Pseudogapping as Pseudo-VP ellipsis

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Abstract. In this paper, we propose an analysis of pseudogapping in Hybrid Type-Logical Categorial Grammar (Hybrid TLCG; Kubota 2010, Kubota and Levine 2012). Pseudogapping poses a particularly challenging problem for previous analyses in both the transformational and non-transformational literature. The flexible notion of constituency countenanced in categorial grammar in general (including Hybrid TLCG) enables a simple analysis of pseudogapping that overcomes the problems for previous approaches. In addition, we show that Hybrid TLCG offers a useful platform for comparing different types of CG (and analytic ideas embodied in them) within a single framework with a linguist-friendly notation. In the context of an analysis of pseudogapping, this enables us to compare the adequacies of two types of treatments of discontinuous pseudogapping. We believe that this type of cross-framework comparison of different analytic ideas is useful for the purpose of testing the predictions of different types of analyses that can respectively be formulated in only one or the other of the more conservative types of CG.

Keywords: pseudogapping, VP ellipsis, anaphora, Hybrid Type-Logical Categorial Grammar, discontinuous constituency

1 Introduction

Pseudogapping is a somewhat odd instance of ellipsis in which a lexical verb embedded under an auxiliary is deleted, leaving behind its own complement(s).

(1) Mary hasn't dated Bill, but she has ∅ Harry.

The proper analysis of this phenomenon has long been a problem in the syntactic literature (see Gengel (2013) and references therein).[3] We argue in this paper that a simple analysis of pseudogapping becomes possible in categorial grammar (CG). The flexible notion of constituency that CG countenances plays a key role in enabling an analysis in which both the syntactic category and the semantic content of the missing material (which is often, but not necessarily, a lexical verb) is explicitly represented as a constituent in the derivation of the antecedent clause, which we show is exactly the information that is needed to license pseudogapping. We formulate our analysis in a variant of CG called Hybrid TLCG

[3] Due to space limitations, we do not discuss the problems for these previous approaches in this paper. This is left for another occasion.

(Kubota 2010, Kubota and Levine 2012), a framework that can be thought to combine the Lambek-based tradition in TLCG with an order-insensitive calculus of linguistic composition pioneered in Oehrle (1994). Though there are now several analyses of ellipsis phenomena in the literature of TLCG (Hendriks 1995, Morrill and Merenciano 1996, Jäger 2005, Barker 2013), so far as we are aware, this is the first analysis of pseudogapping in CG.

It should be noted at the outset that our choice of framework here should *not* be taken as an attempt to demonstrate the advantage of Hybrid TLCG over its many alternatives. In fact, so far as we can see, the core underlying idea of our proposal can be expressed in almost any of the contemporary variants of CG, including Multi-Modal Categorial Type Logics (Moortgat 1997, Bernardi 2002), the Displacement Calculus (Morrill 2010, Morrill et al. 2011) and the family of 'Linear Categorial Grammars' (LCGs) (Oehrle 1994, de Groote 2001, Muskens 2003, Mihaliček and Pollard 2012).[4] However, formulating the analysis in Hybrid TLCG enables us to compare two types of treatments of discontinuous constituency that are respectively associated with the 'standard' TLCG tradition (especially the so-called 'multi-modal' variants thereof) and LCGs (which are equipped with λ-binding in the prosodic component). So far as we are aware, the literature remains utterly silent as to which of the two types of approaches to discontinuity is empirically (as opposed to purely theoretically or computationally) superior, or whether they are largely notational variants of each other as far as empirical coverage is concerned.[5] However, as we discuss below, even in the small domain of pseudogapping, the choice between the two alternative approaches to discontinuous constituency has a nontrivial consequence for the range of sentences that are predicted to be grammatical. For this reason, we believe that a general framework like ours which accomodates different analytic techniques originally developed in different traditions is useful for the purpose of cross-framework comparison. Our hope is that such a cross-framework comparison will ultimate lead us to a better understanding of what kinds of formal techniques are most optimal for the analysis of natural language syntax.

2 Pseudogapping in Type-Logical Categorial Grammar

2.1 Hybrid Type-Logical Categorial Grammar

(Non-modalized) Hybrid TLCG is essentially an extension of the Lambek calculus (Lambek 1958) with one additional, non-directional mode of implication.[6]

[4] An empirical argument for our approach over the theoretically more spartan LCGs comes from a different empirical domain, one involving coordination. See Kubota (2010: section 3.2.1) and Kubota and Levine (2013a: section 3.6) for the relevant discussion. See also Worth (2014) for some initial attempts at simulating a Hybrid TLCG analysis of coordination in an LCG.

[5] But see Kubota (2010, 2014), which argue for the (potentially controversial) position that both of these two techniques are needed for the analysis of complex interactions between coordination, scope-taking operators and complex predicates in Japanese.

[6] We sketch a multi-modal version below, which goes beyond this characterization.

Since Hybrid TLCG utilizes both the directional slashes ($/$ and $\backslash$) from the Lambek calculus and a non-directional slash (notated as $|$) from LCGs, we start from the definition of syntactic types.[7]

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

(3) 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.

(4) 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 then define the functions Sem and Pros which map syntactic types to semantic and prosodic types. The definition for semantic types is a standard one.

(5) a. For atomic syntactic types,
$\mathsf{Sem}(\mathrm{NP}) = e$, $\mathrm{Sem}(\mathrm{S}) = t$, $\mathsf{Sem}(\mathrm{N}) = e \to t$

b. For complex syntactic types,
$\mathsf{Sem}(A/B) = \mathsf{Sem}(B\backslash A) = \mathsf{Sem}(A|B) = \mathsf{Sem}(B) \to \mathsf{Sem}(A)$.

(6) a. For any directional type A, $\mathsf{Pros}(A) = \textbf{st}$ (with **st** for 'strings').

b. For any complex syntactic type $A|B$ involving the vertical slash $|$,
$\mathsf{Pros}(A|B) = \mathsf{Pros}(B) \to \mathsf{Pros}(A)$.

