explicitly encoded in the PHON(OLOGY) feature on each node, and the list-valued DOM feature regulates the way in which the phonology of a mother node is determined based on the phonologies of its daughters. In (25), the verb and the direct object form one unit $\boxed{3}$ (called 'domain object') in the DOM specification of the VP, thus forming an inseparable unit in surface pronunciation. The PP *to Leslie*, on the other hand, forms a domain object by itself, and hence, the adverb *happily* can linearly intervene between the strings *give information* and *to Leslie*, giving rise to a mismatch between combinatoric structure and the surface string realization in (24c).

This kind of architecture potentially allows for a significant mismatch between underlying structure and surface pronunciation. The key idea of the LBE approach is to exploit the flexible mapping between surface form and combinatoric structure in the Linearization-Based setup to technically implement a surface-ellipsis based analysis of non-canonical coordination along the lines of (26) (here and elsewhere, strikeout indicates the material that undergoes ellipsis):

(26) a. [$_S$ I gave Robin a book on Thursday] and [$_S$ ~~(I) gave~~ Leslie a book on Friday].

b. [$_S$ I gave Robin ~~a pair of pliers~~] and [$_S$ Leslie offered Terry, a pair of pliers].

c. [$_S$ Leslie bought a CD], and [$_S$ Robin ~~bought~~ a book].

Since the mapping from the combinatoric structure to the surface string is not one-to-one, it is in principle possible to posit an expression in the underlying structure which does not correspond to an overt string. In the LBE approach, the condition of this surface deletion operation is stated in terms of identity in form to a 'shared' string in the other conjunct. This approach reconciles the mismatch between the overt forms of apparently anomalous coordination in (1) and the null hypothesis of 'like category coordination', but at the expense of faithfully embodying (in a contemporary guise) the key idea of the long-abandoned conjunction reduction analysis from the old transformational literature.

3.2 LBE: major contraindications

3.2.1 Optional Quantifier Merger and quantifier scope

An ellipsis-based analysis of non-canonical coordination along the lines of (26) encounters an immediate empirical challenge in the availability of the non-distributive reading in such non-canonical coordination constructions, as in, for example, (27) (= (16) from the previous section):

(27) Terry gave no man a book on Friday or a record on Saturday.

Assuming LBE automatically imposes, as the null hypothesis, the existence of an exclusive distributive interpretation. In fact, essentially the same point was already made in Partee (1970) with respect to the transformational analysis of similar examples via the operation of Conjunction Reduction, which argued that the nonsynonymy of full and 'conjunction-reduction' versions of sentences containing DE quantifiers was a major flaw of ellipsis-based approaches to coordination in any framework assuming compositionality. There are some sophisticated variants of the LBE approach which attempt to address this issue, as we discuss momentarily. However, as we show below, Partee's arguments still apply to these more elaborate approaches, in that the price that must be paid to evade the problem includes at its core an extremely unattractive assumptions about the syntax/semantics interface.

This point emerges most clearly from Beavers and Sag's (2004) proposal of 'Optional Quantifier Merger' (OQM), a mechanism that is supposed to yield the non-distributive readings for quantifiers in NCC in the LBE approach. As we show below, OQM and similar approaches, such as the proposals in Yatabe (2001, 2012), offer an essentially ad-hoc mechanism that produces the non-distributive reading by fiat, arbitrarily lifting the default compositionality principle just for this purpose. For ease of exposition, we keep the ensuing discussion at a somewhat informal level. Readers who are interested in seeing a more thorough critique of the actual formal analysis presented in Beavers and Sag (2004) are referred to Levine (2011).

Beavers and Sag sketch the content of OQM in the following terms:

(28) Optional Quantifier Merger:
For any elided phrase denoting a generalized quantifier in the domain of either conjunct, the semantics of that phrase may optionally be identified with the semantics of its non-elided counterpart.

The most obvious aspect of this operation is that it is a strikingly ad hoc fix for the marked discrepancy between the default predictions of the LBE analysis on the one hand and the broad array of facts adduced in Sect. 2 on the other. The point can be schematically summarized in (29):

(29)

S
Terry said nothing about Robin on Thursday or
~~(Terry) said nothing~~ about Leslie on Friday;
$\Phi(\lambda x.\textbf{T-said-}x\textbf{-about-R-on-Th} \vee \textbf{T-said-}x\textbf{-about-L-on-Fr})$

S
Terry said nothing about
Robin on Thursday;
$\Phi(\lambda x.\textbf{T-said-}x\textbf{-about-R-on-Th})$

Conj
or

S
Terry said nothing about
Leslie on Thursday;
$\Phi(\lambda x.\textbf{T-said-}x\textbf{-about-L-on-Fr})$

The negated existential operator Φ, which on a strictly compositional account should be represented in the top-level clausal semantics by two separate tokens, instead is merged into one and takes scope over the whole disjunction.[11,12]

[11] Note that when the source clauses in this same structure do not undergo prosodic deletion, as in *Terry said nothing about Robin on Thursday or (Terry) said nothing about Leslie on Friday*, the interpretation in (29) is impossible, and the disjunction necessarily outscopes negation.

[12] One might think that such an operation cannot be formulated, since it involves arbitrarily decomposing and rewriting the formulas that notate the translations of the two clauses. But note that (29) is a simplified notation for an expository purpose only (albeit being highly illustrative of the fundamental problem embodied in OQM). Beavers and Sag (2004) actually implement their analysis in the underspecified semantics

OQM is thus a clear-cut violation of the principle of compositionality. This alone makes it quite suspicious, but one might nonetheless think that, while OQM undeniably violates compositionality on a 'bare-bones' view of the latter, Beavers and Sag (2004) (along with much subsequent HPSG literature) has assumed that constructions themselves may supply extra components of meaning which count in the composition of meaning, and that the disconnection between input and output semantics that Beavers and Sag posit could therefore be attributed to the contribution of the coordination construction itself. But while added constructional effects are assumed to be possible in principle in at least some approaches to meaning in current HPSG, invoking them in connection with OQM does not address the substantive problem, viz., that the specific content of this 'constructional' contribution would still be a hand-written special proviso collapsing the *denotations* of two separate quantifiers in the input clauses just in case there is only a single *phonetic* token of the quantifier. Moreover, this type of non-monotonic (or destructive) construction meaning is unheard of, resembling no other construction-specific meaning proposed in the literature, and, as such, one should be wary of such an operation on methodological grounds.

In addition to this conceptual problem, there is telling morpho-syntactic evidence against any ellipsis-based approach:

(30) I said nothing to Robin on Thursday nor (to) Leslie on Sunday.

For this example, simply recovering the 'elided' material in the second conjunct results in a completely ungrammatical string.[13] Deriving the string in (30) from the grammatical source *I said nothing to Robin on Friday nor did I say anything to Leslie on Sunday* via neg-fronting might seem to be a possibility, but that would involve a host of ad-hoc item-by-item replacements in the mapping from the input structure to the overt form. Finally, if one were to insist that *nor* is a 'prosodic variant' of *or* here, one would have to spell out the exact conditions governing this variation, which is unlikely to be statable in any straightforward way.

It is important to note that, even though OQM is a framework-specific mechanism, it is representative of the kind of solution that one inevitably needs to invoke in an ellipsis-based approach to NCC. By its very nature, ellipsis requires multiple tokens of the elided material in the underlying representation, and when these are (or contain) elements which are scopal, problems arise of exactly the sort that OQM was intended to solve. Given that OQM is a fairly straightforward implementation of a solution for this problem, it seems reasonable to take its failure to be symptomatic of some fundamental analytical flaw of ellipsis-based approaches to NCC in general.[14]

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framework of Minimal Recursion Semantics (Copestake et al. 2005) in which the effect represented in (29) can be encoded. See Levine (2011) for a detailed critique.

[13] An anonymous referee for *L&P* disagrees, noting that (*)*I said nothing to Robin on Thursday nor said nothing to Leslie on Sunday* is acceptable for him/her, suggesting this string as the underlying source for (30). However, the point of our argument is that in many speakers' variants of English (including the second author's), the neg-concord pattern in the referee's example is robustly ill-formed, yet (30) is completely unexceptionable for the same speakers. The fact that the referee accepts this kind of neg-concord example simply means that his/her judgments have no diagnostic consequences for this particular argument.

[14] In fact, a seemingly different approach to the same problem has been proposed by Yatabe (2001, 2012), with a remarkably similar outcome. In a nutshell, Yatabe's approach directly takes prosodic representations of linguistic expressions to be the locus of semantic composition, departing from standard compositionality

3.2.2 *Respectively* and related predicates

As noted in Sect. 2, there is an extensive family of scopal predicates which pattern in parallel fashion in coordination constructions taken to be elliptical under LBE assumptions. Due to space limitations, in the following discussion we focus on the 'respective' readings among these, but essentially the same issue arises with the other two phenomena. We refer the reader to Kubota and Levine (2014e,a) for a more complete discussion on these.

We begin with an evaluation of LBE's empirical implications for examples such as (31) (= (9a)).

(31) I bought and sold a car on Thursday and a bike on Friday, respectively.

As already explained in Sect. 2.1, such examples involve a bijective pairing between the members of a conjunction of predicates on the one hand and a conjunction of nonconstituents sequences each comprising an NP and a temporal PP. In order to account for such data, we must first identify the grammatical origin of this pairing, and here there are in principle two approaches.

On the one hand, we might assume that 'respective' readings are nothing more than a special case of the more general distributive (or cumulative) readings of plurals, where either plural expression may, but need not, be a conjunction. The sentence *700 Dutch companies used 10,000 American computers*, for example, will be true under all mappings of Dutch companies to computers, as long as the total number of Dutch companies involved is 700 and the total number of computers used is 10,000 (the so-called cumulative reading). On this view, 'respective' readings in examples like (32) are just those interpretations in which there is a one-to-one relation between the sets denoted by the two plural terms.

(32) Bill and Tom invited Sue and Anne to the party (respectively).

The bijection requirement is taken to arise either from contextual pragmatic constraints on interpretations or be enforced by the overt adverb *respectively*.

However, this approach does not generalize to examples such as the following:

(33) John and Bill sang and danced (respectively).

As noted in Chaves (2012, 37), cases such as (33), where individuals are mapped not to other individuals but rather to predicates of which they themselves are the arguments cannot be accounted for in terms of the cumulative semantics that might be invoked in the case of examples like (32) (unless one extends the notion of cumulativity in some non-trivial way).

Chaves thus invokes the notion of 'dependent sharing', which is essentially a mechanism that allows a conjoined predicate to take a sum-denoting expression as a syntactic argument, with the semantic effect such that the parts of the conjoined predicate enter into a

principle even more radically. But disregarding the specific implementational details, there is in fact little substantive difference between Yatabe's approach and OQM: the scopal properties of quantifiers and related expressions in NCC does not follow, in any obvious way, from the general architecture of the theory. Rather, much as in Beavers and Sag's account, the what-you-see-is-what-you-get effect is enforced by fiat, via a set of complex conditions embodying a massive amount of sheer coincidentality that are specifically tailored to induce that effect.

predication relation with the parts of the sum-denoting syntactic argument in a 'respective' manner.

The dependent sharing mechanism is directly encoded in the meaning of the conjunction word *and*, which Chaves (re)defines as in (34):

(34) $\lambda P \lambda Q \lambda z_1 \ldots z_n . Q(x_1 \ldots x_n) \wedge P(y_1 \ldots y_n) \wedge z_1 = (x_1 \oplus y_1) \wedge \ldots \wedge z_n = (x_n \oplus y_n)$

With this, (33) receives the following semantic translation (see Chaves (2012) for details):

(35) $\exists e.\, e = (e_1 \oplus e_2) \wedge \mathbf{sang}(x_0)(e_1) \wedge \mathbf{danced}(y_0)(e_2) \wedge (\mathbf{j} \oplus \mathbf{b}) = (x_0 \oplus y_0)$

Here, due to the dependent-sharing mechanism built into the meaning of *and*, the subject NP enters a 'respective' predication relation with the conjoined VP *sang and danced* to induce the desired 'respective' reading.[15]

Chaves' analysis makes explicit the intuition that the 'respective' reading adds a bijective condition to some mapping—invoked either via the cumulative interpretation or by the conjunction operator—between the members of pluralities, a property shared in all contemporary analyses of 'respective' readings including Winter (1995) and Gawron and Kehler (2004).[16]

But an examination of a range of data outside the somewhat restricted dataset analyzed in Chaves (2012) strongly suggests that this approach is not adequate, as seems clear in cases such as (31) (see Kubota and Levine (2014a) for a more thorough discussion on this point). For the cumulative/dependent sharing mechanism to work, it is necessary that either a single predicate take the plural expressions as its (co)arguments as in (32), or that the argument position occupied by the coordinated or summative expression is an *unsaturated* argument position (broadly construed to subsume the displacement-licensing features SLASH and EXTRAP as well) as in (33). But on the LBE approach, neither of these requirements is satisfied in (31): (31) is derived from underlying sources identical in structure to their non-elided counterparts in which the relevant argument positions are already filled *within each conjunct* separately:

(36) I bought and sold a car on Thursday and ~~bought and sold~~ a bike on Friday.

The actual reading observed for (31) does not arise even as a possibility on the semantic inputs to ellipsis displayed in (36). And, for the reasons noted above, neither the dependent sharing mechanism—at least as formulated in (34)—nor the cumulative interpretation mechanism works here. What is related in the respective manner in (9a) is a conjoined

[15] If $x_0 = y_0$ in (34), we obtain the 'strong identity' interpretation (i.e. the standard distributive interpretation), where John and Bill each sang and danced; if the two variables are distinct, we get the 'weak identity' interpretation corresponding to the 'respective' reading as outlined above. The *respectively* operator is supposed to impose a further constraint on the interpretation obtained above, to force the pairings $\mathbf{j} = x_0, \mathbf{b} = y_0$.

[16] Pullum and Gazdar (1982) present an argument against claims of trans-context-freeness for English based on what they showed to be an incorrect analysis of *respectively* based on a one-to-one correspondence between *syntactically* overt members of two coordinate structures. Their argument in no way contraindicates analyses of *respectively* based on matches between denotations of plural expressions which are analyzed as having a list or sum-like structure. Indeed, Gawron and Kehler's (2004) account along these lines, whose key ideas we adopt in our own proposal, explicitly takes Gazdar and Pullum's argument as a point of departure for their own proposal.

predicate and a conjoined dependent cluster. Thus, the relevant mechanism needs to be generalized somehow, but with the underlying source for (31) in (36), it is unclear how this might be done.

As discussed in detail in Kubota and Levine (2014a), the situation is exactly parallel with symmetrical and summative predicates. In short, with these predicates, essentially the same problem arises as in the case of quantifiers when they interact with coordination, but the situation for the LBE approach is worse: currently, there is not even an attempt at fixing the problem.[17]

3.2.3 Wide-scope modal and negation in Gapping

Finally, an ellipsis-based approach fails in the case of Gapping as well, once we extend the dataset from the simplest examples like (1c) above to include more complex examples involving scopal interactions with modals and negation such as the following, repeated from Sect. 2.3.

(37) a. Kim didn't play bingo or Sandy sit at home all evening.
b. John can't eat steak and Mary just spam—it's totally unfair.

For reasons exactly parallel to the cases reviewed above, the availability of the wide-scope readings for modals and negation in Gapping sentences remains a problem for an LBE analysis of Gapping such as Chaves (2005). The default prediction is that only the distributive reading is available, and it is not at all clear how one might go about reconciling this predication with the empirical observation that the non-distributive reading is in fact the more naturally available one.[18]

In view of the foregoing discussion, we must conclude that HPSG (or phrase structure-based approaches more generally) has no viable analysis of coordination. The crucial test cases are ones in which non-canonical coordinations such as NCC and Gapping interact with various scopal phenomena. We have seen that in each case, the LBE approach—virtually the only extant proposal which offers an explicit analysis of the syntax and semantics of

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[17]Importantly, the semantics of these expressions is arguably more complex than that of generalized quantifiers. One property which clearly distinguishes symmetrical, summative and 'respective' predicates from ordinary quantifier is that they can induce multiple dependence with each other, as exemplified by the following data:

(i) a. John and Bill bought the same book at the same store. (on the same day).
b. George and Martha sent a bomb and a nasty letter to the president and the governor respectively.

Moreover, as noted by Barker (2007) (building on Keenan's (1992) formal proof), the compositional semantics of symmetrical predicates extends the expressive power of standard generalized quantification in terms of relations between sets of entities. Given these, extending Beavers and Sag's (2004) OQM strategy (which was originally proposed for quantifiers) to these cases is at the very least not straightforward.

[18]The non-distributive reading for auxiliaries in Gapping poses a significant difficulty not only for deletion-based approaches, but for the so-called interpretive approaches (such as Culicover and Jackendoff (2005)) and construction-based approaches (of the sort proposed by Abeillé et al. (2014)) as well. These approaches obtain the interpretations of Gapping sentences essentially via an anaphoric mechanism, and fail to license the non-distributive reading of auxiliaries precisely for this reason. Culicover and Jackendoff (2005) claim that this is not a problem for their approach, but they do not offer any details of the relevant compositional process. For a critique of Abeillé et al.'s (2014) approach, see Kubota and Levine (2014b).

non-canonical coordinations in phrase structure-based approaches—systematically fails to license the correct interpretations. Partial remedy has been attempted by Beavers and Sag (2004) for the case of quantifier/coordination interaction, but this approach, as we have discussed, is not only conceptually implausible but has a serious empirical problem (cf. the '*nor*' example (30)).

4 Direct licensing of coordination: An alternative in Hybrid Type-Logical Categorial Grammar

In view of the failure of the LBE approach, the direct coordination analysis of NCC (and Gapping) in CG (Steedman 1985; Dowty 1988; Steedman 1990) seems to offer a potentially promising alternative. In this section, we will explore this possibility. We start by reviewing two previous approaches in the CG literature that are respectively equipped with particularly transparent mechanisms for handling coordination and scope-taking phenomena: COMBINATORY CATEGORIAL GRAMMAR (CCG; Ades and Steedman 1982; Steedman 1996, 2000) and LINEAR CATEGORIAL GRAMMAR (LCG; Oehrle 1994; de Groote 2001; Muskens 2003; Pollard 2013). As we discuss below, these two approaches both have their own strengths and weaknesses: CCG is known for its elegant analysis of coordination but turns out to be suboptimal in the analysis of scope-taking phenomena; LCG, on the other hand, offers a particularly transparent analysis of scope-taking phenomena, but it encounters significant difficulties in the analysis of coordination. After reviewing these two alternatives, we present HYBRID TYPE-LOGICAL CATEGORIAL GRAMMAR (Hybrid TLCG; Kubota 2010; Kubota and Levine 2012), a new framework of CG that integrates the key analytic ideas from these two previous approaches. We show that an analysis of coordination in this unified framework predicts exactly the right interactions between non-canonical coordination and various scopal operators reviewed above.

4.1 Previous approaches to coordination and scope-taking in CG

4.1.1 Combinatory Categorial Grammar

CCG is sometimes described as a 'rule-based' extension of the AB grammar, where the latter is the most basic variant of CG consisting of function application alone. Though there are several different variants and extensions, CCG typically consists of rules of TYPE RAISING and FUNCTION COMPOSITION, together with function application. Thus, the following represents a reasonable rule set for a simple CCG fragment:[19]

(38) a. Forward Function Application

$$\frac{\mathsf{a};\ \mathcal{F};\ A/B \quad \mathsf{b};\ \mathcal{G};\ B}{\mathsf{a} \circ \mathsf{b};\ \mathcal{F}(\mathcal{G});\ A}\,\text{FA}$$

b. Backward Function Application

$$\frac{\mathsf{b};\ \mathcal{G};\ B \quad \mathsf{a};\ \mathcal{F};\ B\backslash A}{\mathsf{b} \circ \mathsf{a};\ \mathcal{F}(\mathcal{G});\ A}\,\text{FA}$$

[19] But note that the fragment here is an impoverished version of CCG for an expository purpose only. A linguistically more adequate version of CCG typically involves rules of 'crossed' function composition (for extraction from non-peripheral positions; cf. Steedman 1996) and the so-called 'substitution' rules for the treatment of parasitic gaps (Steedman 1987). We will not discuss these more elaborate rules here since they are not directly relevant for the analysis of coordination.

(39) a. Forward Function Composition

$$\frac{\mathsf{a};\ \boldsymbol{\mathcal{F}};\ A/B \quad \mathsf{b};\ \boldsymbol{\mathcal{G}};\ B/C}{\mathsf{a} \circ \mathsf{b};\ \lambda x.\boldsymbol{\mathcal{F}}(\boldsymbol{\mathcal{G}}(x));\ A/C}\,\mathrm{FC}$$

b. Backward Function Composition

$$\frac{\mathsf{b};\ \boldsymbol{\mathcal{G}};\ C\backslash B \quad \mathsf{a};\ \boldsymbol{\mathcal{F}};\ B\backslash A}{\mathsf{b} \circ \mathsf{a};\ \lambda x.\boldsymbol{\mathcal{F}}(\boldsymbol{\mathcal{G}}(x));\ C\backslash A}\,\mathrm{FC}$$

(40) a. Forward Type Raising

$$\frac{\mathsf{a};\ \boldsymbol{\mathcal{F}};\ A}{\mathsf{a};\ \lambda v.v(\boldsymbol{\mathcal{F}});\ B/(A\backslash B)}\,\mathrm{TR}$$

b. Backward Type Raising

$$\frac{\mathsf{a};\ \boldsymbol{\mathcal{F}};\ A}{\mathsf{a};\ \lambda v.v(\boldsymbol{\mathcal{F}});\ (B/A)\backslash B}\,\mathrm{TR}$$

To facilitate the comparison to other approaches (including ours) below, we adopt a notation where linguistic expressions are written as tuples $\langle \phi, \sigma, \kappa \rangle$ of phonological form (ϕ), semantic translation (σ), and syntactic category (κ). Syntactic rules like those in (38)–(40) above are then formulated in reference to these tuples. We also adopt the 'Lambek' notation of slashes where the argument is always written under the slash. Thus, A/B is a category looking for a B to its right to become an A and $B\backslash A$ is a category looking for a B to its left to become an A (note in particular that the notation is reversed from the standard CCG notation for the backslash \ ).

As noted by Steedman (1985), with type raising and function composition, we can analyze a string of words such as *John loves* as a constituent of type S/NP, that is, an expression that is looking for an NP to its right to become an S:

(41)

$$\frac{\dfrac{\mathsf{john};\ \mathbf{j};\ \mathrm{NP}}{\mathsf{john};\ \lambda f.f(\mathbf{j});\ \mathrm{S/(NP\backslash S)}}\,\mathrm{TR} \quad \mathsf{loves};\ \mathbf{love};\ \mathrm{(NP\backslash S)/NP}}{\mathsf{john} \circ \mathsf{loves};\ \lambda x.\mathbf{love}(\mathbf{j})(x);\ \mathrm{S/NP}}\,\mathrm{FC}$$

Assuming the polymorphic, like-category coordination analysis with syntactic category $(X\backslash X)/X$ for the conjunction word and generalized conjunction (Partee and Rooth 1983) for its semantics, the analysis of RNR sentences such as (42) is then straightforward. The derivation is given in (43) (note the equivalence $\lambda x.P(x) \sqcap \lambda x.Q(x) \equiv \lambda x.P(x) \wedge Q(x)$).

(42) John loves, and Bill hates, Mary.

(43)

$$\frac{\dfrac{\begin{array}{c}\vdots\ \vdots\\ \mathsf{john} \circ \mathsf{loves};\\ \lambda x.\mathbf{love}(\mathbf{j})(x);\mathrm{S/NP}\end{array} \quad \dfrac{\begin{array}{c}\mathsf{and};\\ \sqcap;(X\backslash X)/X\end{array} \quad \begin{array}{c}\vdots\ \vdots\\ \mathsf{bill} \circ \mathsf{hates};\\ \lambda x.\mathbf{hate}(\mathbf{b})(x);\mathrm{S/NP}\end{array}}{\mathsf{and} \circ \mathsf{bill} \circ \mathsf{hates};\ \sqcap(\lambda x.\mathbf{hate}(\mathbf{b})(x));\ \mathrm{(S/NP)\backslash(S/NP)}}\,\mathrm{FA}}{\mathsf{john} \circ \mathsf{loves} \circ \mathsf{and} \circ \mathsf{bill} \circ \mathsf{hates};\ (\lambda x.\mathbf{love}(\mathbf{j})(x)) \sqcap (\lambda x.\mathbf{hate}(\mathbf{b})(x));\ \mathrm{S/NP}}\,\mathrm{FA} \quad \begin{array}{c}\mathsf{mary};\\ \mathbf{m};\mathrm{NP}\end{array}}{\mathsf{john} \circ \mathsf{loves} \circ \mathsf{and} \circ \mathsf{bill} \circ \mathsf{hates} \circ \mathsf{mary};\ \mathbf{love}(\mathbf{j})(\mathbf{m}) \wedge \mathbf{hate}(\mathbf{b})(\mathbf{m});\ \mathrm{S}}\,\mathrm{FA}$$

As discussed by Dowty (1988), this analysis extends straightforwardly to the (slightly) more complex case of dependent cluster coordination (DCC), exemplified by sentences such as the following:

(44) Mary gave Bill the book and John the record.

Since a simpler analysis of DCC becomes possible in the more general CG framework of Type-Logical Categorial Grammar (TLCG) that we present below, we will not go into the details of the CCG analysis of DCC here. We refer the reader instead to Dowty (1988) and Steedman (1996), but the key point is that by first type raising both the direct object *Bill* (to DTV\TV) and the indirect object *the book* (to TV\VP) and then combining them via function composition, we can analyze the string *Bill the book* as a constituent of type DTV\VP, that is, an expression that is looking for a DTV (the syntactic category of *gave*) and an NP to its left to become a sentence (here, DTV, TV and VP are abbreviations for (NP\S)/NP/NP, (NP\S)/NP, and NP\S, respectively). Once this category is assigned to the two conjuncts, the rest of the analysis works exactly the same as in the case of RNR above.

Thus, CCG captures the basic syntax of NCC quite elegantly. Moreover, in principle, the availability of the wide scope reading of shared quantifiers in NCC should not be a problem unlike ellipsis-based approaches like LBE. This is because in the CCG analysis of NCC, non-standard constituents such as *John bought* in (42) and *Bill the book* in (44) are analyzed as full-fledged constituents that are directly coordinated via the conjunction word denoting standard generalized conjunction. Thus, for example, the $\forall > \vee$ reading for the following RNR example is straightforwardly derived as in (46) (here and below, $\mathbf{V_{book}}$ abbreviates the standard generalized quantifier meaning for *every book* $\lambda P.\exists x[\mathbf{book}(x) \wedge P(x)]$; a similar abbreviation is used for existential quantifiers too).

(45) (Either) the department owns, or the library has an interlibrary license to, every single book in the SLAP series.

(46)
$$\dfrac{\begin{array}{l}\vdots \quad \vdots\\ \textsf{the} \circ \textsf{department} \circ \textsf{owns} \circ \textsf{or} \circ \textsf{the} \circ \textsf{library} \circ \textsf{has} \circ \textsf{a} \circ \textsf{license} \circ \textsf{to};\\ \mathbf{own}(\mathbf{d}) \sqcup \mathbf{has\text{-}license}(\mathbf{l}); \mathrm{S/NP}\end{array} \qquad \begin{array}{l}\textsf{every} \circ \textsf{book};\\ \mathbf{V_{book}}; (\mathrm{S/NP})\backslash\mathrm{S}\end{array}}{\begin{array}{l}\textsf{the} \circ \textsf{department} \circ \textsf{owns} \circ \textsf{or} \circ \textsf{the} \circ \textsf{library} \circ \textsf{has} \circ \textsf{a} \circ \textsf{license} \circ \textsf{to} \circ \textsf{every} \circ \textsf{book};\\ \mathbf{V_{book}}(\mathbf{own}(\mathbf{d}) \sqcup \mathbf{has\text{-}license}(\mathbf{l})); \mathrm{S}\end{array}}\mathrm{FA}$$

For this sentence to be true (on the relevant reading), neither the department has to own nor the library has to have access to all the SLAP volumes. It only needs to be the case that one or the other is true of each book in question. The translation obtained in (46) correctly captures these truth conditions.

Things are however not so simple when we consider a wider range of data. First of all, it is unclear how the distributive readings of quantifiers are obtained in CCG. So far as we can tell, this issue remains unaddressed in Steedman (2012), which at the time of writing presents the most comprehensive treatment of quantification in CCG. As discussed in the previous section, the distributive reading is in principle available in both constituent coordination and NCC. Consider, for example, the following example:

(47) (The department used to have a heavy requirement for candidacy. For example, I no longer remember which it was, but) back in those days, every student had to pass at least two language exams or had to write QPs in both syntax and phonology.

In CCG, coordinated VPs are unambiguously of type NP\S and the subject quantifier has category S/(NP\S). Thus, only the weaker $\forall > \vee$ reading is predicted.

It is of course conceivable to extend the rule set of CCG so that the $\vee > \forall$ reading is obtained for (47). In particular, what is needed here is the rule of ARGUMENT RAISING (Hendriks 1993), with which one can derive the $(S/(NP\backslash S))\backslash S$ type from the lower type $NP\backslash S$ for the VP. It should, however, be noted that argument raising is usually not recognized as an admissible rule in standard CCG.[20] Rules such as type raising, function composition, and argument raising are all theorems that can be derived from the more basic rules of inference in the more general, logic-based setup of TLCG (which includes our own approach presented below). One conceptual issue that remains with CCG is that it is not clear what principle determines which of the various theorems provable in TLCG are admitted as 'legal' rules in the rule set of CCG.

There is also an empirical problem. The treatment of scope-taking expressions in CCG, at least the one proposed in Steedman (2012), is limited in its coverage. As discussed by Barker (2007) (based on Keenan's (1992) formal proof), a compositional analysis of symmetrical predicates such as *same* requires a mechanism that goes beyond generalized quantification. In fact, essentially the same problem is found in a much wider empirical domain, as noted briefly above and as argued in more detail in Kubota and Levine (2014a): both 'respective' readings of conjoined expressions and summative predicates such as *a total of* display properties closely resembling that of symmetrical predicates. Kubota and Levine (2014a) develop a unified analysis of these phenomena building on the 'parasitic scope' analysis of symmetrical predicates proposed by Barker (2007). There is currently no explicit analysis of these phenomena in CCG, and if Keenan (1992) and Barker (2007) are right in their key analytic intuitions (which we take it to be the case), this class of phenomena pose a considerable challenge to the tightly constrained, strictly surface-oriented syntax-semantics interface of CCG.

Finally, aside from the problems noted above pertaining to the 'standard' types of NCC (i.e., RNR and DCC), Gapping presents its own quite challenging problem for CCG. As discussed by Kubota and Levine (2012), the analysis of Gapping in CCG by Steedman (1990) predicts only the distributive reading for auxiliaries in examples like those in (22) from the previous section. Space limitations preclude a detailed discussion here, but the nature of the problem is essentially the same as above: the CCG syntax-semantics interface does not allow for a general enough treatment of scope-taking expressions, and this problem becomes particularly apparent when scope-taking expression other than standard generalized quantifiers (such as symmetrical predicates and modal auxiliaries) are taken into account.

Given the issues noted above, we conclude that, despite the elegant analysis of the basic syntax of coordination (whose key insight we will retain in its full form in our own analysis), CCG, at least as it currently stands, does not offer a general enough framework in which to analyze the complex interactions between coordination and scope-taking expressions discussed in the previous section.

4.1.2 Linear Categorial Grammar

The problem that quantification (or scope-taking more generally) poses for CCG essentially stems from the fact that the forward and backward slashes that encode directionality are not the optimal tool for characterizing the mismatch between the surface position of the

[20] We are not sure exactly why, but its exclusion is presumably due to reasons of computational complexity.

quantifier and its semantic scope. In fact, most variants of CG, including the Lambek calculus (Lambek 1958), have essentially the same problem. To cope with this shortcoming, various extensions to the Lambek calculus have been proposed in the TLCG literature (see, e.g., Moortgat 1988; Morrill 1994; Carpenter 1997). We will not review these approaches here since they all involve highly complex mechanisms for reconciling the scope-taking behavior of quantifiers with the fundamentally order-sensitive nature of the Lambek calculus (see Muskens (2003) for a particularly illuminating discussion on this point). Instead, we adopt an altogether different perspective on quantification embodied in a certain line of development in the more recent literature of CG (Oehrle 1994; de Groote 2001; Muskens 2003; Mihaliček and Pollard 2012). We call this family of approaches LINEAR CATEGORIAL GRAMMAR (LCG), and generally follow Pollard (2013) in the following exposition.

Unlike CCG, LCG is a variant of Type-Logical Categorial Grammar (Morrill 1994; Moortgat 1997), which takes the view that syntactic derivations are logical proofs. Following Pollard (2013), we adopt the labelled deduction notation for natural deduction for writing syntactic rules. The underlying logic for LCG is a variant of intuitionistic linear logic, with only one connective for implication. For notational consistency with our own approach, we write this connective with a vertical bar | (and call it VERTICAL SLASH), and write the argument category to the right of the result category. Thus, we write A|B (intuitively, 'if A then B') for what is usually written as $B \multimap A$ in the literature of LCG (and linear logic that it is based on).

Unlike CCG, which recognizes several classes of rules (including at least function application, type raising, and function composition), LCG has only two rules in the grammar: Vertical Slash Introduction and Vertical Slash Elimination. The rules are formulated as in (48):

(48) a. VERTICAL SLASH ELIMINATION

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

b. VERTICAL SLASH INTRODUCTION

$$\dfrac{\dfrac{\begin{array}{ccccccc} \vdots & \vdots & \underline{[\varphi;\ x;\ A]^n} & \vdots & \vdots \\ \vdots & \vdots & \vdots \quad \vdots & \vdots & \vdots \end{array}}{\mathsf{b};\ \boldsymbol{\mathcal{F}};\ B}}{\lambda\varphi.\mathsf{b};\ \lambda x.\boldsymbol{\mathcal{F}};\ B|A}{|\mathrm{I}^n}$$

The Elimination rule is so-called since it eliminates the connective | present in one of the premises. This roughly corresponds to function application in CCG (this point becomes more obvious in the extended calculus of Hybrid TLCG we introduce below, where the Elimination rules for the directional slashes / and \ are in fact exactly the same as the CCG function application rules above). The Introduction rule is so called since it introduces the connective | in the conclusion which is not present in the premise. The combination of the Introduction and Elimination rules does roughly the same work as the more complex rules of function composition and type raising in CCG (again, this becomes more transparent once we introduce the corresponding rules for / and \ ). From a logical perspective, Vertical Slash Elimination (|E) is essentially the rule of MODUS PONENS ($B \to A, B \vdash A$), and Vertical Slash Introduction (|I) is the rule of HYPOTHETICAL REASONING (i.e., concluding $A \to B$ on the basis of a proof of B by hypothetically assuming A).

The key analytical innovation of LCG, which distinguishes it from all other grammatical theories, is that it recognizes λ-binding (and thus functional expressions) not just in the semantic component but also in the prosodic component of linguistic expressions. Note that there is a neat parallel between the semantic and prosodic 'actions' of the two rules in (48): |E does function application in both the semantic component and the prosodic component, whereas |I binds a hypothetically assumed expression by a λ-operator in both semantics and prosody. In the |I rule, the brackets around a premise indicates that it is a hypothesis and the numerical superscript keeps track of where in the whole proof a given hypothesis is withdrawn. The vertical dots around the hypothesis abbreviate an arbitrarily complex proof structure. Thus, (48b) simply means that a hypothesis posited at some previous step in the proof can be withdrawn by |I at any step in the derivation.