One thing that one immediately notices from the above definition of syntactic types is that although we have three connectives $/$, $\backslash$ and $|$, the algebra of syntactic types is not a free algebra generated over the set of atomic types with these three binary connectives. We take this to be a feature, not a bug. For example, in Hybrid TLCG, a vertical slash cannot occur 'under' a directional slash.[8] Thus, an expression like S/(S|NP) is not a well-formed syntactic type according to (4). The intuition behind this is that such a type is ill-formed since directional slashes make sense only when the argument of the functor has a string phonology. Another thing to note is that there is an asymmetry between Sem and Pros as to how they treat the directional slashes $/$ and $\backslash$. The semantic types are 'read off' from syntactic types by taking all of $/$, $\backslash$, $|$ to be type constructors for functions (as expected), but for the mapping from syntactic types to prosodic

[7] We omit parentheses for a sequence of the same type of slash, assuming that $/$ and $|$ are left associative, and $\backslash$ 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.

[8] Note that in this respect, our calculus differs from the closely related Discontinuous Calculus of Morrill (2010) and Morrill et al. (2011).

types, only the vertical slash | is effectively interpreted as functional. Thus, for example, $\mathsf{Sem}(\mathrm{S}|(\mathrm{S}/\mathrm{NP})) = (e \rightarrow t) \rightarrow t$ whereas $\mathsf{Pros}(\mathrm{S}|(\mathrm{S}/\mathrm{NP})) = \textsf{st} \rightarrow \textsf{st}$. Again, this is a feature, not a bug, one which we take to be motivated by linguistic considerations rather than meta-logical ones.

With this definition of syntactic types, we can formulate the syntactic rules of the calculus. Following Oehrle (1994) and Morrill (1994), we utilize the labelled deduction notation for writing syntactic rules. The total set of logical inference rules (formulated in the natural deduction format) are given in (7).[9]

(7) **Connective** **Introduction** **Elimination**

Connective $/$:

Introduction:

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

Elimination:

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

Connective $\backslash$:

Introduction:

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

Elimination:

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

Connective $|$:

Introduction:

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

Elimination:

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

The binary connective $\circ$ in the prosodic component designates the string concatenation operation and is associative in both directions (i.e. $(\varphi_1 \circ \varphi_2) \circ \varphi_3 \equiv \varphi_1 \circ (\varphi_2 \circ \varphi_3)$). Note also that, following Oehrle (1994), we admit functional phonological expressions in addition to simple strings (such expressions are manipulated by the Introduction and Elimination rules for |, whose prosodic 'effects' are lambda abstraction and function application, respectively).

The rules in (7) are the logical rules. There is also one non-logical rule called the P(rosodic)-interface rule, which replaces the prosodic labelling with an equivalent term in the calculus of prosodic objects, which is a type of lambda calculus:[10]

(8) 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)

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[9] For phonological variables we use Greek letters $\varphi_1, \varphi_2, \ldots$ (type $\textsf{st}$); $\sigma_1, \sigma_2, \ldots$ (type $\textsf{st} \rightarrow \textsf{st}$, $\textsf{st} \rightarrow \textsf{st} \rightarrow \textsf{st}$, etc.); $\tau_1, \tau_2, \ldots$ (type $(\textsf{st} \rightarrow \textsf{st}) \rightarrow \textsf{st}$, etc.).

[10] See Kubota (2010) and Kubota and Pollard (2010) for formal details.

There are a couple of points worth noting. First, the prosodic labelling is used here for the purpose of narrowing down the set of possible derivations. In particular, it should be noted that word order is represented in the prosodic labelling in this system rather than the linear order of the premises, and that the applicability of (some of) the rules are constrained by the forms of these prosodic labels.[11] (This in turn means that the order of the premises in the three Elimination rules is immaterial.) Specifically, the Introduction rule for / (\) is applicable only when the variable φ that occurs in the phonology of the premise is on the right (left) periphery. In this sense, the labelling system makes a contribution on its own rather than being isomorphic to the structures of derivations. Note also that there is an asymmetry between | and /, \ in this respect too. Unlike the Introduction rules for / and \, the applicability of the Introduction rule for | is not restricted by the phonological labelling of the premise.

Second, 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 point becomes clearer when we extend the system by incorporating a multi-modal morpho-phonological component below. In a non-modalized system that we work with (except in section 2.3), the role of the P-interface rule is quite limited: it is used only for the purpose of replacing the prosodic labelling with a beta-equivalent term or rebracketing the structure (the latter of which is freely available since $\circ$ is associative in both directions). For the readability of proofs, we assume the application of this rule implicitly, leaving out all brackets from the prosodic terms and directly writing beta-reduced terms for the prosodic labelling (as well as for semantic labelling).

Third, although we do not attempt to provide an explicit translation, it should be intuitively clear that the present system without the rules for | is equivalent to the Lambek calculus **L** (Lambek 1958); if we instead remove the P-interface rule and retain only the rules for | from the set of logical rules, the system is essentially equivalent to ACG and Lambda grammar.[12] Note also that in this latter case, the prosodic labelling becomes isomorphic to the structure of the derivations (and this is true for semantic labelling too, on the condition that one doesn't allow for beta reduction of semantic translations in the derivations).

We now highlight some interesting properties of Hybrid TLCG. First, in Hybrid TLCG, LCG-type lexical entries for verbs with functional phonologies and Lambek-type lexical entries for verbs with string phonologies are interderivable. The proofs are shown in (9) and (10).

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

[12] Linear Grammar (Mihaliček and Pollard 2012, Worth 2014) is different from its kin in the family of LCGs in that it does not assume a functional mapping from syntactic types to either semantic types or prosodic types. Instead the mapping is relational (see in particular Worth (2014: section 1.1) for an explicit statement of this point). We could relax our definitions of Sem and Pros to make our framework compatible with this assumption.