Since directionality (or, linear order) is not specified in the slash, in a LCG lexicon, word order is encoded directly in the prosodic forms of the syntactically (and semantically) functional expressions such as verbs (see, for example, the lexical entry for the verb *saw* in the derivation in (49)). The following is a sample derivation for the sentence *John saw Mary*, which contains one technically unnecessary complication added for the sake of exposition:

(49)

$$\dfrac{\dfrac{\dfrac{\mathsf{john};\ \mathbf{j};\ \mathrm{NP} \qquad \dfrac{\lambda\varphi_1\lambda\varphi_2.\varphi_2 \circ \mathsf{saw} \circ \varphi_1;\ \mathbf{saw};\ \mathrm{S|NP|NP} \quad [\varphi; x; \mathrm{NP}]^1}{\lambda\varphi_2.\varphi_2 \circ \mathsf{saw} \circ \varphi;\ \mathbf{saw}(x);\ \mathrm{S|NP}}\,|\mathrm{E}}{\mathsf{john} \circ \mathsf{saw} \circ \varphi;\ \mathbf{saw}(x)(\mathbf{j});\ \mathrm{S}}\,|\mathrm{E}}{\lambda\varphi.\mathsf{john} \circ \mathsf{saw} \circ \varphi;\ \lambda x.\mathbf{saw}(x)(\mathbf{j});\ \mathrm{S|NP}}\,|\mathrm{I}^1 \qquad \mathsf{mary};\ \mathbf{m};\ \mathrm{NP}}{\mathsf{john} \circ \mathsf{saw} \circ \mathsf{mary};\ \mathbf{saw}(\mathbf{m})(\mathbf{j});\ \mathrm{S}}\,|\mathrm{E}$$

The 'unnecessary complication' (or 'detour' in the proof) is the hypothetical assumption of the object NP and its binding via |I at a later step. The sentence could instead be derived by simply combining the verb with the object and subject NPs via |E alone.

But this extra step of hypothetical reasoning illustrates how a 'movement'-like operation can be implemented in CG transparently via λ-binding in the prosodic component (see Muskens (2003) and Mihaliček and Pollard (2012) for a straightforward application of this technique for the analysis of overt, *wh*-movement; see also below and Kubota and Levine (2014b) for an analysis of Gapping that exploits the λ-binding in prosody). In fact, as we show immediately below, this technique of λ-binding in prosody enables a straightforward analysis of quantifier scope (essentially modelling the 'covert movement' of quantifiers in the present logic-based setup), as noted first by Oehrle (1994).

In Oehrle's (1994) analysis of quantification, the quantifier is of type S|(S|NP) and is a function both prosodically and semantically, taking an expression of type S|NP (of the sort derived above) as an argument. The following example illustrates the inverse scope reading for the sentence *Someone talked to everyone yesterday*:

(50)

$$\dfrac{\begin{matrix}\lambda\sigma.\sigma(\mathsf{everyone});\\ \boldsymbol{\forall}_{\mathbf{person}};\\ \mathrm{S}|(\mathrm{S}|\mathrm{NP})\end{matrix} \quad \dfrac{\dfrac{\begin{matrix}\lambda\sigma.\sigma(\mathsf{someone});\\ \boldsymbol{\exists}_{\mathbf{person}};\\ \mathrm{S}|(\mathrm{S}|\mathrm{NP})\end{matrix} \quad \dfrac{\dfrac{\dfrac{\left[\begin{matrix}\varphi_2;\\ y;\\ \mathrm{NP}\end{matrix}\right]^2 \quad \dfrac{\begin{matrix}\lambda\varphi_1\lambda\varphi_2.\\ \varphi_2\circ\mathsf{talked}\circ\mathsf{to}\circ\varphi_1;\\ \mathbf{talked\text{-}to};\mathrm{S}|\mathrm{NP}|\mathrm{NP}\end{matrix} \quad \left[\begin{matrix}\varphi_1;\\ x;\\ \mathrm{NP}\end{matrix}\right]^1}{\begin{matrix}\lambda\varphi_2.\varphi_2\circ\mathsf{talked}\circ\mathsf{to}\circ\varphi_1;\\ \mathbf{talked\text{-}to}(x);\mathrm{S}|\mathrm{NP}\end{matrix}}|\mathrm{E}}{\varphi_2\circ\mathsf{talked}\circ\mathsf{to}\circ\varphi_1;\ \mathbf{talked\text{-}to}(x)(y);\ \mathrm{S}}|\mathrm{E} \quad \begin{matrix}\lambda\varphi.\varphi\circ\mathsf{yesterday};\\ \mathbf{yest};\mathrm{S}|\mathrm{S}\end{matrix}}{\begin{matrix}\varphi_2\circ\mathsf{talked}\circ\mathsf{to}\circ\varphi_1\circ\mathsf{yesterday};\\ \mathbf{yest}(\mathbf{talked\text{-}to}(x)(y));\mathrm{S}\end{matrix}}|\mathrm{E}}{\begin{matrix}\lambda\varphi_2.\varphi_2\circ\mathsf{talked}\circ\mathsf{to}\circ\varphi_1\circ\mathsf{yesterday};\\ \lambda y.\mathbf{yest}(\mathbf{talked\text{-}to}(x)(y));\mathrm{S}|\mathrm{NP}\end{matrix}}|\mathrm{I}^2}{\begin{matrix}\mathsf{someone}\circ\mathsf{talked}\circ\mathsf{to}\circ\varphi_1\circ\mathsf{yesterday};\\ \boldsymbol{\exists}_{\mathbf{person}}(\lambda y.\mathbf{yest}(\mathbf{talked\text{-}to}(x)(y)));\mathrm{S}\end{matrix}}|\mathrm{E}}{\begin{matrix}\lambda\varphi_1.\mathsf{someone}\circ\mathsf{talked}\circ\mathsf{to}\circ\varphi_1\circ\mathsf{yesterday};\\ \lambda x.\boldsymbol{\exists}_{\mathbf{person}}(\lambda y.\mathbf{yest}(\mathbf{talked\text{-}to}(x)(y)));\mathrm{S}|\mathrm{NP}\end{matrix}}|\mathrm{I}^1}{\begin{matrix}\mathsf{someone}\circ\mathsf{talked}\circ\mathsf{to}\circ\mathsf{everyone}\circ\mathsf{yesterday};\\ \boldsymbol{\forall}_{\mathbf{person}}(\lambda x.\boldsymbol{\exists}_{\mathbf{person}}(\lambda y.\mathbf{yest}(\mathbf{talked\text{-}to}(x)(y))));\mathrm{S}\end{matrix}}|\mathrm{E}$$

A quantifier has the ordinary GQ meaning, but its phonology is a function of type (**st** → **st**) → **st** (where **st** is the type of strings). Thus, by abstracting over the position in which the quantifier 'lowers into' in an S, we have an expression of type S|NP (phonologically **st** → **st**) (the $|\mathrm{I}^2$ step), which can be given as an argument to the subject quantifier *someone*. By function application via |E (immediately following $|\mathrm{I}^2$), *someone* then semantically scopes over the sentence and lowers its phonology to the 'gap' position kept track of via |. 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.

This is essentially a formalization of Montague's (1973) quantifying-in, or Quantifier Raising in an LF-based approach (May 1985), but note one subtle but crucial difference from its precursors: unlike the syncategorematic treatment in Montague (1973) or its movement-based analog via structure manipulation operations in derivational approaches, this formalization captures the tight correlation between the semantic and prosodic operations associated with quantification neatly, by modelling both the semantic and prosodic 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; Kubota and Levine 2014a), 'respective' readings (Kubota and Levine 2014a) and the 'split scope' of negative quantifiers (Kubota and Levine 2014b) and modified numerals such as *exactly N* (Pollard 2014).

Thus, so far as scope-taking phenomena are concerned, LCG offers an attractively simple treatment that is at the same time empirically more adequate than directional variants of CG such as CCG and the Lambek calculus. Notwithstanding this advantage, however, LCG has its own, quite serious empirical shortcoming, which has not received sufficient attention in the literature (but see Muskens (2001) for a cursory remark, noting but ultimately dismissing the issue): unlike CCG and the Lambek calculus, in which there is a very simple analysis of coordination extending straightforwardly to NCC, in LCG, coordination becomes an almost intractable problem. Since this is an important empirical issue, we discuss it in some detail in the rest of this section. A more complete and thoroughgoing discussion addressing various partial fixes one might make in LCG, such as adding information about grammatical case (none of which generalizes properly), is found in Moot (2014) (see also Kubota (2010, Sect. 3.2.1)).

The problem can be succinctly illustrated by RNR examples such as the following:

(51) Terry hates, and Leslie likes, Robin.

Suppose we attempt to derive this example in LCG. The derivation in (52) goes through straightforwardly.

(52)
$$\dfrac{\dfrac{\dfrac{\lambda\varphi_1\lambda\varphi_2.\varphi_2 \circ \mathsf{hates} \circ \varphi_1;\ \mathbf{hate};\ \mathrm{S|NP|NP} \quad [\varphi_3; x; \mathrm{NP}]^3}{\lambda\varphi_2.\varphi_2 \circ \mathsf{hates} \circ \varphi_3;\ \mathbf{hate}(x);\ \mathrm{S|NP}} \quad \mathsf{terry};\ \mathbf{t};\ \mathrm{NP}}{\mathsf{terry} \circ \mathsf{hates} \circ \varphi_3;\ \mathbf{hate}(x)(\mathbf{t});\ \mathrm{S}}}{\lambda\varphi_3.\mathsf{terry} \circ \mathsf{hates} \circ \varphi_3;\ \lambda x.\mathbf{hate}(x)(\mathbf{t});\ \mathrm{S|NP}}$$

A parallel derivation yields the category S|NP for *Leslie likes.* But a complication arises at this point, since, unlike in CCG (or in the Lambek calculus), in LCG, the conjuncts do not correspond to strings; they are functional terms of type $\mathsf{st} \to \mathsf{st}$. Thus, they cannot be directly concatenated to form the coordinated string. One might think that assigning the following type of lexical entry for the conjunction *and* (of type $(\mathsf{st} \to \mathsf{st}) \to (\mathsf{st} \to \mathsf{st}) \to (\mathsf{st} \to \mathsf{st})$) would work:

(53) $\lambda\sigma_1\lambda\sigma_2\lambda\varphi.\sigma_2(\boldsymbol{\epsilon}) \circ \mathsf{and} \circ \sigma_1(\varphi);\ \sqcap;\ \mathrm{(S|NP)|(S|NP)|(S|NP)}$

Applying this functor to the two conjuncts indeed yields the following sign for the whole coordinate structure:

(54) $\lambda\varphi.\mathsf{terry} \circ \mathsf{hates} \circ \boldsymbol{\epsilon} \circ \mathsf{and} \circ \mathsf{leslie} \circ \mathsf{likes} \circ \varphi;\ \lambda x.\mathbf{hate}(x)(\mathbf{t}) \wedge \mathbf{like}(x)(\mathbf{r});\ \mathrm{S|NP}$

to which the object NP *Robin* can be given as an argument to complete the derivation.

This analysis, however, overgenerates in a quite serious way. To see this, note that the following can also be derived as a well-formed sign with category S|NP in this type of approach:

(55) $\lambda\varphi_1.\varphi_1 \circ \mathsf{likes} \circ \mathsf{robin};\ \mathbf{like}(\mathbf{r})(x);\ \mathrm{S|NP}$

Conjoining this with the same first conjunct *Terry hates* above yields the following expression:

(56) $\lambda\varphi.\mathsf{terry} \circ \mathsf{hates} \circ \boldsymbol{\epsilon} \circ \mathsf{and} \circ \varphi \circ \mathsf{likes} \circ \mathsf{robin};\ \lambda x.\mathbf{hate}(x)(\mathbf{t}) \wedge \mathbf{like}(\mathbf{r})(x);\ \mathrm{S|NP}$

By giving *Leslie* as an argument to this functor, we have an analysis for the sentence *Terry hates and Leslie likes Robin* to which the meaning 'Terry hates Leslie and Leslie likes Robin' is assigned, which is obviously wrong. The problem, of course, is that what in a directional CG would be two distinct types S/NP and NP\S are, in a non-directional CG, conflated as both instances of S|NP, and therefore there is no apparent way to avoid conjoining *Terry hates* with *likes Robin.*

A problem of essentially the same nature arises with even more basic cases of constituent coordination such as the following:

(57) John caught and ate the fish.

here, too, giving rise to absurd overgeneration. Note that, in LCG, the following two signs are interderivable (hypothesizing an object and subject NPs and withdrawing them in the opposite order derives (58b) from (58a)):

(58) a. $\lambda\varphi_1\lambda\varphi_2.\varphi_2 \circ \mathsf{ate} \circ \varphi_1$; **ate**; S|NP|NP
b. $\lambda\varphi_2\lambda\varphi_1.\varphi_2 \circ \mathsf{ate} \circ \varphi_1$; $\lambda x\lambda y.\mathbf{ate}(y)(x)$; S|NP|NP

Then, a conjunction entry of the following form for coordination of transitive verbs of type S|NP|NP can license (57), at the expense that the analysis predicts that the sentence is ambiguous in all of the four readings in (60).

(59) $\lambda\sigma_1\lambda\sigma_2\lambda\varphi_1\lambda\varphi_2.\varphi_2 \circ \sigma_2(\boldsymbol{\epsilon})(\boldsymbol{\epsilon}) \circ \mathsf{and} \circ \sigma_1(\boldsymbol{\epsilon})(\boldsymbol{\epsilon}) \circ \varphi_1$; $\sqcap$; (S|NP|NP)|(S|NP|NP)|(S|NP|NP)

(60) a. $\mathbf{caught}(\mathbf{j})(\mathbf{the\text{-}fish}) \wedge \mathbf{ate}(\mathbf{j})(\mathbf{the\text{-}fish})$
b. $\mathbf{caught}(\mathbf{j})(\mathbf{the\text{-}fish}) \wedge \mathbf{ate}(\mathbf{the\text{-}fish})(\mathbf{j})$
c. $\mathbf{caught}(\mathbf{the\text{-}fish})(\mathbf{j}) \wedge \mathbf{ate}(\mathbf{j})(\mathbf{the\text{-}fish})$
d. $\mathbf{caught}(\mathbf{the\text{-}fish})(\mathbf{j}) \wedge \mathbf{ate}(\mathbf{the\text{-}fish})(\mathbf{j})$

4.2 Hybrid Type-Logical Categorial Grammar

The above discussion has, we hope, made it clear that neither the purely directional system of CCG nor the purely non-directional system of LCG offers a general enough framework to properly analyze the interactions between coordination and various scopal phenomena reviewed in Sect. 2. In this section, we propose a new framework of CG called Hybrid Type-Logical Categorial Grammar (Hybrid TLCG; Kubota 2010, 2014, to appear; Kubota and Levine 2012, 2013a,b,c, 2014c,b), which integrates these two strands of research in a single framework. After presenting the formal system, we show that this unified framework predicts exactly the right interactions between non-canonical coordination and various scopal operators reviewed above. We have made every effort to make the exposition below as self-contained as possible, but due to space limitations, the presentation is perhaps a bit dense for readers not familiar with the previous CG literature. We refer such readers to Kubota (2010) and Kubota (to appear) for a more leisurely presentation of Hybrid TLCG. Also, for ease of exposition, we relegate some technical details to Appendix A. Formally savvy readers should consult this part if anything is unclear from the exposition in the main text below.

Hybrid TLCG is essentially an extension of the Lambek calculus (Lambek 1958) with one additional, non-directional mode of implication incorporated from LCG. The calculus thus recognizes /, \, and | as three variants of linear implication connective, and there are Introduction and Elimination rules for each of these connectives. See Appendix A for the definition of syntactic types and the functional mappings from syntactic types to semantic and prosodic types.

Since the rules for the nondirectional slash is exactly the same as in LCG, we will not discuss them further here. The rules for directional slashes are formulated in the same way as in the Lambek calculus. The Lambek calculus (and thus Hybrid TLCG which properly contains it) can be thought of as a generalization of the (somewhat simplified) fragment of

CCG presented above. The main conceptual difference is that, instead of positing separate rules for type raising and function composition, we take the forward and backward slashes to be directional variants of implication, each having a status similar to that of the vertical slash within the overall deductive system. The Introduction and Elimination rules for / and \ are formulated as follows:

(61) a. Forward Slash Elimination

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

b. Backward Slash Elimination

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

(62) a. Forward Slash Introduction

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

b. Backward Slash Introduction

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

Some comments are in order here. The connective $\circ$ in the prosodic component designates string concatenation and is associative in both directions (i.e. $(\varphi_1 \circ \varphi_2) \circ \varphi_3 \equiv \varphi_1 \circ (\varphi_2 \circ \varphi_3)$). Thus, if the grammar contained only these rules, it would be essentially equivalent to the (associative) Lambek calculus **L** (Lambek 1958).[21] Importantly, in this labelled deduction formulation, the prosodic 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 (62a) is conditioned on the prosody of the hypothesis φ appearing at the right periphery of the prosody of the input expression. Note in particular that, as in the |I rule, the vertical dots in the /I and \I rules abbreviate any arbitrarily complex proof structure. Thus, unlike in the more standard formulation of the Lambek calculus using the natural deduction format, the hypotheses to be withdrawn in these rules do not need to occupy the right or left periphery in the proof tree itself. Word order is instead explicitly kept track of via the prosodic labelling at each step of the derivation, and the Introduction and Elimination rules correspondingly only make reference to the order of elements in the prosodic forms of the premises and the conclusion (since the rules in (61) and (62) are logical deductive rules, we call the 'input' and 'output' of the rules premise and conclusion). This also means that the left to right order of the two premises in the top line of the Elimination rules in (61) does not play any role. In practice, we often write premises in an order reflecting the actual word order, but only so as to enhance the readability of derivations.

Note that the /I and \I rules are exactly identical to the function application rules in CCG. Type raising and function composition (as well as other theorems; see, e.g., Jäger (2005, Sect. 2.2.5, pp. 46–)) are derivable as theorems in the Lambek calculus from the more basic rules in (61) and (62), taken as axioms. As an illustration, the proofs for (40a) and (39a) are shown in (63) and (64), respectively.

[21] As far as we are aware, Morrill (1994) was the first to recast the Lambek calculus in this labelled deduction format.

(63)
$$\dfrac{\dfrac{\mathsf{a};\ \boldsymbol{\mathcal{F}};\ A \quad [\varphi; v; A\backslash B]^1}{\mathsf{a}\circ\varphi;\ v(\boldsymbol{\mathcal{F}});\ B}\backslash\mathrm{E}}{\mathsf{a};\ \lambda v.v(\boldsymbol{\mathcal{F}});\ B/(A\backslash B)}/\mathrm{I}^1$$

(64)
$$\dfrac{\dfrac{\mathsf{a};\ \boldsymbol{\mathcal{F}};\ A/B \quad \dfrac{\mathsf{b};\ \boldsymbol{\mathcal{G}};\ B/C \quad [\varphi; x; C]^1}{\mathsf{b}\circ\varphi;\ \boldsymbol{\mathcal{G}}(x);\ B}/\mathrm{E}}{\mathsf{a}\circ\mathsf{b}\circ\varphi;\ \boldsymbol{\mathcal{F}}(\boldsymbol{\mathcal{G}}(x));\ A}/\mathrm{E}}{\mathsf{a}\circ\mathsf{b};\ \lambda x.\boldsymbol{\mathcal{F}}(\boldsymbol{\mathcal{G}}(x));\ A/C}/\mathrm{I}^1$$

For linguistic application, the significance of the /I and \I rules is that they permit the reanalysis of any substring of a sentence as a constituent looking for the missing material to become a full-fledged sentence.[22] This enables a straightforward analysis of NCC embodying essentially the same analytic idea as the CCG analysis outlined above.[23] For example, we can analyze the string *John loves* as a constituent of type S/NP, by first assuming an object NP to the right of the verb and then withdrawing the hypothesis after the whole sentence is built (note that, here, we have deliberately placed the object NP hypothesis to the left of the verb in the proof tree, to underscore the fact that, in our notation, the left-to-right order of premises in the proof tree is insignificant for the actual word order):

(65)
$$\dfrac{\dfrac{\mathsf{john};\ \mathbf{j};\ \mathrm{NP} \quad \dfrac{[\varphi; x; \mathrm{NP}]^1 \quad \mathsf{loves};\ \mathbf{love};\ (\mathrm{NP}\backslash\mathrm{S})/\mathrm{NP}}{\mathsf{loves}\circ\varphi;\ \mathbf{love}(x);\ \mathrm{NP}\backslash\mathrm{S}}/\mathrm{E}}{\mathsf{john}\circ\mathsf{loves}\circ\varphi;\ \mathbf{love}(x)(\mathbf{j});\ \mathrm{S}}\backslash\mathrm{E}}{\mathsf{john}\circ\mathsf{loves};\ \lambda x.\mathbf{love}(x)(\mathbf{j});\ \mathrm{S}/\mathrm{NP}}/\mathrm{I}^1$$

The effect we get here is essentially the same as in the CCG analysis sketched above. But note that a general rule of hypothetical reasoning replaces the combination of type raising and function composition in the CCG setup. The rest of the analysis of RNR then goes in exactly the same way as in CCG.

This analysis of RNR immediately extends to DCC. (66) shows the 'reanalysis' of the string *Bill the book* as a derived constituent. This involves hypothesizing a ditransitive verb and withdrawing that hypothesis after a whole VP is formed:

(66)
$$\dfrac{\dfrac{\dfrac{[\varphi; f; \mathrm{VP}/\mathrm{NP}/\mathrm{NP}]^1 \quad \mathsf{bill};\ \mathbf{b};\ \mathrm{NP}}{\varphi\circ\mathsf{bill};\ f(\mathbf{b});\ \mathrm{VP}/\mathrm{NP}}/\mathrm{E} \quad \mathsf{the}\circ\mathsf{book};\ \iota(\mathbf{bk});\ \mathrm{NP}}{\varphi\circ\mathsf{bill}\circ\mathsf{the}\circ\mathsf{book};\ f(\mathbf{b})(\iota(\mathbf{bk}));\ \mathrm{VP}}/\mathrm{E}}{\mathsf{bill}\circ\mathsf{the}\circ\mathsf{book};\ \lambda f.f(\mathbf{b})(\iota(\mathbf{bk}));\ (\mathrm{VP}/\mathrm{NP}/\mathrm{NP})\backslash\mathrm{VP}}\backslash\mathrm{I}^1$$

Then, after like-category coordination, the missing verb and the subject NP are supplied to yield a complete sentence (the last step is omitted):

[22] One might worry about overgeneration; see the discussion at the end of this section and Sect. 4.6.2.

[23] Note that, even though Hybrid TLCG incorporates LCG as its subsystem, the type of overgeneration in LCG in coordination discussed in Sect. 4.1.2 does not arise in Hybrid TLCG. The problem with LCG in a nutshell is that since the system allows for only the vertical slash |, which does not encode linear order, one is forced to specify the conjunction category for functional expressions (such as verbs) in terms of |, losing control over linear order. In Hybrid TLCG (as in CCG), the conjunction category is specified in terms of directional slashes (except for the case of Gapping, which receives a different treatment due to the fact that the 'gap' is medial), and conjunction entries such as (53) and (59) discussed above are not posited.

(67)

$$
\dfrac{
\begin{array}{c}\mathsf{gave};\\ \mathbf{gave};\\ \mathrm{VP/NP/NP}\end{array}
\qquad
\dfrac{
\begin{array}{c}\vdots\quad\vdots\\ \mathsf{bill} \circ \mathsf{the} \circ \mathsf{book};\\ \lambda f.f(\mathbf{b})(\iota(\mathbf{bk}));\\ (\mathrm{VP/NP/NP})\backslash\mathrm{VP}\end{array}
\quad
\dfrac{
\begin{array}{c}\mathsf{and};\\ \lambda\mathcal{W}\lambda\mathcal{V}.\mathcal{V}\sqcap\mathcal{W};\\ (X\backslash X)/X\end{array}
\quad
\begin{array}{c}\vdots\quad\vdots\\ \mathsf{john} \circ \mathsf{the} \circ \mathsf{record};\\ \lambda f.f(\mathbf{j})(\iota(\mathbf{rc}));\\ (\mathrm{VP/NP/NP})\backslash\mathrm{VP}\end{array}
}{
\begin{array}{c}\mathsf{and} \circ \mathsf{john} \circ \mathsf{the} \circ \mathsf{record};\\ \lambda\mathcal{V}.\mathcal{V}\sqcap\lambda f.f(\mathbf{b})(\iota(\mathbf{bk}));\\ ((\mathrm{VP/NP/NP})\backslash\mathrm{VP})\backslash((\mathrm{VP/NP/NP})\backslash\mathrm{VP})\end{array}
}\;/\mathrm{E}
}{
\begin{array}{c}\mathsf{bill} \circ \mathsf{the} \circ \mathsf{book} \circ \mathsf{and} \circ \mathsf{john} \circ \mathsf{the} \circ \mathsf{record};\\ \lambda f.f(\mathbf{j})(\iota(\mathbf{rc}))\sqcap\lambda f.f(\mathbf{b})(\iota(\mathbf{bk})); (\mathrm{VP/NP/NP})\backslash\mathrm{VP}\end{array}
}\;\backslash\mathrm{E}
}{
\mathsf{gave} \circ \mathsf{bill} \circ \mathsf{the} \circ \mathsf{book} \circ \mathsf{and} \circ \mathsf{john} \circ \mathsf{the} \circ \mathsf{record};\ \mathbf{gave}(\mathbf{j})(\iota(\mathbf{rc}))\sqcap\mathbf{gave}(\mathbf{b})(\iota(\mathbf{bk}));\ \mathrm{VP}
}\;\backslash\mathrm{E}
$$

While we focus on the analysis of coordination in the present paper, it should be noted that the flexibility of constituency in CG (including Hybrid TLCG) is motivated by a much wider range of empirical phenomena, including the 'verb clustering' properties of complex predicates in various languages (Steedman 1985; Moortgat and Oehrle 1994; Kubota 2008, 2010), the 'nonconstituent clefting' phenomenon in Japanese discussed in Kubota and Smith (2006); Kubota (2010), and the various 'nonconstituent ellipsis' patterns found in Gapping and pseudogapping (Kubota and Levine 2014b,d).

In particular, the latter case of 'nonconstituent ellipsis' has not received much attention in the literature, but we believe that it constitutes equally important evidence for the notion of flexibility of constituency as the more widely known types of evidence. Note, for example, sentences such as the following:

(68) a. John **wants to try to write** a novel, and Mary, ∅ a play.

b. I'm sure I would **like him to eat** fruit more than I would ∅ cookies.

As discussed in Kubota and Levine (2014b), examples like (68a) pose significant challenges to movement-based analyses of Gapping (such as Johnson (2000)) that assume that the material that goes missing in the second conjunct is a syntactic constituent (in the phrase structure-based sense). Examples like (68b) will likely pose similar problems for current major analyses of pseudogapping such as Jayaseelan (1990) and Lasnik (1999), though we leave a detailed investigation of this issue for a future study. The analyses of Gapping and pseudogapping in Hybrid TLCG (Kubota and Levine 2014b,c) handle cases like those in (68) effortlessly (see also Steedman's (1990) analysis of Gapping). As in transformational approaches, the missing material in these constructions are analyzed as constituents, but the flexible notion of constituency entertained in Hybrid TLCG enables us to analyze the missing strings in these examples as full-fledged constituents via hypothetical reasoning, thereby subsuming these more complex cases directly under the independently motivated basic analyses of Gapping and pseudogapping.

Another question that one might raise at this point is how the flexible notion of constituency generally available in the grammar is properly constrained. There are two aspects to this question. First, even for nonconstituent coordination, just saying that any substring of a sentence can be reanalyzed as a conjoinable constituent is actually an idealization and leads to overgeneration. In the CG setup, there are in principle two types of approach to this issue. We discuss these briefly in Sect. 4.6.2. Second, one might wonder how one can prevent phenomena such as *wh*-movement from targeting such non-standard constituents (e.g. **Who what did John give?*). We take this to be essentially a language-specific constraint about extraction constructions in English.[24] The relevant constraint can be stated quite easily as a restriction on the syntactic category of the extracted expression, encoded in the lexical properties of the operators that trigger extraction phenomena.[25] Thus, the fact that the grammar allows for non-standard constituents does not automatically mean that such constituents are allowed across the board in all grammatical phenomena.[26]

4.3 NCC and quantifier scope

In what follows, we formulate analyses of the empirical facts from Sect. 2 in Hybrid TLCG, starting with the quantifier scope data. To review the relevant facts, we have observed in Sect. 2.2 that all types of quantifiers in principle allow for both the distributive and non-distributive readings in both constituent coordination and NCC. As we show below, this is precisely what is predicted by the present fragment.

Unlike in ellipsis-based approaches, in the CG analysis of NCC, the non-distributive reading is straightforwardly obtained by letting the quantifier scope over the whole coordinate structure, as in the analysis for (69) in (70).

(69) Terry gave a present to Robin on Thursday and to Leslie on Friday.

[24] There indeed seems to be some cross-linguistic variation here. For example, in many Slavic languages, multiple *wh*-fronting is possible (cf., e.g., Rudin 1988), and Japanese allows a nonconstituent clefting construction (Koizumi 2000; Takano 2002; see in particular Kubota and Smith (2006); Kubota (2010) for a CG analysis of nonconstituent clefting).

[25] Note that such syntactic category restrictions need to be specified in extraction constructions anyway, since different types of extraction phenomena allow for slightly different sets of categories as admissible gaps/fillers (for example, APs can be topicalized and fronted in *wh*-questions, but cannot be relativized).

[26] It should already be clear at this point that the criticism that Beavers and Sag (2004) raise for the CCG analysis of NCC do not apply to our approach. Most of Beavers and Sag's criticism is directed at the treatment of coordination and extraction via the same mechanism of directional slashes in CCG. Since our approach employs distinct mechanisms (specifically, directional slashes for the former and the vertical slash for the latter), this part of their criticism does not carry over to our setup. There is, however, one particular issue that Beavers and Sag raise, which does not specifically relate to this identification of extraction and coordination in CCG. Beavers and Sag claim that examples like the following are not derivable in CCG and that this provides an argument for an ellipsis-based analysis of coordination:

(i) Jan travels to Rome tomorrow, to Paris on Friday, and will fly to Tokyo on Sunday.

This is potentially problematic for our approach as well. Beavers and Sag briefly discuss Steedman's proposal of analyzing (i) in terms of an empty conjunction category (conjoining *to Rome tomorrow* and *to Paris on Friday* inside the VP), dismissing it essentially on the basis of the fact that, on such an account, there is no reason that the null conjunction and the higher overt conjunction 'agree' in terms of their semantics (i.e., conjunction vs. disjunction). We do not find this counterargument to be particularly strong. In all examples of the sort of (i) (Beavers and Sag provide a couple more similar examples), the conjuncts stand in a semantically parallel relation to each other, being contrasted with one another in some sense in the larger discourse structure (note, for example, that ??*Jan travels to Rome tomorrow, to Paris on Friday, and will have a nice vacation time in these two places* sounds considerably degraded as compared to (i)). But then, the requirement of semantic matching of the null and overt conjunction independently follows from the discourse/pragmatic considerations.

(70)

$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{[\varphi_1; P; \mathrm{VP/PP/NP}]^1 \quad [\varphi_2; x; \mathrm{NP}]^2}{\varphi_1 \circ \varphi_2;\ P(x);\ \mathrm{VP/PP}}/\mathrm{E} \quad \begin{array}{l}\mathsf{to} \circ \mathsf{robin};\\ \mathbf{r}; \mathrm{PP}\end{array}}{\varphi_1 \circ \varphi_2 \circ \mathsf{to} \circ \mathsf{robin};\ P(x)(\mathbf{r});\ \mathrm{VP}}/\mathrm{E} \quad \begin{array}{l}\mathsf{on} \circ \mathsf{thursday};\\ \mathbf{onTh}; \mathrm{VP\backslash VP}\end{array}}{\varphi_1 \circ \varphi_2 \circ \mathsf{to} \circ \mathsf{robin} \circ \mathsf{on} \circ \mathsf{thursday};\ \mathbf{onTh}(P(x)(\mathbf{r}));\ \mathrm{VP}}\backslash\mathrm{E}}{\varphi_2 \circ \mathsf{to} \circ \mathsf{robin} \circ \mathsf{on} \circ \mathsf{thursday};\ \lambda P.\mathbf{onTh}(P(x)(\mathbf{r}));\ \mathrm{(VP/PP/NP)\backslash VP}}\backslash\mathrm{I}^1}{\mathsf{to} \circ \mathsf{robin} \circ \mathsf{on} \circ \mathsf{thursday};\ \lambda x \lambda P.\mathbf{onTh}(P(x)(\mathbf{r}));\ \mathrm{NP\backslash(VP/PP/NP)\backslash VP}}\backslash\mathrm{I}^2}$$

$$\dfrac{\begin{array}{l}\vdots \quad \vdots\\ \mathsf{to} \circ \mathsf{robin} \circ \mathsf{on} \circ \mathsf{thursday};\\ \lambda x \lambda P.\mathbf{onTh}(P(x)(\mathbf{r}));\\ \mathrm{NP\backslash(VP/PP/NP)\backslash VP}\end{array} \quad \dfrac{\begin{array}{l}\mathsf{and};\\ \lambda \mathcal{V} \lambda \mathcal{W}.\mathcal{W} \sqcap \mathcal{V};\\ (X\backslash X)/X\end{array} \quad \begin{array}{l}\vdots \quad \vdots\\ \mathsf{to} \circ \mathsf{leslie} \circ \mathsf{on} \circ \mathsf{friday};\\ \lambda x \lambda P.\mathbf{onFr}(P(x)(\mathbf{l}));\\ \mathrm{NP\backslash(VP/PP/NP)\backslash VP}\end{array}}{\begin{array}{l}\mathsf{and} \circ \mathsf{to} \circ \mathsf{leslie} \circ \mathsf{on} \circ \mathsf{friday};\\ \lambda \mathcal{W}.\mathcal{W} \sqcap [\lambda x \lambda P.\mathbf{onFr}(P(x)(\mathbf{l}))];\\ \mathrm{(NP\backslash(VP/PP/NP)\backslash VP)\backslash(NP\backslash(VP/PP/NP)\backslash VP)}\end{array}}/\mathrm{E}}{\begin{array}{l}\mathsf{to} \circ \mathsf{robin} \circ \mathsf{on} \circ \mathsf{thursday} \circ \mathsf{and} \circ \mathsf{to} \circ \mathsf{leslie} \circ \mathsf{on} \circ \mathsf{friday};\\ \lambda x \lambda P \lambda z.\mathbf{onFr}(P(x)(\mathbf{l}))(z) \wedge \mathbf{onTh}(P(x)(\mathbf{r}))(z);\\ \mathrm{NP\backslash(VP/PP/NP)\backslash VP}\end{array}}\backslash\mathrm{E}$$