(9)

$$\dfrac{\dfrac{\dfrac{\begin{bmatrix}\varphi_2;\\ y;\\ \mathrm{NP}\end{bmatrix}^2 \quad \dfrac{\begin{array}{l}\lambda\varphi_3\lambda\varphi_4.\\ \varphi_4 \circ \mathsf{met} \circ \varphi_3;\\ \mathbf{meet}; (\mathrm{S|NP})|\mathrm{NP}\end{array} \quad \begin{bmatrix}\varphi_1;\\ x;\\ \mathrm{NP}\end{bmatrix}^1}{\begin{array}{c}\lambda\varphi_4.\varphi_4 \circ \mathsf{met} \circ \varphi_1;\\ \mathbf{meet}(x); \mathrm{S|NP}\end{array}}|\mathrm{E}}{\varphi_2 \circ \mathsf{met} \circ \varphi_1;\ \mathbf{meet}(x)(y);\ \mathrm{S}}|\mathrm{E}}{\mathsf{met} \circ \varphi_1;\ \lambda y.\mathbf{meet}(x)(y);\ \mathrm{NP\backslash S}}\backslash \mathrm{I}^2}{\mathsf{met};\ \lambda x\lambda y.\mathbf{meet}(x)(y);\ (\mathrm{NP\backslash S})/\mathrm{NP}}/\mathrm{I}^1$$

(10)

$$\dfrac{\dfrac{\dfrac{\begin{bmatrix}\varphi_2;\\ y; \mathrm{NP}\end{bmatrix}^2 \quad \dfrac{\begin{array}{l}\mathsf{met};\\ \mathbf{meet};\\ (\mathrm{NP\backslash S})/\mathrm{NP}\end{array} \quad \begin{bmatrix}\varphi_1;\\ x; \mathrm{NP}\end{bmatrix}^1}{\begin{array}{c}\mathsf{met} \circ \varphi_1;\\ \mathbf{meet}(x); \mathrm{NP\backslash S}\end{array}}/\mathrm{E}}{\varphi_2 \circ \mathsf{met} \circ \varphi_1;\ \mathbf{meet}(x)(y);\ \mathrm{S}}\backslash \mathrm{E}}{\begin{array}{c}\lambda\varphi_2.\varphi_2 \circ \mathsf{met} \circ \varphi_1;\\ \lambda y.\mathbf{meet}(x)(y); \mathrm{S|NP}\end{array}}|\mathrm{I}^2}{\begin{array}{l}\lambda\varphi_1\lambda\varphi_2.\varphi_2 \circ \mathsf{met} \circ \varphi_1;\\ \lambda x\lambda y.\mathbf{meet}(x)(y); (\mathrm{S|NP})|\mathrm{NP}\end{array}}|\mathrm{I}^1$$

Note also that a type S/(NP\S) entry for a quantifier (for the subject position) is derivable from the type S|(S|NP) type entry ($\mathbf{\forall_{person}}$ abbreviates the term $\lambda P.\forall x[\mathbf{person}(x) \to P(x)]$):

(11)

$$\dfrac{\dfrac{\begin{array}{c}\lambda\sigma.\sigma(\mathsf{everyone});\\ \mathbf{\forall_{person}}; \mathrm{S|(S|NP)}\end{array} \quad \dfrac{\dfrac{[\varphi_1; x; \mathrm{NP}]^1 \quad [\varphi_2; P; \mathrm{NP\backslash S}]^2}{\varphi_1 \circ \varphi_2;\ P(x);\ \mathrm{S}}\backslash \mathrm{E}}{\lambda\varphi_1.\varphi_1 \circ \varphi_2;\ \lambda x.P(x);\ \mathrm{S|NP}}|\mathrm{I}^1}{\mathsf{everyone} \circ \varphi_2;\ \mathbf{\forall_{person}}(\lambda x.P(x));\ \mathrm{S}}|\mathrm{E}}{\mathsf{everyone};\ \lambda P.\mathbf{\forall_{person}}(\lambda x.P(x));\ \mathrm{S/(NP\backslash S)}}/\mathrm{I}^2$$

We call this type of proof *slanting*. Slanting is a general set of theorems. For example, a type (S/NP)\S entry (for the object position) and a type (S/NP/NP)\(S/NP) entry (e.g., for a medial quantifier in a sentence like *Kim showed everyone Felix*) for a quantifier are also derivable from the type S|(S|NP) entry (derivations are omitted due to space limitations).

But importantly, a proof in the other direction doesn't go through.

(12)

$$\dfrac{\mathsf{everyone};\ \mathbf{\forall_{person}};\ \mathrm{S/(NP\backslash S)} \quad \dfrac{\dfrac{[\sigma; P; \mathrm{S|NP}]^1 \quad [\varphi; x; \mathrm{NP}]^2}{\sigma(\varphi);\ P(x);\ \mathrm{S}}|\mathrm{E}}{???;\ \lambda x.P(x);\ \mathrm{NP\backslash S}}\backslash \mathrm{I}^2}{\mathrm{FAIL}}$$

The proof fails at the step where we try to apply \I to derive the category NP\S. In order for this rule to be applicable, the prosodic variable φ for the hypothesis to be withdrawn needs to occupy the left periphery of the phonology of the premise. But the term σ(φ) does not tell us where the variable φ occurs inside the whole term. The failure of this proof is intuitively the right result, since a quantifier with syntactic category S/(NP\S) has a more restricted distribution (limited to the subject position) than one with the category S|(S|NP) (which can appear in any argument position).

As discussed in Kubota and Levine (2013a, 2014), slanting has many important empirical consequences, especially in situations where a semantic operator that appears outside of coordination syntactically is semantically distributed to each conjunct.

2.2 The basic analysis of pseudogapping

Our analysis builds on some ideas from the previous literature. In particular, we follow Miller (1990) in assuming that the ellipsis in pseudogapping essentially involves an anaphoric mechanism. But we also borrow from the transformational approaches (whose insight goes back to Kuno (1981)) the idea that pseudogapping and VP ellipsis are derived by essentially the same mechanism.