$$\dfrac{\begin{array}{l}\lambda\sigma.\sigma(\mathsf{a} \circ \mathsf{present});\\ \exists_{\mathbf{pr}}; \mathrm{GQ}\end{array} \quad \dfrac{\dfrac{\begin{array}{l}\mathsf{terry};\\ t; \mathrm{NP}\end{array} \quad \dfrac{\begin{array}{l}\mathsf{gave};\\ \mathbf{gave};\\ \mathrm{VP/NP/PP}\end{array} \quad \dfrac{\begin{bmatrix}\varphi_3;\\ x; \mathrm{NP}\end{bmatrix}^3 \quad \begin{array}{l}\vdots \quad \vdots\\ \mathsf{to} \circ \mathsf{robin} \circ \mathsf{on} \circ \mathsf{thursday} \circ\\ \mathsf{and} \circ \mathsf{to} \circ \mathsf{leslie} \circ \mathsf{on} \circ \mathsf{friday};\\ \lambda x \lambda P \lambda z.\mathbf{onFr}(P(x)(\mathbf{l}))(z)\\ \wedge \mathbf{onTh}(P(x)(\mathbf{r}))(z);\\ \mathrm{NP\backslash(VP/PP/NP)\backslash VP}\end{array}}{\begin{array}{l}\varphi_3 \circ \mathsf{to} \circ \mathsf{robin} \circ \mathsf{on} \circ \mathsf{thursday} \circ\\ \mathsf{and} \circ \mathsf{to} \circ \mathsf{leslie} \circ \mathsf{on} \circ \mathsf{friday};\\ \lambda P \lambda z.\mathbf{onFr}(P(x)(\mathbf{l}))(z) \wedge \mathbf{onTh}(P(x)(\mathbf{r}))(z);\\ \mathrm{(VP/PP/NP)\backslash VP}\end{array}}\backslash\mathrm{E}}{\begin{array}{l}\mathsf{gave} \circ \varphi_3 \circ \mathsf{to} \circ \mathsf{robin} \circ \mathsf{on} \circ \mathsf{thursday} \circ \mathsf{and} \circ \mathsf{to} \circ \mathsf{leslie} \circ \mathsf{on} \circ \mathsf{friday};\\ \lambda z.\mathbf{onFr}(\mathbf{gave}(x)(\mathbf{l}))(z) \wedge \mathbf{onTh}(\mathbf{gave}(x)(\mathbf{r}))(z); \mathrm{VP}\end{array}}\backslash\mathrm{E}}{\begin{array}{l}\mathsf{terry} \circ \mathsf{gave} \circ \varphi_3 \circ \mathsf{to} \circ \mathsf{robin} \circ \mathsf{on} \circ \mathsf{thursday} \circ \mathsf{and} \circ \mathsf{to} \circ \mathsf{leslie} \circ \mathsf{on} \circ \mathsf{friday};\\ \mathbf{onFr}(\mathbf{gave}(x)(\mathbf{l}))(t) \wedge \mathbf{onTh}(\mathbf{gave}(x)(\mathbf{r}))(t); \mathrm{S}\end{array}}\backslash\mathrm{E}}{\begin{array}{l}\lambda\varphi_3.\mathsf{terry} \circ \mathsf{gave} \circ \varphi_3 \circ \mathsf{to} \circ \mathsf{robin} \circ \mathsf{on} \circ \mathsf{thursday} \circ \mathsf{and} \circ \mathsf{to} \circ \mathsf{leslie} \circ \mathsf{on} \circ \mathsf{friday};\\ \lambda x.\mathbf{onFr}(\mathbf{gave}(x)(\mathbf{l}))(t) \wedge \mathbf{onTh}(\mathbf{gave}(x)(\mathbf{r}))(t); \mathrm{S|NP}\end{array}}|\mathrm{I}^3}{\begin{array}{l}\mathsf{terry} \circ \mathsf{gave} \circ \mathsf{a} \circ \mathsf{present} \circ \mathsf{to} \circ \mathsf{robin} \circ \mathsf{on} \circ \mathsf{thursday} \circ \mathsf{and} \circ \mathsf{to} \circ \mathsf{leslie} \circ \mathsf{on} \circ \mathsf{friday};\\ \exists_{\mathbf{pr}}(\lambda x.\mathbf{onFr}(\mathbf{gave}(x)(\mathbf{l}))(t) \wedge \mathbf{onTh}(\mathbf{gave}(x)(\mathbf{r}))(t)); \mathrm{S}\end{array}}|\mathrm{E}$$

The key point here is that the string *to Robin on Thursday and to Leslie on Friday* forms a syntactic constituent with a full-fledged meaning assigned to it in the usual way. Then the quantifier takes scope above this whole coordination structure, yielding the non-distributive, quantifier wide-scope interpretation.

The derivation for the distributive reading is a bit more complex. We first illustrate the relevant steps with constituent coordination (71) and then show that the NCC case is treated in essentially the same way.

(71) During the past month, a mob boss was assassinated in Boston and executed in New York.

To see how the distributive reading is derived, note first that a quantifier entry of type S|(S|NP) (with phonological type (**st**→**st**)→**st**) can be converted to a sign with type S/(NP\S) (with a simple string phonology) via a series of inference steps as follows (see Appendix B for a step-by-step 'verbalization' of this proof):

(72)

$$\dfrac{\dfrac{\lambda\sigma.\sigma(\mathsf{a}\circ\mathsf{mob}\circ\mathsf{boss});\ \boldsymbol{\exists}_{\mathbf{mb}};\ \mathrm{S}|(\mathrm{S}|\mathrm{NP}) \qquad \dfrac{\dfrac{[\varphi_1; x; \mathrm{NP}]^1 \quad [\varphi_2; P; \mathrm{NP}\backslash\mathrm{S}]^2}{\varphi_1\circ\varphi_2;\ P(x);\ \mathrm{S}}\backslash\mathrm{E}}{\lambda\varphi_1.\varphi_1\circ\varphi_2;\ \lambda x.P(x);\ \mathrm{S}|\mathrm{NP}}|\mathrm{I}^1}{\mathsf{a}\circ\mathsf{mob}\circ\mathsf{boss}\circ\varphi_2;\ \boldsymbol{\exists}_{\mathbf{mb}}(\lambda x.P(x));\ \mathrm{S}}|\mathrm{E}}{\mathsf{a}\circ\mathsf{mob}\circ\mathsf{boss};\ \lambda P.\boldsymbol{\exists}_{\mathbf{mb}}(\lambda x.P(x));\ \mathrm{S}/(\mathrm{NP}\backslash\mathrm{S})}/\mathrm{I}^2$$

This 'lowered' quantifier entry is identical to the familiar type specification for quantifiers in variants of CG with directional slashes such as CCG.

Once we have this derived entry, the distributive reading is straightforwardly obtained. The derivation involves first lifting the type of the VP to take GQ-type arguments in the subject position and then coordinating such higher-order VPs, to which the quantifier is then given as an argument:

(73)

$$\dfrac{\begin{array}{c}\vdots\ \ \vdots\\ \begin{array}{l}\mathsf{a}\circ\mathsf{mob}\circ\mathsf{boss};\\ \boldsymbol{\exists}_{\mathbf{mb}};\mathrm{S}/\mathrm{VP}\end{array}\end{array} \quad \dfrac{\dfrac{\dfrac{\begin{bmatrix}\varphi;\\ \mathscr{P};\\ \mathrm{S}/\mathrm{VP}\end{bmatrix}^1 \quad \begin{array}{l}\mathsf{was}\circ\mathsf{assassinated}\circ\\ \mathsf{in}\circ\mathsf{boston};\\ \mathbf{ass'd\text{-}in\text{-}b};\mathrm{VP}\end{array}}{\begin{array}{l}\varphi\circ\mathsf{was}\circ\mathsf{assassinated}\circ\\ \mathsf{in}\circ\mathsf{boston};\\ \mathscr{P}(\mathbf{ass'd\text{-}in\text{-}b});\mathrm{S}\end{array}}\backslash\mathrm{E}}{\begin{array}{l}\mathsf{was}\circ\mathsf{assassinated}\circ\\ \mathsf{in}\circ\mathsf{boston};\\ \lambda\mathscr{P}.\mathscr{P}(\mathbf{ass'd\text{-}in\text{-}b});\\ (\mathrm{S}/\mathrm{VP})\backslash\mathrm{S}\end{array}}/\mathrm{I}^1 \quad \dfrac{\begin{array}{l}\mathsf{and};\\ \lambda\mathcal{W}\lambda\mathcal{V}.\mathcal{V}\sqcap\mathcal{W};\\ (X\backslash X)/X\end{array} \quad \begin{array}{c}\vdots\ \ \vdots\\ \begin{array}{l}\mathsf{was}\circ\mathsf{executed}\circ\\ \mathsf{in}\circ\mathsf{ny};\\ \lambda\mathscr{P}.\mathscr{P}(\mathbf{ex'd\text{-}in\text{-}ny});\\ (\mathrm{S}/\mathrm{VP})\backslash\mathrm{S}\end{array}\end{array}}{\begin{array}{l}\mathsf{and}\circ\mathsf{was}\circ\mathsf{executed}\circ\mathsf{in}\circ\mathsf{ny};\\ \lambda\mathcal{V}.\mathcal{V}\sqcap\lambda\mathscr{P}.\mathscr{P}(\mathbf{ex'd\text{-}in\text{-}ny});\\ ((\mathrm{S}/\mathrm{VP})\backslash\mathrm{S})\backslash((\mathrm{S}/\mathrm{VP})\backslash\mathrm{S})\end{array}}/\mathrm{E}}{\begin{array}{l}\mathsf{was}\circ\mathsf{assassinated}\circ\mathsf{in}\circ\mathsf{boston}\circ\mathsf{and}\circ\mathsf{was}\circ\mathsf{executed}\circ\mathsf{in}\circ\mathsf{ny};\\ \lambda\mathscr{P}.\mathscr{P}(\mathbf{ass'd\text{-}in\text{-}b})\sqcap\lambda\mathscr{P}.\mathscr{P}(\mathbf{ex'd\text{-}in\text{-}ny});(\mathrm{S}/\mathrm{VP})\backslash\mathrm{S}\end{array}}\backslash\mathrm{E}}{\begin{array}{l}\mathsf{a}\circ\mathsf{mob}\circ\mathsf{boss}\circ\mathsf{was}\circ\mathsf{assassinated}\circ\mathsf{in}\circ\mathsf{boston}\circ\mathsf{and}\circ\mathsf{was}\circ\mathsf{executed}\circ\mathsf{in}\circ\mathsf{ny};\\ \boldsymbol{\exists}_{\mathbf{mb}}(\mathbf{ass'd\text{-}in\text{-}b})\wedge\boldsymbol{\exists}_{\mathbf{mb}}(\mathbf{ex'd\text{-}in\text{-}ny});\mathrm{S}\end{array}}\backslash\mathrm{E}$$

We call the type of derivation shown in (72) SLANTING, in the sense that an expression involving the vertical slash is converted to one involving 'slanted' (i.e. forward and backward) slashes. As in (72), slanting exploits the hybrid architecture of the present framework in which syntactic inferences involving the vertical slash freely interacts with those involving the forward and backward slashes. See Appendix B for more on slanting.

Since slanting and type-lifting are generally available as theorems for any argument position of a verb, they can be applied to induce the distributive reading for quantifiers that occupy any argument position of a verb (extension to adjunct positions is also straightforward). In the NCC example (69), the quantifier occupies the direct object position of a prepositional ditransitive verb. Thus, the distributive reading for this quantifier can be obtained by lifting the type of this argument position for the verb and slanting the quantifier accordingly. Note that the type of the argument clusters is a bit more complex than in the simpler cases since they are specified to take the slanted quantifier as one of their arguments (so that the quantifier meaning is distributed to each conjunct). The derivation is given in (74). (Here, PTV abbreviates VP/PP; note that we are assuming an 'already slanted' version of the quantifier in (74)—for the derivation of this (PTV/NP)\PTV entry for the quantifier, see (109) in Appendix B.)

(74)

$$
\dfrac{
 \dfrac{
  \dfrac{
   \dfrac{
    \dfrac{
     \left[\begin{array}{l}\varphi_2;\\ P;\mathrm{PTV/NP}\end{array}\right]^2
     \quad
     \left[\begin{array}{l}\varphi_1;\\ \mathscr{P};(\mathrm{PTV/NP})\backslash\mathrm{PTV}\end{array}\right]^1
    }{\varphi_2\circ\varphi_1;\ \mathscr{P}(P);\ \mathrm{PTV}}\,/\mathrm{E}
    \quad
    \begin{array}{l}\mathsf{to}\circ\mathsf{robin};\\ \mathbf{r};\mathrm{PP}\end{array}
   }{\varphi_2\circ\varphi_1\circ\mathsf{to}\circ\mathsf{robin};\ \mathscr{P}(P)(\mathbf{r});\ \mathrm{VP}}\,/\mathrm{E}
   \quad
   \begin{array}{l}\mathsf{on}\circ\mathsf{thursday};\\ \mathbf{onTh};\mathrm{VP}\backslash\mathrm{VP}\end{array}
  }{\varphi_2\circ\varphi_1\circ\mathsf{to}\circ\mathsf{robin}\circ\mathsf{on}\circ\mathsf{thursday};\ \mathbf{onTh}(\mathscr{P}(P)(\mathbf{r}));\ \mathrm{VP}}\,\backslash\mathrm{E}
 }{\varphi_1\circ\mathsf{to}\circ\mathsf{robin}\circ\mathsf{on}\circ\mathsf{thursday};\ \lambda P.\mathbf{onTh}(\mathscr{P}(P)(\mathbf{r}));\ (\mathrm{PTV/NP})\backslash\mathrm{VP}}\,\backslash\mathrm{I}^2
}{\begin{array}{l}\mathsf{to}\circ\mathsf{robin}\circ\mathsf{on}\circ\mathsf{thursday};\\ \lambda\mathscr{P}\lambda P.\mathbf{onTh}(\mathscr{P}(P)(\mathbf{r}));((\mathrm{PTV/NP})\backslash\mathrm{PTV})\backslash(\mathrm{PTV/NP})\backslash\mathrm{VP}\end{array}}\,\backslash\mathrm{I}^1
$$

$$
\dfrac{
 \begin{array}{l}\mathsf{gave};\\ \mathbf{gave};\\ \mathrm{PTV/NP}\end{array}
 \quad
 \dfrac{
  \begin{array}{c}\vdots\quad\vdots\\ \begin{array}{l}\mathsf{a}\circ\mathsf{present};\\ \lambda P\lambda y\lambda z.\mathbf{\exists_{pr}}(\lambda x.P(x)(y)(z));\\ (\mathrm{PTV/NP})\backslash\mathrm{PTV}\end{array}\end{array}
  \quad
  \begin{array}{c}\vdots\quad\vdots\\ \begin{array}{l}\mathsf{to}\circ\mathsf{robin}\circ\mathsf{on}\circ\mathsf{thursday}\circ\\ \mathsf{and}\circ\mathsf{to}\circ\mathsf{leslie}\circ\mathsf{onfriday};\\ \lambda\mathscr{P}\lambda P.\mathbf{onTh}(\mathscr{P}(P)(\mathbf{r}))\sqcap\\ \lambda\mathscr{P}\lambda P.\mathbf{onFr}(\mathscr{P}(P)(\mathbf{l}));\\ ((\mathrm{PTV/NP})\backslash\mathrm{PTV})\backslash(\mathrm{PTV/NP})\backslash\mathrm{VP}\end{array}\end{array}
 }{
  \begin{array}{l}\mathsf{a}\circ\mathsf{present}\circ\mathsf{to}\circ\mathsf{robin}\circ\mathsf{on}\circ\mathsf{thursday}\circ\\ \mathsf{and}\circ\mathsf{to}\circ\mathsf{leslie}\circ\mathsf{onfriday};\\ \lambda P.\mathbf{onTh}(\mathbf{\exists_{pr}}(P)(\mathbf{r}))\sqcap\lambda P.\mathbf{onFr}(\mathbf{\exists_{pr}}(P)(\mathbf{l}));\\ (\mathrm{PTV/NP})\backslash\mathrm{VP}\end{array}
 }
}{
 \begin{array}{l}\mathsf{gave}\circ\mathsf{a}\circ\mathsf{present}\circ\mathsf{to}\circ\mathsf{robin}\circ\mathsf{on}\circ\mathsf{thursday}\circ\mathsf{and}\circ\mathsf{to}\circ\mathsf{leslie}\circ\mathsf{onfriday};\\ \mathbf{onTh}(\mathbf{\exists_{pr}}(\mathbf{gave})(\mathbf{r}))\sqcap\mathbf{onFr}(\mathbf{\exists_{pr}}(\mathbf{gave})(\mathbf{l}));\mathrm{VP}\end{array}
}
$$

Thus, the present approach licenses both distributive and non-distributive readings for quantifiers when they interact with coordination, both in the constituent coordination and NCC cases. We take this to be an empirically correct result. As we discussed in Sect. 2, the apparent difficulty for the distributive reading for DE quantifiers disappears once appropriate contexts are established.[27]

[27] There does nonetheless seem to be an overwhelming preference for the non-distributive readings for DE quantifiers in many cases, especially in 'out of the blue' contexts. We believe that this is a reflection of a much larger generalization about the (preferred) scopal relation between negation (which is part of the meaning of DE quantifiers) and other operators. Specifically, negation tends to resist inverse scope readings in relation to operators that they 'c-command':

(i) a. John didn't talk to every teacher. $(??\forall > \neg)$
b. No student/few students/hardly any student talked to every teacher. (??$\forall>$ *no, few, hardly any*)

Note in particular that ordinary negation exhibits basically the same pattern as DE quantifiers when it interacts with coordination:

(ii) a. Terry didn't say anything to Robin or Leslie. $(\neg > \vee,\ {}^*\vee > \neg)$
b. Terry didn't say anything to Robin on Thursday or to Leslie on Friday. $(\neg > \vee,\ {}^*\vee > \neg)$

At least in the disjunction cases like (ii), the dispreference for the distributive reading is clear in both constituent coordination and NCC. The relative inaccessibility of the distributive reading in such examples most likely results from a complex interaction of multiple factors, one of which is the absence (in ordinary contexts) of the relevant discourse relations (of the sort discussed in Sect. 2) supporting the distributive reading.

4.4 NCC and 'respective' readings

As we have just seen, the interaction between the directional and non-directional slashes plays a crucial role in capturing the scopal interactions between NCC and quantifiers in our analysis. Symmetrical, summative and respective predicates invoke a somewhat more complex interdependence among two (or more) terms that are related to one another in a certain way. It turns out that their interaction with NCC also immediately falls out in our setup once an independently motivated analysis of these phenomena is in place.

In this section, we sketch an analysis of 'respective' readings and show how it interacts with the analysis of NCC presented above to yield the correct readings for the examples discussed in Sect. 2.1. These examples are especially important since, unlike the interactions with generalized quantifiers, there currently does not exist any explicit proposal in the literature that captures the relevant interactions of the empirical phenomena (Chaves (2012) offers a partial attempt, but see Sect. 3.2.2 above and Kubota and Levine (2014a) for a discussion that Chaves's (2012) approach falls far short of the necessary generality). Due to space limitations, we omit a full analysis of 'respective' readings that covers multiple dependency and an extension of the analysis to symmetrical and summative predicates. A complete analysis that covers these two extensions can be found in Kubota and Levine (2014a).

For the basic semantic analysis of 'respective' readings, we adopt Gawron and Kehler's (2004) proposal, except that we cast it in a tuple-based analysis building on ideas explored in Winter (1995) and Bekki (2006), rather than Gawron and Kehler's original (generalized) sum-based analysis. We first illustrate this with the following simple example:

(75) Mary and Sue married John and Bill (respectively).

To assign the right meaning to the sentence, the two pairs (or tuples) $\langle \mathbf{mary}, \mathbf{susan} \rangle$ and $\langle \mathbf{john}, \mathbf{bill} \rangle$ each denoted by the subject and object NPs need to be related to each other in a 'respective' manner with respect to the relation **married**: Mary married John and Susan married Bill. Establishing this 'respective' relation is mediated by the **resp** operator defined as in (76), which takes a relation and two tuple-denoting terms as arguments, and relates each member of the two tuples in the 'respective' manner with respect to the relation in question:[28]

(76) $\mathbf{resp} = \lambda \mathcal{R} \lambda \mathcal{T}_\times \lambda \mathcal{U}_\times . \prod_i^n \mathcal{R}(\pi_i(\mathcal{T}_\times))(\pi_i(\mathcal{U}_\times))$

We assume, following Gawron and Kehler (2004), that the adverb *respectively* denotes this **resp** operator and that the 'respective' readings of sentences without an explicit occurrence of *respectively* are derived via an empty operator having the same denotation as (76).

By assuming that the conjunction forms a tuple:

(77) and; $\lambda \mathcal{W} \lambda \mathcal{V} . \langle \mathcal{V}, \mathcal{W} \rangle$; $(X \backslash X)/X$

resp takes the three arguments identified above to yield the following:

[28] Here, π_i is the standard projection function such that, for example, $\pi_1(\langle a, b \rangle) = a$ and $\pi_2(\langle a, b \rangle) = b$. $\prod_i^n$ is the tuple-forming operator such that $\prod_i^n a_i = \langle a_1, \ldots, a_n \rangle$. We omit the superscript when the cardinality of the tuple is unambiguous.

(78) $\mathbf{resp}(\mathbf{married})(\langle \mathbf{j}, \mathbf{b}\rangle)(\langle \mathbf{m}, \mathbf{s}\rangle) = \prod_i^2 \mathbf{married}(\pi_i(\langle \mathbf{m}, \mathbf{s}\rangle))(\pi_i(\langle \mathbf{j}, \mathbf{b}\rangle))$
$= \langle \mathbf{married}(\mathbf{j})(\mathbf{m}), \mathbf{married}(\mathbf{b})(\mathbf{s})\rangle$

This tuple of two propositions is then mapped to a boolean conjunction via the following phonologically empty operator:

(79) $\lambda \varphi_1.\varphi_1;\ \lambda p.\bigwedge_i \pi_i(p);\ \mathrm{S|S}$

By applying (79) to (78), we obtain the boolean conjunction of the two propositions:

(80) $\bigwedge_i \pi_i(\langle \mathbf{married}(\mathbf{j})(\mathbf{m}), \mathbf{married}(\mathbf{b})(\mathbf{s})\rangle) = \mathbf{married}(\mathbf{j})(\mathbf{m}) \wedge \mathbf{married}(\mathbf{b})(\mathbf{s})$

Though we do not have space here to demonstrate this point explicitly, keeping the two components separate in the form of a tuple after the application of the **resp** operator is crucial for dealing with multiple 'respective' (or symmetrical/summative) readings discussed in footnote 17 (see Kubota and Levine (2014a) for details).

For the syntax-semantics interface, the three arguments of the **resp** operator can be obtained by abstracting over the two positions that the conjoined (or plural) terms occupy in the sentence. (This is necessary for generalizing the analysis to more complex cases where the two terms to be related via the **resp** operator do not happen to be co-arguments of the same predicate.) In Hybrid TLCG, this can be implemented straightforwardly by (two instances of) hypothetical reasoning via the vertical slash, as we show momentarily. Crucially, the interdependence between the two tuples is mediated by double abstraction via | in the syntax, whose output (together with the two tuples themselves) is immediately given to the **resp** operator. This is essentially an implementation of Barker's (2007) analysis of 'parasitic scope'.

The lexical entry for the **resp** operator can then be formulated as follows (note that its phonology is an identity function of type $(\mathsf{st} \to \mathsf{st} \to \mathsf{st}) \to (\mathsf{st} \to \mathsf{st} \to \mathsf{st})$):

(81) $\lambda \sigma_0 \lambda \varphi_1 \lambda \varphi_2.\sigma_0(\varphi_1)(\varphi_2);\ \mathbf{resp};\ (Z|X|Y)|(Z|X|Y)$

and the analysis for (75) goes as in (82):

(82)

$$
\dfrac{
\begin{array}{l}\lambda\varphi_1.\varphi_1;\\ \lambda p.\bigwedge_i \pi_i(p);\\ \mathrm{S|S}\end{array}
\quad
\dfrac{
\begin{array}{l}\vdots \quad \vdots\\ \mathsf{mary} \circ \mathsf{and} \circ\\ \mathsf{sue};\\ \langle \mathbf{m}, \mathbf{s}\rangle; \mathrm{NP}\end{array}
\quad
\dfrac{
\begin{array}{l}\vdots \quad \vdots\\ \mathsf{john} \circ \mathsf{and} \circ\\ \mathsf{bill};\\ \langle \mathbf{j}, \mathbf{b}\rangle; \mathrm{NP}\end{array}
\quad
\dfrac{
\begin{array}{l}\lambda\sigma_0\lambda\varphi_1\lambda\varphi_2.\sigma_0(\varphi_1)(\varphi_2);\\ \mathbf{resp};\\ (Z|X|Y)|(Z|X|Y)\end{array}
\quad
\begin{array}{l}\vdots \quad \vdots\\ \lambda\varphi_3\lambda\varphi_4.\\ \varphi_4 \circ \mathsf{married} \circ \varphi_3;\\ \mathbf{married}; (\mathrm{S|NP})|\mathrm{NP}\end{array}
}{
\begin{array}{l}\lambda\varphi_1\lambda\varphi_2.\varphi_2 \circ \mathsf{married} \circ \varphi_1;\\ \mathbf{resp}(\mathbf{married}); \mathrm{S|NP|NP}\end{array}
}|\mathrm{E}
}{
\begin{array}{l}\lambda\varphi_2.\varphi_2 \circ \mathsf{married} \circ \mathsf{john} \circ \mathsf{and} \circ \mathsf{bill};\\ \mathbf{resp}(\mathbf{married})(\langle \mathbf{j}, \mathbf{b}\rangle); \mathrm{S|NP}\end{array}
}|\mathrm{E}
}{
\begin{array}{l}\mathsf{mary} \circ \mathsf{and} \circ \mathsf{sue} \circ \mathsf{married} \circ \mathsf{john} \circ \mathsf{and} \circ \mathsf{bill};\\ \mathbf{resp}(\mathbf{married})(\langle \mathbf{j}, \mathbf{b}\rangle)(\langle \mathbf{m}, \mathbf{s}\rangle); \mathrm{S}\end{array}
}|\mathrm{E}
}{
\begin{array}{l}\mathsf{mary} \circ \mathsf{and} \circ \mathsf{sue} \circ \mathsf{married} \circ \mathsf{john} \circ \mathsf{and} \circ \mathsf{bill};\\ \mathbf{married}(\mathbf{j})(\mathbf{m}) \wedge \mathbf{married}(\mathbf{b})(\mathbf{s}); \mathrm{S}\end{array}
}|\mathrm{E}
$$

The three syntactic arguments that the 'respective' operator takes (the functor $Z|X|Y$ and its two arguments Y and X) correspond to its three semantic arguments. Thus, in (82), Y and X are instantiated as NP and Z as S. Note that the correct meaning is paired with the surface form of the sentence in this analysis.

The lexical entry for the 'respective' operator is generalized for any type of binary relation, since the two tuple-denoting terms that it relates in the 'respective' manner are not necessarily of type e, as in the more complex example involving NCC such as (83):

(83) I lent *Syntactic Structures* and *Barriers* to John on Wednesday and to Mary on Thursday, respectively.

The only difference from the simpler example (75) above is that, here, one of the conjoined terms given as arguments to the **resp** operator is a conjunction of two 'nonconstituent strings'. Since the polymorphic **resp** operator in (81) is compatible with arguments of any arbitrary type, the analysis is straightforward:

(84)

$$\dfrac{\begin{array}{l}\lambda\varphi_1.\varphi_1;\\ \lambda p.\bigwedge_i \pi_i(p);\\ \mathrm{S}|\mathrm{S}\end{array} \quad \dfrac{\begin{array}{l}\vdots \quad \vdots\\ \mathsf{to} \circ \mathsf{robin} \circ \mathsf{on} \circ \mathsf{thursday} \circ\\ \mathsf{and} \circ \mathsf{to} \circ \mathsf{leslie} \circ \mathsf{on} \circ \mathsf{friday};\\ \langle \lambda x\lambda P\lambda z.\mathbf{onFr}(P(x)(\mathbf{l}))(z),\\ \lambda x\lambda P\lambda z.\mathbf{onTh}(P(x)(\mathbf{r}))(z)\rangle;\\ \mathrm{NP}\backslash(\mathrm{VP}/\mathrm{PP}/\mathrm{NP})\backslash\mathrm{VP}\end{array} \quad \dfrac{\begin{array}{l}\mathsf{ss} \circ\\ \mathsf{and} \circ \mathsf{b};\\ \langle \mathbf{s}, \mathbf{b}\rangle; \mathrm{NP}\end{array} \quad \dfrac{\begin{array}{l}\lambda\sigma_0\lambda\varphi_1\lambda\varphi_2.\\ \sigma_0(\varphi_1)(\varphi_2);\\ \mathbf{resp};\\ (Z|X|Y)|(Z|X|Y)\end{array} \quad \begin{array}{l}\vdots \quad \vdots\\ \lambda\varphi_1\lambda\varphi_2.\mathsf{I} \circ \mathsf{lent} \circ \varphi_1 \circ \varphi_2;\\ \lambda x\lambda f.f(x)(\mathbf{lent})(\mathbf{I});\\ \mathrm{S}|(\mathrm{NP}\backslash(\mathrm{VP}/\mathrm{PP}/\mathrm{NP})\backslash\mathrm{VP})|\mathrm{NP}\end{array}}{\begin{array}{l}\lambda\varphi_1\lambda\varphi_2.\mathsf{I} \circ \mathsf{lent} \circ \varphi_1 \circ \varphi_2;\\ \mathbf{resp}(\lambda x\lambda f.f(x)(\mathbf{lent})(\mathbf{I}));\\ \mathrm{S}|(\mathrm{NP}\backslash(\mathrm{VP}/\mathrm{PP}/\mathrm{NP})\backslash\mathrm{VP})|\mathrm{NP}\end{array}}}{\begin{array}{l}\lambda\varphi_2.\mathsf{I} \circ \mathsf{lent} \circ \mathsf{ss} \circ \mathsf{and} \circ \mathsf{b} \circ \varphi_2;\\ \mathbf{resp}(\lambda x\lambda f.f(x)(\mathbf{lent})(\mathbf{I}))(\langle s, b\rangle);\\ \mathrm{S}|(\mathrm{NP}\backslash(\mathrm{VP}/\mathrm{PP}/\mathrm{NP})\backslash\mathrm{VP})\end{array}}}{\begin{array}{l}\mathsf{I} \circ \mathsf{lent} \circ \mathsf{ss} \circ \mathsf{and} \circ \mathsf{b} \circ \mathsf{to} \circ \mathsf{robin} \circ \mathsf{on} \circ \mathsf{thursday} \circ \mathsf{and} \circ \mathsf{to} \circ \mathsf{leslie} \circ \mathsf{on} \circ \mathsf{friday};\\ \mathbf{resp}(\lambda x\lambda f.f(x)(\mathbf{lent})(\mathbf{I}))(\langle s, b\rangle)\\ (\langle \lambda x\lambda P\lambda z.\mathbf{onFr}(P(x)(\mathbf{l}))(z), \lambda x\lambda P\lambda z.\mathbf{onTh}(P(x)(\mathbf{r}))(z)\rangle); \mathrm{S}\end{array}}}{\begin{array}{l}\mathsf{I} \circ \mathsf{lent} \circ \mathsf{ss} \circ \mathsf{and} \circ \mathsf{b} \circ \mathsf{to} \circ \mathsf{robin} \circ \mathsf{on} \circ \mathsf{thursday} \circ \mathsf{and} \circ \mathsf{to} \circ \mathsf{leslie} \circ \mathsf{on} \circ \mathsf{friday};\\ \mathbf{onTh}(\mathbf{lent}(\mathbf{s})(\mathbf{r}))(\mathbf{I}) \wedge \mathbf{onFr}(\mathbf{lent}(\mathbf{b})(\mathbf{l}))(\mathbf{I}); \mathrm{S}\end{array}}$$

Note that, by assigning full-fledged semantic interpretations to non-canonical constituents like *to Robin on Thursday* directly, the correct interpretation is automatically obtained for the whole sentence via the general analysis of 'respective' readings in a way fully parallel to the more basic case in (82).

4.5 Wide-scope modal and negation in Gapping

The present framework offers a conceptually simple analysis of Gapping in terms of like-category coordination on a par with other types of non-canonical coordination. The only difference is that, in Gapping, the missing material appears medially rather than at peripheral positions. Due to space limitations, we can only sketch the gist of the analysis here, illustrating how it predicts the apparently surprising auxiliary wide scope readings. For a full account of scope ambiguity, a related scope puzzle in determiner gapping (e.g., *No dog eats Whiskas or cat Alpo* ($\neg\exists > \vee$); cf. McCawley (1993); Johnson (2000)), and a comparison with related CG approaches (Oehrle 1987; Steedman 1990; Hendriks 1995; Morrill et al. 2011), the reader is referred to Kubota and Levine (2012, 2014b).

The key analytic intuition behind our analysis is that Gapping involves coordination of two (or more) sentences missing a verb in the middle, of category $\mathrm{S}|(\mathrm{VP}/\mathrm{NP})$ (if the missing verb is transitive). Such an expression can be derived via hypothetical reasoning with the vertical slash in the usual manner:

(85)

$$\dfrac{\dfrac{\lambda\sigma.\sigma(\mathsf{a}\circ\mathsf{book});\ \exists_{\mathbf{book}};\ \mathrm{S}|(\mathrm{S}|\mathrm{NP}) \quad \dfrac{\dfrac{\mathsf{robin};\ \mathbf{r};\ \mathrm{NP} \quad \dfrac{\begin{bmatrix}\varphi_1;\\ P;\mathrm{VP}/\mathrm{NP}\end{bmatrix}^1 \quad \begin{bmatrix}\varphi_2;\\ x;\mathrm{NP}\end{bmatrix}^2}{\varphi_1\circ\varphi_2;\ P(x);\ \mathrm{VP}}/\mathrm{E}}{\mathsf{robin}\circ\varphi_1\circ\varphi_2;\ P(x)(\mathbf{r});\ \mathrm{S}}\backslash\mathrm{E}}{\lambda\varphi_2.\mathsf{robin}\circ\varphi_1\circ\varphi_2;\ \lambda x.P(x)(\mathbf{r});\ \mathrm{S}|\mathrm{NP}}|\mathrm{I}^2}{\mathsf{robin}\circ\varphi_1\circ\mathsf{a}\circ\mathsf{book};\ \exists_{\mathbf{book}}(\lambda x.P(x)(\mathbf{r}));\ \mathrm{S}}|\mathrm{E}}{\lambda\varphi_1.\mathsf{robin}\circ\varphi_1\circ\mathsf{a}\circ\mathsf{book};\ \lambda P.\exists_{\mathbf{book}}(\lambda x.P(x)(\mathbf{r}));\ \mathrm{S}|(\mathrm{VP}/\mathrm{NP})}|\mathrm{I}^1$$

Note that the derived 'gapped' S is of type **st**→**st** prosodically, since the gap position is kept track of via λ-binding in the prosodic component. For coordinating such **st**→**st** functions, we introduce the following Gapping-specific lexical entry for the conjunction (with TV = VP/NP):

(86) $\lambda\sigma_2\lambda\sigma_1\lambda\varphi.\sigma_1(\varphi)\circ\mathsf{and}\circ\sigma_2(\boldsymbol{\epsilon});\ \lambda\mathcal{W}\lambda\mathcal{V}.\mathcal{V}\sqcap\mathcal{W};\ (\mathrm{S}|\mathrm{TV})|(\mathrm{S}|\mathrm{TV})|(\mathrm{S}|\mathrm{TV})$

where $\boldsymbol{\epsilon}$ is the empty string. Syntactically, this is like-category coordination (with $|$), and correspondingly, the semantics is just the standard generalized conjunction. The only slight complication is in the phonology. The output phonology is of the same type **st**→**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 $\boldsymbol{\epsilon}$, capturing the idiosyncrasy of Gapping (where the verb is not pronounced in the second conjunct) via a lexical specification.