The key underlying idea is very simple: pseudogapping in examples like (13) is just transitive verb ellipsis. In VP ellipsis as in (14), the whole VP is deleted, and its meaning is resolved by anaphorically referring back to the VP in the antecedent clause. Pseudogapping is different only in that what's missing is not a full VP but just the verb. But the key anaphoric mechanism that retrieves the missing meaning is the same.

(13) John can eat the pear. Bill can ∅ the fig.

(14) John can sing. Bill can't ∅.

In this section, we first formulate an analysis of pseudogapping using directional slashes alone, demonstrating that the core analysis of pseudogapping can be formulated in a purely directional calculus. In the next section, we turn to some empirical challenges that this analysis faces in the domain of discontinuous pseudogapping and sketch two alternative solutions for that problem, each building on different types of techniques for handling discontinuous constituency. A comparison of these two alternatives suggests that the two approaches make different predictions as to the range of admissible pseudogapping sentences. We take this conclusion to be suggestive of the kinds of considerations that one should bear in mind in applying formal techniques to the analysis of linguistic data.

We start with an analysis of VP ellipsis, and then extend the analysis to pseudogapping. The basic idea is that VP ellipsis is licensed by an alternative sign for the auxiliary verb that does not subcategorize for a VP but instead anaphorically retrieves the relevant VP meaning in reference to the preceding discourse. For this purpose, we posit the following empty operator that applies to the lexical sign of auxiliaries of the form in (16) and saturates the VP argument slot that it subcategorizes for (here and in what follows, we use VP, TV and DTV as abbreviations for NP\S, (NP\S)/NP and (NP\S)/NP/NP, respectively).

(15) ε; $\lambda \mathscr{F}.\mathscr{F}(P)$; VP/(VP/VP)
where P is a free variable whose value is identified with the meaning of some linguistic sign in the preceding discourse with category VP

(16) can; $\lambda P \lambda x.\Diamond P(x)$; VP/VP

With (15), (17) is analyzed as in (18) (here and in what follows, the syntactic category of the sign that antecedes the VP ellipsis is set in boldface).

(17) John can sing. Bill can't ∅.

(18)

$$\dfrac{\mathsf{john};\ \mathbf{j};\mathrm{NP} \qquad \dfrac{\mathsf{can};\ \lambda P\lambda x.\Diamond P(x);\ \mathrm{VP/VP} \qquad \mathsf{sing};\ \mathbf{sing};\ \mathbf{VP}}{\mathsf{can}\circ\mathsf{sing};\ \lambda x.\Diamond\mathbf{sing}(x);\mathrm{VP}}}{\mathsf{john}\circ\mathsf{can}\circ\mathsf{sing};\ \Diamond\mathbf{sing}(\mathbf{j});\mathrm{S}} \qquad \dfrac{\mathsf{bill};\ \mathbf{b};\mathrm{NP} \qquad \dfrac{\varepsilon;\ \lambda\mathscr{F}.\mathscr{F}(\mathbf{sing});\ \mathrm{VP/(VP/VP)} \qquad \mathsf{can't};\ \lambda P\lambda x.\neg\Diamond P(x);\ \mathrm{VP/VP}}{\mathsf{can't};\ \lambda x.\neg\Diamond\mathbf{sing}(x);\mathrm{VP}}}{\mathsf{bill}\circ\mathsf{can't};\ \neg\Diamond\mathbf{sing}(\mathbf{b});\mathrm{S}}$$

Some comments are in order as to our choice of this analysis involving an empty operator. There are at least three alternatives to this approach: (i) an analysis involving binding of a hypothetical VP to an antecedent VP (Morrill et al. 2011); (ii) one that posits an empty VP; and (iii) one that posits an alternative auxiliary entry (identical to the output of our syntactic empty operator) in the lexicon (Jäger 2005). The binding approach does not extend to intersentential anaphora easily; especially problematic are cases where VP ellipsis occurs across speakers. The present approach is superior to an empty VP approach in capturing the generalization that auxiliaries (including the 'infinitive marker' *to*) are the triggers of VP ellipsis.[13] We believe that our approach is superior to a lexical approach (i.e. (iii)) in straightforwardly generalizing to the pseudogapping case (see below). It is not clear whether one can arrive at a general characterization of the set of alternative entries for the auxiliary on a purely lexical approach like Jäger's (2005).

This approach has at least the same empirical coverage as previous analyses of VP ellipsis in TLCG (Morrill and Merenciano 1996, Jäger 2005). Although space limitations preclude a detailed demonstration, it can account for interactions between VP ellipsis and other phenomena such as quantifier scope and strict/sloppy ambiguity exemplified by well-known examples (such as the $\forall > \mathbf{before}$ reading for *John read every book before Bill did* and the strict/sloppy ambiguity of *John talked to his boss. Bill did, too*).

There is some evidence that English allows for TV ellipsis other than in pseudogapping. Jacobson (1992, 2008) argues that antecedent contained deletion is to be analyzed as TV ellipsis rather than VP ellipsis. The idea is that in (19), what is missing after *had* is just the transitive verb *showed* instead of a full VP.

(19) John showed Bill every place that Harry already had.

This requires analyzing auxiliaries in the category TV/TV instead of VP/VP and generalizing the entry for the VP ellipsis operator accordingly (see below in (21)). In the present TLCG setup, the TV/TV entry for the auxiliary can be derived from the more basic VP/VP entry as an instance of the Geach theorem:

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13 Note in this connection that the entry in (15) is a simplification, since, as it is, it can combine with any VP/VP. We take it that there is an additional constraint on this empty operator that it can only combine with expressions that have the phonologies of auxiliaries (such as *do*, *should* and *will*). This constraint could be stated easily if the operator instead had the syntactic category VP|(VP/VP) (involving the vertical slash) and phonology $\lambda\varphi.\varphi$ (which would take us from the directional fragment we are working with), in which case it could simply be stated as a restriction on the phonology of the linguistic expression that this operator takes as an argument.