With this entry for the conjunction, the sentence *Leslie bought a CD, and Robin, a book* can be analyzed as in (87):

(87)

$$\dfrac{\begin{array}{l}\mathsf{bought};\\ \mathbf{bought};\\ \mathrm{TV}\end{array} \quad \dfrac{\begin{array}{l}\vdots\quad\vdots\\ \lambda\varphi.\mathsf{leslie}\circ\varphi\circ\mathsf{a}\circ\mathsf{CD};\\ \lambda Q.\exists_{\mathbf{cd}}(\lambda y.Q(y)(\mathbf{l}));\\ \mathrm{S}|\mathrm{TV}\end{array} \quad \dfrac{\begin{array}{l}\lambda\sigma_2\lambda\sigma_1\lambda\varphi.\sigma_1(\varphi)\circ\\ \mathsf{and}\circ\sigma_2(\boldsymbol{\epsilon});\\ \lambda\mathcal{W}\lambda\mathcal{V}.\mathcal{V}\sqcap\mathcal{W};\\ (\mathrm{S}|\mathrm{TV})|(\mathrm{S}|\mathrm{TV})|(\mathrm{S}|\mathrm{TV})\end{array} \quad \begin{array}{l}\vdots\quad\vdots\\ \lambda\varphi.\mathsf{robin}\circ\varphi\circ\mathsf{a}\circ\mathsf{book};\\ \lambda P.\exists_{\mathbf{book}}(\lambda x.P(x)(\mathbf{r}));\\ \mathrm{S}|\mathrm{TV}\end{array}}{\begin{array}{l}\lambda\sigma_1\lambda\varphi.\sigma_1(\varphi)\circ\mathsf{and}\circ\mathsf{robin}\circ\boldsymbol{\epsilon}\circ\mathsf{a}\circ\mathsf{book};\\ \lambda\mathcal{V}.\mathcal{V}\sqcap\lambda P.\exists_{\mathbf{book}}(\lambda x.P(x)(\mathbf{r}));(\mathrm{S}|\mathrm{TV})|(\mathrm{S}|\mathrm{TV})\end{array}}|\mathrm{E}}{\begin{array}{l}\lambda\varphi[\mathsf{leslie}\circ\varphi\circ\mathsf{a}\circ\mathsf{CD}\circ\mathsf{and}\circ\mathsf{robin}\circ\boldsymbol{\epsilon}\circ\mathsf{a}\circ\mathsf{book}];\\ \lambda Q.\exists_{\mathbf{cd}}(\lambda y.Q(y)(\mathbf{l}))\sqcap\lambda P.\exists_{\mathbf{book}}(\lambda x.P(x)(\mathbf{r}));\mathrm{S}|\mathrm{TV}\end{array}}|\mathrm{E}}{\begin{array}{l}\mathsf{leslie}\circ\mathsf{bought}\circ\mathsf{a}\circ\mathsf{CD}\circ\mathsf{and}\circ\mathsf{robin}\circ\boldsymbol{\epsilon}\circ\mathsf{a}\circ\mathsf{book};\\ \exists_{\mathbf{cd}}(\lambda y.\mathbf{bought}(y)(\mathbf{l}))\wedge\exists_{\mathbf{book}}(\lambda x.\mathbf{bought}(x)(\mathbf{r}));\mathrm{S}\end{array}}|\mathrm{E}$$

Note that the right meaning is obtained compositionally in this like-category coordination analysis without positing a phonetically empty copy of the verb in the gapped conjunct. This point becomes crucial in the more complex cases involving scopal interactions with auxiliaries, as we show immediately below.

The key to the solution for the surprising wide-scope interpretation for auxiliaries comes from assuming that auxiliaries are scope-taking expressions just like quantifiers. But unlike ordinary GQs (whose distribution is that of an NP), auxiliaries syntactically behave like VP/VP expressions. We thus assign the syntactic category S|(S|(VP/VP)) to auxiliaries to capture the mismatch between its surface syntactic distribution and semantic scope (here, $\mathsf{id}_{et} = \lambda P_{et}.P$):[29]

(88) $\lambda\sigma.\sigma(\mathsf{must});\ \lambda\mathscr{F}.\Box\mathscr{F}(\mathsf{id}_{et});\ \mathrm{S}|(\mathrm{S}|(\mathrm{VP}/\mathrm{VP}))$

Semantically, the auxiliary fills in an identity function to the VP/VP 'trace' it binds, and contributes the modal operator scoping over the whole proposition.

This scopal analysis of auxiliaries enables assigning the **must** $> \exists$ reading for the sentence *Someone must be present (at the meeting)* without assuming that the auxiliary lexically subcategorizes for the subject in the GQ-type:

(89)

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

With this analysis of auxiliaries, the auxiliary wide-scope readings in examples like (90) is straightforward.

(90) John can't eat steak and Mary pizza.

Since both the verb and the auxiliary are gapped in (90), we first conjoin two S|TV expressions in just the same way as in (87) above, and then lower a type VP/NP constituent (formed via hypothetical reasoning) consisting of the verb and the type VP/VP gap position for the auxiliary:

(91)

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

Then, by binding the type VP/VP hypothesis via |, the sentence is of the right type to be given as an argument to the auxiliary, which is lowered to the right position in the first conjunct:

(92)

$$\dfrac{\begin{matrix}\lambda\sigma_0.\sigma_0(\mathsf{can't});\\ \lambda\mathscr{F}.\neg\Diamond\mathscr{F}(\mathsf{id}_{et});\\ \mathrm{S}|(\mathrm{S}|(\mathrm{VP}/\mathrm{VP}))\end{matrix} \quad \dfrac{\begin{matrix}\vdots\quad\vdots\\ \mathsf{john}\circ\varphi_0\circ\mathsf{eat}\circ\mathsf{steak}\circ\mathsf{and}\circ\mathsf{mary}\circ\boldsymbol{\epsilon}\circ\mathsf{pizza};\\ f(\mathbf{eat}(\mathbf{s}))(\mathbf{j})\wedge f(\mathbf{eat}(\mathbf{p}))(\mathbf{m});\mathrm{S}\end{matrix}}{\begin{matrix}\lambda\varphi_0.\mathsf{john}\circ\varphi_0\circ\mathsf{eat}\circ\mathsf{steak}\circ\mathsf{and}\circ\mathsf{mary}\circ\boldsymbol{\epsilon}\circ\mathsf{pizza};\\ \lambda f.[f(\mathbf{eat}(\mathbf{s}))(\mathbf{j})\wedge f(\mathbf{eat}(\mathbf{p}))(\mathbf{m})];\mathrm{S}|(\mathrm{VP}/\mathrm{VP})\end{matrix}}{|\mathrm{I}^0}}{\mathsf{john}\circ\mathsf{can't}\circ\mathsf{eat}\circ\mathsf{steak}\circ\mathsf{and}\circ\mathsf{mary}\circ\boldsymbol{\epsilon}\circ\mathsf{pizza};\ \neg\Diamond[\mathbf{eat}(\mathbf{s})(\mathbf{j})\wedge\mathbf{eat}(\mathbf{p})(\mathbf{m})];\ \mathrm{S}}{|\mathrm{E}}$$

[29]To prevent overgeneration (where the auxiliary scopes out of the local clause in which it occurs), tensed and untensed Ss need to be distinguished via a syntactic feature. See Kubota and Levine (2014b).

Crucially, since the auxiliary takes the coordinated sentence (after the verb is fed to the latter) as its argument, we obtain the auxiliary wide-scope interpretation. Essentially, in the present account, the wide-scope option for the auxiliary in examples like (90) trivially follows from the fact that the (tectogrammatical) syntax of Gapping involves *directly* coordinating sentences with missing elements. Thus, when the missing element is scopal, the prediction is crucially different from the deletion-based and interpretive approaches, which incorrectly predict that only the distributive reading is possible for auxiliaries in such sentences.

Moreover, this analysis of Gapping licenses the distributive reading of auxiliaries straightforwardly too. As discussed in Kubota and Levine (2014b), the S|(S|(VP/VP)) entry for the auxiliary can be lowered to the VP/VP type (with the familiar GPSG/CCG-type semantics for auxiliaries) via slanting in a fashion essentially parallel to the case of quantifiers in (72). Once this alternative entry is derived, the distributive reading is obtained by merely replacing the auxiliary in (92) by this derived entry, which then is given as an argument to the functor S|(VP/VP).

4.6 Overgeneration concerns

4.6.1 Spurious ambiguity and related issues

Unlike more constrained types of CG such as CCG, the present approach allows for unconstrained type lifting (available as theorems in the calculus). One might find this worrisome, especially for parsing-related considerations. One reviewer for the present paper has also noted that the availability of slanting in the grammar adds another level of spurious ambiguity (i.e., the existence of multiple derivations for a given string) on top of its prevalence in other variants of CG (especially TLCG). A related issue arises in connection with this latter point as to why we need the vertical slash to begin with, since if we replace the lexical entries for quantifiers with all the possible slanted entries that are practically needed, then we can capture all the scoping relations of quantifiers in a CCG-like grammar employing only directional slashes. These issues all relate to what one takes to be the right 'form' of linguistic theory and what one takes to be the primary goal of syntactic theorizing. While differences of opinion seems inevitable on such a fundamental issue, we would like to address these points here so as to at least clarify our position.

Regarding the need for the vertical slash, our response essentially is that replacing the single entry for the quantifier S|(S|NP) with the slanted variants misses an important empirical generalization. In such an approach, there is essentially no reason why quantifiers in English are associated with syntactic types such as S/(NP\S) and (S/NP)\S, but not, for example, (NP\S)\S. As discussed in Appendix B, assigning quantifiers in the general S|(S|NP) type and deriving the 'Lambek' entries via slanting automatically excludes the latter possibility. Moreover, | is extensively used in the analyses of more complex empirical phenomena such as 'respective', symmetrical, and summative predicates (see Kubota and Levine (2014a) for a detailed justification for the analysis outlined in Sect. 4.4) and the modal/negation-Gapping interaction (see above and Kubota and Levine 2014b). For these more complex cases, it is currently not clear whether a CCG-like analysis is possible.

Regarding spurious ambiguity, note first that what we are interested in is the theory of human linguistic competence and not that of performance. Spurious ambiguity is already present in most variants of CG (especially TLCG), and, following authors such as Carpenter

(1997), we do not see this as an intrinsic problem for a theory of the competence grammar. Moreover, spurious ambiguity can be eliminated systematically via the standard technique of proof normalization (Hepple 1997). In connection with this, decidability of Hybrid TLCG follows from recent work by Richard Moot (Moot 2014), which shows that Hybrid TLCG can be embedded in first-order linear logic. This means that there is an automatic algorithm for proof normalization for any given proof in Hybrid TLCG. Given these considerations, we think that 'spurious ambiguity' is a spurious issue devoid of actual content.

But one might still think that unconstrained type lifting is an overkill for the grammar of natural language, since decidability is after all a fairly weak result (it only means that the search space is finite; it doesn't guarantee the existence of an efficient parsing algorithm). To such a response, we can only repeat our previous point that our goal here is to characterize the competence grammar. How to construct an efficient parser based on that grammar is a different question (see, for example, Moot (2013) for some initial work on constructing treebanks for TLCG, a first step for wide-coverage efficient parsing). Note in this connection that slanting and general type lifting are crucially exploited in our analysis of distributive readings of quantifiers, and that, as noted in Sect. 4.1.1, CCG currently lacks any systematic account of distributive readings (adding argument raising may have the consequence that its nice computational properties get lost). There is obviously a trade-off between generality of analysis and computational efficiency, but we think that it is a methodological mistake to prioritize the latter over the former when one's goal is to construct a theory of natural language, for which descriptive adequacy is the foremost concern.

4.6.2 Syntactic and semantic islands

One might raise a more general concern about overgeneration with our approach. Note that we have assumed above that the directional slashes are associative as in the Lambek calculus and that there is no constraint on the movement-like mechanism of hypothetical reasoning involving the vertical slash.

Regarding associativity, assuming that any substring of a sentence is a conjoinable constituent in fact overgenerates radically. For example, note that the infamous Dekker's puzzle arises in our setup, just as in the Lambek calculus, overgenerating the following string as a sentence:[30]

(93) *[Bill thinks]$_{\mathrm{S/VP/NP}}$, and [the brother of]$_{\mathrm{S/VP/NP}}$, John walks.

A standard response to this issue in contemporary CG is to control the availability of associativity in the prosodic calculus by the notion of 'multi-modality' (Moortgat and Oehrle

[30] A reviewer notes that our grammar also overgenerates the following string with the interpretation 'five guys left and five girls arrived' (here, Det abbreviations S/(NP\S)/N):

(i) Five [guys left]$_{\mathrm{Det\backslash S}}$ and [girls arrived]$_{\mathrm{Det\backslash S}}$.

We do not see this as an overgeneration. (i) seems quite acceptance with the following intonation:

(ii)		L+H*		L+ H* H−			L+ H*		!H* L-L%
	five	guys	came	in	$\mid$	and	girls	went	out $\|$

1994; Dowty 1996b; Baldridge 2002; Muskens 2007; Kubota 2010). This will, for example, prevent the inference S/S $\vdash$ S/VP/NP (valid in **L**) in the enriched calculus. Hybrid TLCG can be extended along these lines. See Kubota (2010, 2014) for a detailed study of word order-related phenomena found in the domain of complex predicates (including their interaction with coordination) exploiting this technique.

Regarding the so-called 'island constraints', our system does not impose any constraint in the grammar itself to rule out violations of either syntactic islands (for extraction) or semantic islands (for scope taking). As for syntactic islands, current literature suggests that there is independent reason to think that processing, coherence and other functionally-based principles are the source of island effects in the typical extraction contexts (Deane 1991; Kluender 1992, 1998; Kehler 2002; Hofmeister and Sag 2010; Hofmeister et al. 2012a,b).[31]

This leaves only the 'scope islands' as a potential case that our system overgenerates and for which some constraint at the syntax-semantics interface may be called for.[32] For example, Rodman's constraint (Rodman 1976), which prohibits quantifiers to scope out of relative clauses, is pretty robust, and a similarly robust prohibition exists for scoping out of adjuncts:

(94) a. Fido has a bone that is in every corner of the house.
b. If every woman in this room gave birth to John, then he has a nice mother. (Winter 2001)

(94a) has only the strange reading according to which there is a single bone possessed by

[31] Note also that the generality of the hypothetical reasoning mechanism mediating filler-gap dependency in the present setup entails that, unlike CCG (cf. Steedman 1996), the present proposal does not capture the nested dependency constraint (Fodor 1978) as a syntactic constraint, predicting that both of the following two sentences are licensed by the grammar:

(i) a. *Which sonata$_i$ is this violin$_j$ easy to play t_i on t_j?
b. Which violin$_i$ is this sonata$_j$ easy to play t_j on t_i?

But here again, note that there are structurally isomorphic examples that are perfectly acceptable:

(ii) There are certain jokes which$_i$ I always wonder [to whom]$_j$ it's safe to tell t_i t_j.

(iii) You know what$_i$ Robin$_j$ is like t_i to talk to t_j.

The key difference between examples like (ia) and (ii)–(iii) seems to be that in the latter two cases, there is minimal ambiguity in the possible assignment of fillers to gap sites (for example, in the case of (ii), this is facilitated by the distinct syntactic categories of the two filler-gap pairs). Thus, following, e.g., Fodor (1983) and Pollard and Sag (1994), we take the nested dependency constraint to be essentially a processing-oriented condition, one which takes effect only when there is a potential ambiguity in the linking of the fillers and gaps.

[32] A reviewer additionally notes that our approach overgenerates the inverse scope reading for the following sentence:

(i) Someone talked to at least three people yesterday.

We disagree with the reviewer's judgment here. For the second author of this paper, (i) is acceptable on its inverse scope reading (where potentially different individuals are associated with the three or more people in question in the 'talked to' relation). Judgments on inverse scope are often quite subtle, and it is indeed the case that the inverse scope reading is more difficult to obtain than the surface scope reading in general, and in particular in examples like (i). However, we do not take this to be a combinatoric constraint.

Fido that is in every corner of the house (compare: *Fido has a bone in every corner of the house*). Similarly, if the quantifier were able to scope out of the *if*-clause in (94b), the sentence should have a sensible interpretation 'for every woman in the room, it is the case that if she gave birth to John, then John has a nice mother'. However, (94b) has only the nonsensical reading entertaining the possibility that John has multiple mothers giving birth to him.

One point that should be stressed before we speculate on any possible sources for the anomaly in (94) is that the traditional argument that these data provide evidence for the representational treatment of scope via syntactic movement (see, e.g., Winter (2001, 81–84) and Ruys and Winter (2010) for relatively recent arguments of this sort) loses much of its force given that the allegedly parallel syntactic islands can be ameliorated quite readily, as noted by Kluender (1992, 1998), among others:

(95) a. Which article do you need to find someone who can translate __?
b. This is the famous symphony that Schubert died before he was able to finish __.

As noted by Kluender (1998), Complex NP Constraint violation becomes nearly impeccable by increasing the referential specificity of the filler and decreasing that of the material that intervenes the filler and the gap (compare (95a) with ??*What do you need to find the professor who can translate __?*). It does not seem that similar factors such as referential specificity would improve the examples involve semantic, scope islands in (94) (thus, *I need to find someone who can translate every article on set theory written between 1920 and 1940 in Poland into English* seems to resist inverse scope just as robustly as (94a)).

There are two possible lines to take on the issue of scope islands, and at this point we do not want to commit ourselves to either of these, since we believe that, first and foremost, a more thorough empirical study is needed in this domain to clarify the relevant issues. One possibility is obviously to encode these restrictions in the grammar itself. We can build on Pogodalla and Pompigne's (2012) approach for this purpose, which proposes to encode island constraints via the notion of dependent typing in a variant of LCG. But despite the non-parallel between syntactic and semantic islands noted above, it may be too hasty to rule out the possibility for a processing-oriented account of semantic island effects. After all, syntactic and semantic processing pertain to different components of grammar and deal with somewhat different types of abstract representations of linguistic knowledge. Thus, it would be hardly surprising if it turned out that the same type of dependency/configuration presents a much more robust processing difficulty in one domain than the other. Admittedly, this is all still highly speculative and in order to defend the processing account fully, one needs to propose a concrete and independently motivated account of why it is that the semantic island effects tend to be much more robust than syntactic ones. But this is beyond the scope of the present paper and we leave further investigation of this issue to a future study.

5 Conclusion

The present paper offers what we believe is a reasonably comprehensive survey of noncanonical coordinations in English. In particular, we provided an extensive review of empirical data in which these coordination constructions interact with scopal expressions, since these are the cases that crucially tease apart the predictions of two competing approaches to the phenomenon. As we have noted, the empirical patterns observed pose a number of severe challenges to an ellipsis-based analysis of noncanonical coordination in Linearization-Based HPSG, which, at the time of writing, is the most explicit and well-developed analysis of these data in phrase structure-based approaches to syntax. We offered an alternative analysis in Hybrid TLCG, a novel variant of categorial grammar, and showed that the coordination/scope interactions that are problematic for the ellipsis-based approach fall out straightforwardly in our CG-based analysis.

While the TLCG literature has so far tended to focus primarily on metalogical concerns, our approach is unique in that it takes empirical considerations as its starting point. We hope to have shown in this paper that this is a viable and interesting approach. But this is not to deny the importance of metalogical and mathematical considerations. Rather, our point (echoing that of Dowty (1996a)) is that the two should go in tandem. In fact, there is already work in progress which attempt to clarify (from somewhat different angles) the notion of 'hybrid' implication inherent to our system (involving the interaction of directional and non-directional modes of implication), and to provide a more rigorous formal interpretation to it. Moot (2014) shows that Hybrid TLCG can be embedded in first-order linear logic, thereby providing completely explicit formal mathematical underpinnings to it. Decidability and NP-completeness of Hybrid TLCG immediately follow from this result (the latter of which in turn means that, in terms of computational complexity, Hybrid TLCG belongs to the same class as the Lambek calculus and Abstract Categorial Grammar). Worth (2014) investigates the relationship between Hybrid TLCG and LCG, in an attempt at modelling the former in the latter via an extensive use of prosodic subtyping (our critique in Sect. 4.1.2 is directed toward more conservative variants of LCG that are not equipped with such prosodic subtyping). This latter work may clarify the deeper logical properties of the notion of directionality in our system, by re-locating the directionality-related properties (which is encoded via the primitive distinction between / and \ in the current formulation of our system) to a separate prosodic calculus.

In addition to these purely formal issues, our approach opens up many important empirical issues both in relation to existing variants of CG (most importantly, CCG) and in relation to other syntactic theories more generally. We have briefly touched on some of the key questions throughout the paper, especially in Sect. 4.6. In a certain sense, our framework resembles more closely transformational approaches than it does the so-called 'lexicalist' approaches to syntax such as CCG and HPSG (the main difference being that it is formalized much more rigorously than virtually all variants of transformational syntax). But there is one important difference: unlike the standard transformational literature, we do not take island constraints to be syntactic. This results in a grammar which (in our view) is attractively simple in its underlying architecture, but which radically overgenerates the scoping possibilities of quantifiers. The question then is whether independently motivated extra grammatical factors such as pragmatic and processing-oriented constraints and factors pertaining to surface prosodic forms are sufficient to prevent overgeneration. We believe that this is a promising line to take, but the issue is certainly far from settled. We welcome challenges, and hope that our proposal will stimulate vibrant discussion of these fundamental questions.

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A Hybrid TLCG

A.1 Syntactic, semantic and prosodic types

Syntactic types in Hybrid TLCG are defined as follows:

(96) Atomic types include (at least) NP, N and S.

(97) Directional types

a. An atomic type is a directional type.

b. If A and B are directional types, then (A/B) is a directional type.

c. If A and B are directional types, then $(B\backslash A)$ is a directional type.

d. Nothing else is a directional type.

(98) Syntactic types

a. A directional type is a syntactic type.
b. If A and B are syntactic types, then $(A|B)$ is a syntactic type.
c. Nothing else is a syntactic type.

We omit outermost parentheses and 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.

Note that the algebra of syntactic types is *not* a free algebra generated over the set of atomic types with the three binary connectives /, \, and |. Specifically, given the definitions in (96)–(98), in Hybrid TLCG, a vertical slash cannot occur 'under' a directional slash. Thus, S/(S|NP) is not a well-formed syntactic type.

The functions Sem and Pros, which map syntactic types to semantic and prosodic types, can be defined as follows:

(99) a. For atomic syntactic types,
$\mathsf{Sem}(\mathrm{NP}) = e$, $\mathsf{Sem}(\mathrm{S}) = t$, $\mathsf{Sem}(\mathrm{N}) = e \to t$
b. For complex syntactic types,
$\mathsf{Sem}(A/B) = \mathsf{Sem}(B\backslash A) = \mathsf{Sem}(A|B) = \mathsf{Sem}(B) \to \mathsf{Sem}(A)$.

(100) a. For any directional type A, $\mathsf{Pros}(A) = \mathbf{st}$ (with **st** for 'strings').
b. For any complex syntactic type $A|B$ involving the vertical slash |,
$\mathsf{Pros}(A|B) = \mathsf{Pros}(B) \to \mathsf{Pros}(A)$.

Note in particular that, corresponding to the asymmetry between /, \, and | in the definition of syntactic types, the two types of slashes behave differently in the mapping from syntactic to prosodic types. Specifically, for the mapping from syntactic types to prosodic types, only the vertical slash | is effectively interpreted as functional. Thus, for example, $\mathsf{Sem}(\mathrm{S}|(\mathrm{S}/\mathrm{NP})) = (e \to t) \to t$ whereas $\mathsf{Pros}(\mathrm{S}|(\mathrm{S}/\mathrm{NP})) = \mathbf{st} \to \mathbf{st}$.

The prosodic calculus is a λ-calculus with constants of type **st** (which includes ordinary string phonologies such as john, walks, etc., and the empty string ϵ) and a binary connective $\circ$ for string concatenation. In addition to beta equivalence, the following axioms hold in the prosodic calculus:

(101) a. $\epsilon \circ a \equiv a$ (left identity)
b. $a \circ \epsilon \equiv a$ (right identity)

(102) $a \circ (b \circ c) \equiv (a \circ b) \circ c$ (associativity)

In the derivations, we omit parentheses for $\circ$ and implicitly assume associativity.

A.2 Sample lexicon

(103) a. john; **j**; NP
b. mary; **m**; NP
c. walks; **walk**; NP\S
d. loves; **love**; (NP\S)/NP
e. $\lambda\sigma.\sigma(\mathsf{everyone})$; $\mathbf{\forall_{person}}$; S|(S|NP)
f. $\lambda\varphi\lambda\sigma.\sigma(\mathsf{every} \circ \varphi)$; $\mathbf{\forall}$; S|(S|NP)|N
g. $\lambda\sigma.\sigma(\mathsf{must})$; $\lambda\mathscr{F}.\Box\mathscr{F}(\mathsf{id}_{et})$; S|(S|(VP/VP))
(where $\mathsf{id}_{et} = \lambda P_{et}.P$)

For strings in prosodic representations we use sans-serif; semantic constants are written in **bold face**; for prosodic variables we use Greek letters $\varphi_1, \varphi_2, \ldots$ (type **st** for string); $\sigma_1, \sigma_2, \ldots$ (type $\mathbf{st}\to\mathbf{st}$, $\mathbf{st}\to\mathbf{st}\to\mathbf{st}$, etc.); $\tau_1, \tau_2, \ldots$ (type $(\mathbf{st}\to\mathbf{st})\to\mathbf{st}$, etc.) and for semantic variables roman italics (x, y, z, p, q ...); calligraphic letters ($\mathcal{U}, \mathcal{V}, \mathcal{W}, \ldots$) are invariably used for variables with polymorphic types and copperplate letters ($\mathscr{P}, \mathscr{Q}, \ldots$) for higher-order variables.

A.3 Syntactic rules

A.3.1 Logical rules

(104)

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

All of the three slashes are linear. That is, the three connectives can bind only one occurrence of a hypothesis at a time. Note also that the prosodic labels in Hybrid TLCG are not proof terms, but rather are used for the purpose of narrowing down the set of possible derivations. Specifically, the applicability of the Introduction rule for / (\) is conditioned by the presence of the variable φ at the right (left) periphery in the phonology of the premise.

A.3.2 Non-logical rule

(105) P-interface rule

$$\frac{\varphi_0; \boldsymbol{\mathcal{F}}; A}{\varphi_1; \boldsymbol{\mathcal{F}}; A}\mathrm{PI}$$

(where φ_0 and φ_1 are equivalent terms in the prosodic calculus)

The P-interface rule is the analog of the structural rules (or interaction postulates) in the more standard variants of TLCG (Morrill 1994; Moortgat 1997). This rule is used for applying beta-reduction to prosodic terms obtained by function application via the |E rule. In practice, we often omit explicitly writing the application of this rule to avoid cluttering the derivations.

One way to understand the (apparent) asymmetry between the |I rule and the /I and \I rules as formulated above in terms of the explicit presence of λ-binding in the prosodic component in the former but not in the latter two is to think of the /I and \I rules as abbreviations of the following proof steps:

(106)

$$\cfrac{\cfrac{\cfrac{\begin{matrix}\vdots\;\vdots & \underline{[\varphi; x; A]^n} & \vdots\;\vdots\\ \vdots\;\vdots & \vdots\;\vdots & \vdots\;\vdots\end{matrix}}{b \circ \varphi; \boldsymbol{\mathcal{F}}; B}}{\lambda_{\mathsf{r}}\varphi.[b \circ \varphi](\epsilon); \lambda x.\boldsymbol{\mathcal{F}}; B/A}/\mathrm{I}^n}{b; \lambda x.\boldsymbol{\mathcal{F}}; B/A}\mathrm{PI}$$

That is, there is actually lambda binding (by 'left' and 'right' lambdas) in the prosody in the /I and \I rules, but the functional lambda terms obtained are immediately applied to an empty string to 'close off' the gap. Thus, the /I and \I rules are not so different from the |I rule after all, but the key difference is that, unlike the |I rule, the /I and \I rules are immediately followed by an obligatory application to an empty string, so that a string phonology rather than a functional phonology is obtained.

B Slanting

As discussed in Sect. 4.3, an operation (or a family of theorems) called Slanting plays a crucial role in deriving entries of quantifiers that are used in licensing distributive readings of quantifiers in coordination examples. We reproduce here the slanting derivation for the subject position quantifier (107) (= (72)), together with two more cases, one for the object position for transitive verbs (108) and the other for the direct object position of prepositional ditransitive verbs (109) (the latter is used in the derivation of the distributive reading for an NCC example in (74)).

(107)

$$\dfrac{\dfrac{\lambda\sigma.\sigma(\mathsf{a}\circ\mathsf{mob}\circ\mathsf{boss});\ \boldsymbol{\exists}_{\mathbf{mb}};\ \mathrm{S}|(\mathrm{S}|\mathrm{NP}) \qquad \dfrac{\dfrac{[\varphi_1;x;\mathrm{NP}]^1 \quad [\varphi_2;P;\mathrm{NP}\backslash\mathrm{S}]^2}{\varphi_1\circ\varphi_2;\ P(x);\ \mathrm{S}}\,\backslash\mathrm{E}}{\lambda\varphi_1.\varphi_1\circ\varphi_2;\ \lambda x.P(x);\ \mathrm{S}|\mathrm{NP}}\,|\mathrm{I}^1}{\mathsf{a}\circ\mathsf{mob}\circ\mathsf{boss}\circ\varphi_2;\ \boldsymbol{\exists}_{\mathbf{mb}}(\lambda x.P(x));\ \mathrm{S}}\,|\mathrm{E}}{\mathsf{a}\circ\mathsf{mob}\circ\mathsf{boss};\ \lambda P.\boldsymbol{\exists}_{\mathbf{mb}}(\lambda x.P(x));\ \mathrm{S}/(\mathrm{NP}\backslash\mathrm{S})}\,/\mathrm{I}^2$$

The derivation in (107) can be understood as follows. We start by hypothesizing a VP (i.e., NP\S, indexed as 2) and an NP (indexed as 1). After a complete S is formed, the NP hypothesis is withdrawn so that the quantifier can take scope. The resulting expression is indeed of the right type (S|NP) to be given as an argument to the quantifier, and the quantifier string is lowered to the subject position. This yields a string in which the prosody of the hypothesized VP φ_2 appears at the right periphery, satisfying the applicability condition of /I. By applying /I, the string *a mob boss* is paired with the original denotation of the quantifier (note that the final translation is equivalent to $\boldsymbol{\exists}_{\mathbf{mb}}$ via eta-equivalence) and the syntactic category S/(NP\S).

(108)

$$\dfrac{\dfrac{\lambda\sigma.\sigma(\mathsf{a}\circ\mathsf{mob}\circ\mathsf{boss});\ \boldsymbol{\exists}_{\mathbf{mb}};\ \mathrm{S}|(\mathrm{S}|\mathrm{NP}) \qquad \dfrac{\dfrac{[\varphi_2;P;\mathrm{S}/\mathrm{NP}]^2 \quad [\varphi_1;x;\mathrm{NP}]^1}{\varphi_2\circ\varphi_1;\ P(x);\ \mathrm{S}}\,\backslash\mathrm{E}}{\lambda\varphi_1.\varphi_2\circ\varphi_1;\ \lambda x.P(x);\ \mathrm{S}|\mathrm{NP}}\,|\mathrm{I}^1}{\varphi_2\circ\mathsf{a}\circ\mathsf{mob}\circ\mathsf{boss};\ \boldsymbol{\exists}_{\mathbf{mb}}(\lambda x.P(x));\ \mathrm{S}}\,|\mathrm{E}}{\mathsf{a}\circ\mathsf{mob}\circ\mathsf{boss};\ \lambda P.\boldsymbol{\exists}_{\mathbf{mb}}(\lambda x.P(x));\ (\mathrm{S}/\mathrm{NP})\backslash\mathrm{S}}\,/\mathrm{I}^2$$

(109)

$$\dfrac{\dfrac{\dfrac{\dfrac{\begin{array}{l}\lambda\sigma.\sigma(\mathsf{a}\circ\mathsf{present});\\ \boldsymbol{\exists}_{\mathbf{pr}};\\ \mathrm{S}|(\mathrm{S}|\mathrm{NP})\end{array} \qquad \dfrac{\dfrac{\begin{bmatrix}\varphi_3;\\ z;\mathrm{NP}\end{bmatrix}^3 \quad \dfrac{\dfrac{\begin{bmatrix}\varphi_0;\\ P;\mathrm{VP}/\mathrm{PP}/\mathrm{NP}\end{bmatrix}^0 \quad \begin{bmatrix}\varphi_1;\\ x;\mathrm{NP}\end{bmatrix}^1}{\varphi_0\circ\varphi_1;\ P(x);\ \mathrm{VP}/\mathrm{PP}}\,/\mathrm{E} \quad \begin{bmatrix}\varphi_2;\\ y;\mathrm{PP}\end{bmatrix}^2}{\varphi_0\circ\varphi_1\circ\varphi_2;\ P(x)(y);\ \mathrm{VP}}\,/\mathrm{E}}{\varphi_3\circ\varphi_0\circ\varphi_1\circ\varphi_2;\ P(x)(y)(z);\ \mathrm{S}}\,\backslash\mathrm{E}}{\lambda\varphi_1.\varphi_3\circ\varphi_0\circ\varphi_1\circ\varphi_2;\ \lambda x.P(x)(y)(z);\ \mathrm{S}|\mathrm{NP}}\,|\mathrm{I}^1}{\varphi_3\circ\varphi_0\circ\mathsf{a}\circ\mathsf{present}\circ\varphi_2;\ \boldsymbol{\exists}_{\mathbf{pr}}(\lambda x.P(x)(y)(z));\ \mathrm{S}}\,|\mathrm{E}}{\varphi_0\circ\mathsf{a}\circ\mathsf{present}\circ\varphi_2;\ \lambda z.\boldsymbol{\exists}_{\mathbf{pr}}(\lambda x.P(x)(y)(z));\ \mathrm{VP}}\,\backslash\mathrm{I}^3}{\varphi_0\circ\mathsf{a}\circ\mathsf{present};\ \lambda y\lambda z.\boldsymbol{\exists}_{\mathbf{pr}}(\lambda x.P(x)(y)(z));\ \mathrm{PTV}}\,/\mathrm{I}^2}{\mathsf{a}\circ\mathsf{present};\ \lambda P\lambda y\lambda z.\boldsymbol{\exists}_{\mathbf{pr}}(\lambda x.P(x)(y)(z));\ (\mathrm{PTV}/\mathrm{NP})\backslash\mathrm{PTV}}\,\backslash\mathrm{I}^0$$

It is important to note that, although Slanting is a very flexible operation, it never yields entries of quantifiers that disrupts word order. For example, it is impossible to derive an entry for the quantifier of type (NP\S)\S from the lexically specified type S|(S|NP) (If such a derivation were possible, it would overgenerate the string **Loves a sailor every boy* with the reading 'Every boy loves a sailor', clearly a wrong result.)

The following failed derivation for S|(S|NP) ⊢ (NP\S)\S illustrates the point succinctly:

(110)

$$\dfrac{\lambda\sigma.\sigma(\mathsf{a}\circ\mathsf{mob}\circ\mathsf{boss});\ \mathbf{\exists_{mb}};\ \mathrm{S}|(\mathrm{S}|\mathrm{NP}) \quad \dfrac{\dfrac{[\varphi_1; x; \mathrm{NP}]^1 \quad [\varphi_2; P; \mathrm{NP}\backslash\mathrm{S}]^2}{\varphi_1\circ\varphi_2;\ P(x);\ \mathrm{S}}\backslash\mathrm{E}}{\lambda\varphi_1.\varphi_1\circ\varphi_2;\ \lambda x.P(x);\ \mathrm{S}|\mathrm{NP}}|\mathrm{I}^1}{\dfrac{\mathsf{a}\circ\mathsf{mob}\circ\mathsf{boss}\circ\varphi_2;\ \mathbf{\exists_{mb}}(\lambda x.P(x));\ \mathrm{S}}{\mathrm{FAIL}}{**}\backslash\mathrm{I}^{2}{**}}|\mathrm{E}$$

The proof starts by hypothesizing NP\S, since this is the category that needs to be withdrawn at the last step via \I to obtain the category (NP\S)\S. Then the proof proceeds in the same way as (107) above until the very final step, where it fails. At this final step, in order to obtain the (NP\S)\S category instead of the S/(NP\S) category as in (72), we need to apply \I. However, this is impossible since the applicability condition of the \I rule requires the prosody of the hypothesis to be withdrawn to appear on the left periphery of the input string—a condition that is not satisfied in (110). Thus, this derivation is correctly blocked.

In general, Slanting that disrupts word order is underivable in Hybrid TLCG since the prosodic labelling keeps track of the string positions of both hypothesized and real expressions so that anything that goes against the linear order properties encoded via / and \ in the syntactic categories of the relevant expressions will be automatically ruled out in the calculus. Thus, the hybrid logic underlying our system, though highly flexible, governs the interactions between directional and non-directional slashes in a completely systematic manner.