(20)
$$\dfrac{\dfrac{\dfrac{\mathsf{had};\ \lambda P\lambda y.P(y);\ \mathrm{VP/VP} \qquad \dfrac{[\varphi_2; f; \mathrm{TV}]^2 \quad [\varphi_3; x; \mathrm{NP}]^3}{\varphi_2 \circ \varphi_3;\ f(x);\ \mathrm{VP}}}{\mathsf{had} \circ \varphi_2 \circ \varphi_3;\ \lambda y.f(x)(y);\ \mathrm{VP}}}{\mathsf{had} \circ \varphi_2;\ \lambda x \lambda y.f(x)(y);\ \mathrm{TV}}/\mathrm{I}^3}{\mathsf{had};\ \lambda f \lambda x \lambda y.f(x)(y);\ \mathrm{TV/TV}}/\mathrm{I}^2$$

For more details of the analysis of antecedent contained deletion, see Jacobson (1992, 2008).

We schematize the ellipsis operator in (15) using Steedman's (2000) $-notation, since pseudogapping is sometimes not just TV ellipsis, but also DTV ellipsis, etc.:

(21) ε; $\lambda \mathscr{F}.\mathscr{F}(P)$; $(\mathrm{VP}/\$)/((\mathrm{VP}/\$)/(\mathrm{VP}/\$))$
where P is a free variable whose value is identified with the meaning of some linguistic sign in the preceding discourse with category VP/$

VP/$ is a metavariable notation for a set of categories where any number of arguments (of any category) are sought via / (VP, VP/NP, VP/NP/PP, etc.). The three occurrences of VP/$ in (21) are to be instantiated in the same way.

Basic pseudogapping like (22) can then be analyzed as in (23). The auxiliary is first derived as TV/TV (cf. (20)) before the 'VP ellipsis' operator applies.

(22) John should eat the pear. Bill should ∅ the fig.

(23)
$$\dfrac{\mathsf{john};\ \mathbf{j};\ \mathrm{NP} \qquad \dfrac{\mathsf{should};\ \lambda P \lambda x.\Box P(x);\ \mathrm{VP/VP} \qquad \dfrac{\mathsf{eat};\ \mathbf{eat};\ \mathbf{TV} \quad \mathsf{the} \circ \mathsf{pear};\ \mathbf{p};\ \mathrm{NP}}{\mathsf{eat} \circ \mathsf{the} \circ \mathsf{pear};\ \mathbf{eat}(\mathbf{p});\ \mathrm{VP}}}{\mathsf{should} \circ \mathsf{eat} \circ \mathsf{the} \circ \mathsf{pear};\ \lambda x.\Box\mathbf{eat}(\mathbf{p})(x);\ \mathrm{VP}}}{\mathsf{john} \circ \mathsf{should} \circ \mathsf{eat} \circ \mathsf{the} \circ \mathsf{pear};\ \Box\mathbf{eat}(\mathbf{p})(\mathbf{j}); \mathrm{S}}$$

$$\dfrac{\mathsf{bill};\ \mathbf{b};\ \mathrm{NP} \qquad \dfrac{\dfrac{\varepsilon;\ \lambda\mathscr{F}.\mathscr{F}(\mathbf{eat});\ \mathrm{TV/(TV/TV)} \qquad \begin{matrix}\vdots\ \vdots \\ \mathsf{should};\ \lambda f \lambda x \lambda y.\Box f(x)(y);\ \mathrm{TV/TV}\end{matrix}}{\mathsf{should};\ \lambda x \lambda y.\Box\mathbf{eat}(x)(y); \mathrm{TV}} \qquad \mathsf{the} \circ \mathsf{fig};\ \mathbf{f};\ \mathrm{NP}}{\mathsf{should} \circ \mathsf{the} \circ \mathsf{fig};\ \lambda y.\Box\mathbf{eat}(\mathbf{f})(y); \mathrm{VP}}}{\mathsf{bill} \circ \mathsf{should} \circ \mathsf{the} \circ \mathsf{fig};\ \Box\mathbf{eat}(\mathbf{f})(\mathbf{b}); \mathrm{S}}$$

Miller (1990) discusses an interesting type of example of the following form, in which a ditransitive verb instantiates different subcategorization frames (V NP NP vs. V NP PP) in the antecedent clause and the pseudogapping clause:

(24) I will give Mary my books if YOU will ∅ your records to Ann.

Miller claims that examples like this pose problems for syntactic approaches. Our analysis can accomodate such examples rather straightforwardly, by employing the $\wedge$ connective from Morrill (1994) and Bayer (1996) originally used for the analysis of unlike category coordination. Specifically, by specifying the alternative subcategorization frames for ditransitives with this connective in the lexicon[14] and by assuming that the ellipsis operator can access either of the two category-meaning pairs of such signs, (24) can be analyzed as in (25).

[14] See Kubota and Levine (2013b) for independent evidence for this assumption in the context of argument cluster coordination.

(25)

$$\dfrac{\dfrac{\text{i}; \mathbf{i}; \mathrm{NP} \quad \dfrac{\text{will}; \lambda P\lambda x. P(x); \mathrm{VP/VP} \quad \dfrac{\dfrac{\dfrac{\text{give}; \langle \lambda x\lambda y\lambda z.\mathbf{give}(x)(y)(z), \lambda y\lambda x\lambda z.\mathbf{give}(x)(y)(z)\rangle; (\mathrm{VP/PP/NP}) \wedge (\mathbf{VP/NP/NP})}{\text{give}; \lambda x\lambda y\lambda z.\mathbf{give}(x)(y)(z); \mathrm{VP/PP/NP}} \quad \text{my} \circ \text{books}; \textbf{my-bks}; \mathrm{NP}}{\text{give} \circ \text{my} \circ \text{books}; \lambda y\lambda z.\mathbf{give}(\textbf{my-bks})(y)(z); \mathrm{VP/PP}} \quad \text{to} \circ \text{mary}; \mathbf{m}; \mathrm{PP}}{\text{give} \circ \text{my} \circ \text{books} \circ \text{to} \circ \text{mary}; \lambda z.\mathbf{give}(\textbf{my-bks})(\mathbf{m})(z); \mathrm{VP}}}{\text{will} \circ \text{give} \circ \text{my} \circ \text{books} \circ \text{to} \circ \text{mary}; \lambda z.\mathbf{give}(\textbf{my-bks})(\mathbf{m})(z); \mathrm{VP}}}{\text{i} \circ \text{will} \circ \text{give} \circ \text{my} \circ \text{books} \circ \text{to} \circ \text{mary}; \mathbf{give}(\textbf{my-bks})(\mathbf{m})(\mathbf{i}); \mathrm{S}}}{}$$

$$\vdots \qquad \vdots$$

$$\dfrac{\text{you}; \mathbf{you}; \mathrm{NP} \quad \dfrac{\dfrac{\dfrac{\varepsilon; \lambda\mathscr{F}.\mathscr{F}(\lambda y\lambda x\lambda z.\mathbf{give}(x)(y)(z)); \mathrm{DTV/(DTV/DTV)} \quad \text{will}; \lambda f\lambda x\lambda y\lambda z.f(x)(y)(z); \mathrm{(VP/NP/NP)/(VP/NP/NP)}}{\text{will}; \lambda x\lambda y\lambda z.\mathbf{give}(y)(x)(z); \mathrm{DTV}} \quad \text{ann}; \mathbf{a}; \mathrm{NP}}{\text{will} \circ \text{ann}; \lambda y\lambda z.\mathbf{give}(y)(\mathbf{a})(z); \mathrm{TV}} \quad \text{your} \circ \text{records}; \textbf{your-rcs}; \mathrm{NP}}{\text{will} \circ \text{ann} \circ \text{your} \circ \text{records}; \lambda z.\mathbf{give}(\textbf{your-rcs})(\mathbf{a})(z); \mathrm{VP}}}{\text{you} \circ \text{will} \circ \text{ann} \circ \text{your} \circ \text{records}; \mathbf{give}(\textbf{your-rcs})(\mathbf{a})(\mathbf{you}); \mathrm{S}}$$

As the following examples show, the 'deleted' material in pseudogapping is not necessarily a syntactic constituent in the traditional sense:

(26) a. You can't **take the lining out of** that coat. You can ∅ this one.
b. It [an enema] **leaves some water in** you. At least, it does ∅ me.
c. I **expect this idea to be** a problem more than you do ∅ a solution.

In an associative calculus (like the present one), such examples are straightforward. Strings like *take the lining out of* are directly licenseable as constituents, and the ellipsis operator simply refers to such constituents in the antecedent clause for anaphora resolution.[15]

2.3 Discontinuous pseudogapping

Although a directional calculus is good at handling examples like (26), where the 'nonconstituent' that the ellipsis operator targets is a contiguous string, discontinuous pseudogapping exemplified by data such as the following poses a problem for the purely directional analysis of pseudogapping presented above:

(27) a. Although I didn't **give** Bill **the book**, I did ∅ Susan ∅.
b. She **found** her co-worker **attractive** but she didn't ∅ her husband ∅.

[15] More challenging cases come from examples involving split antecedents (Miller 1990):

(i) John **saw** Mary and Peter **heard** Ann, but neither did ∅ me.

Here, it seems likely that we would need to relax the condition on anaphora resolution in such a way that the free variable P can be instantiated not just as the meaning of a *single* antecedent verb but a conjunction or disjunction of such antecedent verbs.

An analysis of discontinuous constituency with 'wrapping' One way to handle discontinuity is to assume a 'wrapping' operation (Bach 1979, 1984, Dowty 1982), where the elided discontinuous string in examples like those in (27) are units in the combinatoric structure to which the element in the middle is 'infixed'. In the so-called 'multi-modal' variants of TLCG (see, e.g., Morrill (1994), Moortgat and Oehrle (1994), Bernardi (2002)), wrapping is formalized as a string manipulation operation in an algebra that governs surface morpho-phonological realization of linguistic expressions. Here we adopt a particular implementation of this general idea worked out in Kubota (2010) and Kubota and Pollard (2010). In this approach, the prosodic component of a linguistic expression is a term in a preordered algebra, and the ordering relation imposed on this algebra governs the various reordering and restructuring operations pertaining to surface morpho-syntactic constituency.

For our purposes, it suffices to distinguish between two modes of composition in the prosodic algebra: the ordinary concatenation mode ($\circ$) and the infixation mode (which we notate as $\circ_{\bullet}$). Prosodic terms are ordered in the prosodic algebra by the *deducibility* relation between terms (where $\varphi_1 \leq \varphi_2$ is to be read 'φ_2 is deducible from φ_1'), where beta-equivalent terms are inter-deducible and there are mode-specific deducibility relations. In our impoverished fragment (which deals with wrapping in English only), it suffices to posit just one deducibility relation of the following form:

(28) $(A \circ_{\bullet} B) \circ C \leq (A \circ C) \circ B$

The intuition behind this is that when A and B are combined in the infixation mode, an expression C that combines with that unit at a later point in the derivation can be infixed in the middle by a surface morpho-phonological reordering operation. The P-interface rule is slightly revised so that it now refers to the deducibility relation rather than the equivalence relation between the terms.

(29) P-interface rule

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

(where $\varphi_0 \leq \varphi_1$ holds in the prosodic calculus)

The syntactic rules of the calculus are also revised to take into account the sensitivity to modes of composition (for space reasons, we only reproduce the rules for /, but the rules for \ are similarly revised; the rules for | remain the same as above):

(30)

Connective	Introduction	Elimination
/	$\dfrac{\dfrac{\vdots\ \vdots\ \vdots\quad \dfrac{[\varphi;\ x;\ A]^n}{\vdots\ \vdots}\quad \vdots\ \vdots\ \vdots}{b \circ_i \varphi;\ \mathcal{F};\ B}}{b;\ \lambda x.\mathcal{F};\ B/_iA}\ /\text{I}^n$	$\dfrac{a;\ \mathcal{F};\ A/_iB \quad b;\ \mathcal{G};\ B}{a \circ_i b;\ \mathcal{F}(\mathcal{G});\ A}\ /\text{E}$

We can then analyze (27a) as follows:[16]

(31)

$$\dfrac{\dfrac{\mathsf{i};\ \mathbf{i}; \mathrm{NP} \qquad \dfrac{\begin{array}{l}\mathsf{didn't};\\ \lambda P \lambda x.\neg P(x);\\ \mathrm{VP/VP}\end{array} \qquad \dfrac{\dfrac{\dfrac{\begin{array}{l}\mathsf{give};\\ \mathbf{give}; \mathrm{VP/NP/.NP}\end{array} \quad \begin{array}{l}\mathsf{thebook};\\ \mathbf{the\text{-}book}; \mathrm{NP}\end{array}}{\mathsf{give} \circ\!.\ \mathsf{thebook};\ \mathbf{give}(\mathbf{the\text{-}book});\ \mathbf{VP/NP}} \quad \begin{array}{l}\mathsf{bill};\\ \mathbf{b}; \mathrm{NP}\end{array}}{(\mathsf{give} \circ\!.\ \mathsf{thebook}) \circ \mathsf{bill};\ \mathbf{give}(\mathbf{the\text{-}book})(\mathbf{b});\ \mathrm{VP}}}{\mathsf{give} \circ \mathsf{bill} \circ \mathsf{thebook};\ \mathbf{give}(\mathbf{the\text{-}book})(\mathbf{b});\ \mathrm{VP}}\ \mathrm{PI}}{\mathsf{didn't} \circ \mathsf{give} \circ \mathsf{bill} \circ \mathsf{thebook};\ \lambda x.\neg \mathbf{give}(\mathbf{the\text{-}book})(\mathbf{b})(x);\ \mathrm{VP}}}{\mathsf{i} \circ \mathsf{didn't} \circ \mathsf{give} \circ \mathsf{bill} \circ \mathsf{thebook};\ \neg \mathbf{give}(\mathbf{the\text{-}book})(\mathbf{b})(\mathbf{i});\ \mathrm{S}}}{}$$

$$\vdots \qquad \vdots$$

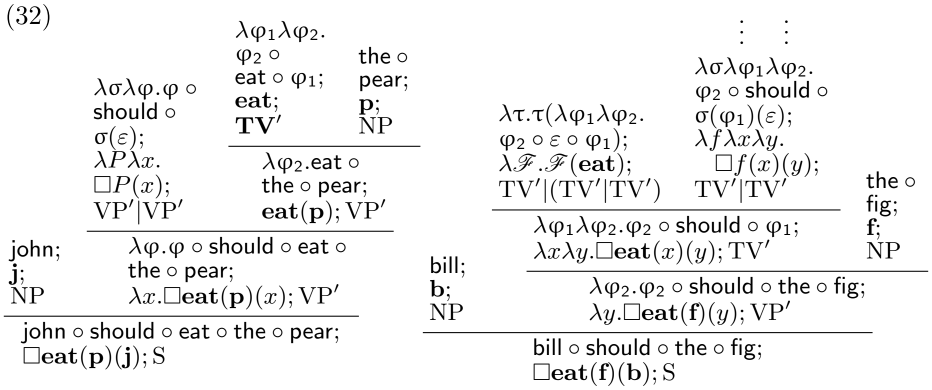
$$\dfrac{\mathsf{i};\ \mathbf{i}; \mathrm{NP} \qquad \dfrac{\dfrac{\begin{array}{l}\varepsilon;\\ \lambda \mathscr{F}.\mathscr{F}(\mathbf{give}(\mathbf{the\text{-}book}));\\ \mathrm{TV/(TV/TV)}\end{array} \quad \begin{array}{l}\mathsf{did};\\ \lambda f \lambda x \lambda y. f(x)(y);\\ \mathrm{TV/TV}\end{array}}{\mathsf{did};\ \lambda x \lambda y.\mathbf{give}(\mathbf{the\text{-}book})(x)(y);\ \mathrm{TV}} \quad \begin{array}{l}\mathsf{susan};\\ \mathbf{s}; \mathrm{NP}\end{array}}{\mathsf{did} \circ \mathsf{susan};\ \lambda y.\mathbf{give}(\mathbf{the\text{-}book})(\mathbf{s})(y);\ \mathrm{VP}}}{\mathsf{i} \circ \mathsf{did} \circ \mathsf{susan};\ \mathbf{give}(\mathbf{the\text{-}book})(\mathbf{s})(\mathbf{i});\ \mathrm{S}}$$

The point of this derivation is that the (surface) discontinuous string *give __ the book* behaves as a unit in the tectogrammatical derivation (motivation for this assumption comes from patterns of argument structure-sensitive phenomena such as passivization and binding; see, for example, Dowty (1982, 1996)). The pseudogapping operator can then directly refer to the syntactic category and the semantics of this 'underlying constituent' to supply the relevant subcategorization frame and the meaning of the missing TV to the auxiliary, just in the same way as in the non-discontinuous pseudogapping examples above. (27b) can be analyzed in the same way by assuming that the verb-adjective pair *find __ attractive* is a discontinuous constituent that wraps around the direct object *her co-worker*.

Discontinuous constituency with prosodic λ-binding Another approach to discontinuity is to exploit λ-binding in prosody in LCGs (see also the closely related mechanism involving the 'Lambda' structural postulate in some versions of the Continuation-based Grammar (Barker 2007, Barker and Shan to appear)). In fact, we can formulate the whole analysis of pseudogapping in a subset of Hybrid TLCG involving only the vertical slash (thus simulating a purely LCG analysis). This involves systematically replacing the lexical entries for all lexical items (including the VP ellipsis operator) with ones involving only the vertical slash. The analysis for the basic pseudogapping sentence then goes as follows (here, VP′ and TV′ respectively abbreviate S|NP and S|NP|NP):

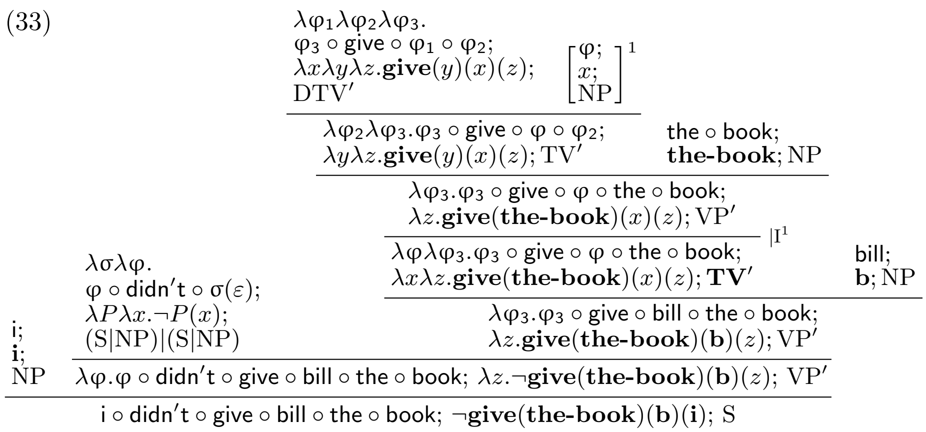
[16] We are here ignoring the internal structure of the NP *the book*. For the analysis to properly interact with the wrapping rule in (28), the determiner and the noun need to be combined in a mode that is distinct from the concatenation mode (∘).

(32)



The lexical entry for the pseudogapping operator in (32) already enables us to treat the discontinuous pseudogapping example in (27a). To see this, note that, in this kind of setup, the elided discontinuous constituent *give __ the book* can be analyzed as an expression that has exactly the same syntactic type S|NP|NP as the transitive verb that is elided in the normal pseudogapping example above. This is shown in (33). The pseudogapping clause *I did Susan* can then be analyzed in exactly the same way as in the above example in (32).

(33)



Comparison of the two approaches to discontinuity The question at this point is whether there are any principled grounds for choosing one approach to discontinuity over the other. Since wrapping is lexically-triggered (at least in most proposals), the wrapping-based analysis predicts that discontinuous pseudogapping is possible only when the elided material is a tectogrammatical constituent reflecting the combinatorial property of some lexical item. By contrast, LCGs are equipped with a much more general mechanism for syntactically deriving various sorts of discontinuous constituents. It is then predicted on this latter approach that any discontinuous constituent that can be so derived should in principle be able to undergo pseudogapping. From the (admittedly limited) investigation we have conducted so far, it seems that the 'wrapping'-type approach captures the distribution of pseudogapping in English better than an LCG-type approach. Thus, we tentatively conclude that the former is a more appropriate type of analysis at least so far as pseudogapping is concerned. For example, in addition to the examples above the LCG-type analysis can easily license an example like the following, which however does not seem to be an acceptable instance of pseudogapping:[17]

(34) *John **laughed when** Bill **arrived**, but he didn't ∅ Sue ∅.

3 Conclusion

There are a couple of useful conclusions to draw from the above analysis of pseudogapping. The first obvious point is that as long as we limit our attention to basic examples such as pseudogapping of a simple transitive verb, we are not likely to arrive at any interesting observations which may potentially distinguish between the predictions of different approaches, since basic examples can be handled in some way or other in any approach. This means that, in order to test the predictions of different approaches (and compare their empirical adequacies), we need to examine more complex cases in which the phenomenon in question interacts with other linguistic phenomena. This is a very basic methodological principle in any scientific domain, but this type of inquiry seems to be significantly underrepresented in the current literature of CG. We have demonstrated in this paper that, in the case of pseudogapping, data that enable this type of potential theory comparison come from interactions between pseudogapping and discontinuous constituency. Our comparison of the 'wrapping'-type analysis and the prosodic λ-binding-based analysis of discontinuous constituency revealed that the latter potentially allows for a much wider range of examples to be licensed by the grammar. This seems to allow for too much flexibility in the patterns exhibited by pseudogapping, and we have tentatively concluded that the 'wrapping'-type analysis seems more appropriate for the analysis of discontinuous pseudogapping. This of course does not mean that prosodic λ-binding in LCGs is an inappropriate tool for the analysis of natural language. It only means that care should be taken in applying such a powerful tool, and that, with any theoretical tool and any empirical phenomenon, one needs to weigh the pros and cons of applying the former to the latter based on several criteria,

[17] Levin (1979) provides several examples of (apparent) discontinuous pseudogapping. So far as we can tell, all of her examples belong to one of the following three classes: (i) antecedentless pseudogapping; (ii) pseudogapping combined with an independent nominal ellipsis or adjunct ellipsis; (iii) wrapping-type pseudogapping. For example, her (36) on p. 77 *Does it [writing a check at a grocery store] usually take this long? – No, it never did me before* can be analyzed as an instance of (i), where what's missing after *did* is simply the verb (plus preposition) *happen to*. We take such data to be analyzed along lines similar to antecedentless VP ellipsis discussed in Miller and Pullum (2012). Examples such as (1) on p. 75 *We'll share it–like we do ∅ the pink [blouse]* is an instance of (ii), where the ellipsis of *blouse* after *pink* is nominal ellipsis independent of pseudogapping.

including the issue of overgeneration (which was prominent in our discussion above) as well as the generality and simplicity of the analysis (which, in the case of other phenomena, such as quantifier scope and extraction, may argue in favor of employing a λ-binding-based technique over other types of techniques). In any event, we believe that it is only through such theory comparison based on careful empirical study (and one that seriously attempts to maintain the best balance between multiple, often conflicting theoretical desiderata) that we can ultimately arrive at a better understanding of what kinds of formal techniques are indispensable (or most optimal) for the analysis of natural language.

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