Right-Node Wrapping: A Combinatory Account*

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Abstract

This paper aims to show that a new pattern of non-canonical coordination (NCC), going under the rubric Right-Node Wrapping (RNW), follows naturally from independently motivated accounts of coordination and discontinuous constituency. The analysis is seated in a combinatory variant of Categorial Grammar (CG) which licenses discontinuous constituency in a highly constrained way that nonetheless describes a broad range of phenomena. It also demonstrates that the coordination data captured by Dowty's (1988) continuous combinatory CG can be accounted for straightforwardly in the present system with minor extensions. The central claim then is that these independent accounts together predict nearly the full range of observed RNW data, including some previously unknown variants of the phenomenon. In RNW coordinations, the pivot expression shared by the conjuncts is followed by some additional expression interpreted as part of the rightmost conjunct alone (Wilder, 1999; Whitman, 2009). Due to empirical similarities between RNW and NCC, any adequate account of NCC should naturally predict RNW. However, previous like-category coordination analyses of NCC in CG can only generate peripheral pivots, thereby failing on RNW. The proposal succeeds in this respect by assigning the right conjunct discontinuous constituency. The present formulation of discontinuity is compared favorably to existing discontinuity-based analyses of RNW in multimodal Type Logical Grammar (TLG) (Whitman, 2009; Kubota, 2014, Ms.) and Linearization Based HPSG (Chaves, 2014). Finally, it is argued that the variety of discontinuity found in RNW cannot be subsumed under more general notions of discontinuity in TLG (e.g. Kubota and Levine, forthcoming; Morrill and Valentín, 2012).

Keywords: Right-Node Wrapping, discontinuity, Discontinuous Combinatory Categorial Grammar, coordination, wrap, Type-Logical Grammar

1 Introduction

Categorial Grammar[1] (CG) is celebrated for its elegant accounts of non-canonical constituent coordination (NCC) (e.g. Steedman, 1985; Dowty, 1988) and discontinuous constituency by *wrapping* (e.g. Bach, 1979; Moortgat, 1988). Only recently, however, have novel empirical discoveries—namely the Right-Node Wrapping (RNW) phenomenon (Wilder, 1999; Whitman, 2009)—focused research on the intersection of these domains.[2]

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[1]Herein 'Categorial Grammar' and 'CG' refer to both the combinatory and type-logical approaches. I use 'CCG' and 'TLG' respectively to express this distinction. 'CCG' is not restricted to Steedman's (e.g. 2000) theory of the same name.

[2]Of course Gapping represents a long-known type of discontinuous coordination, but as I argue in §4.5 this is not properly a *wrap* phenomenon.

For the present discussion, RNW is defined as any coordination (non-canonical or otherwise) in which the rightmost conjunct is a discontinuous constituent surrounding some expression shared by all the conjuncts (henceforth the 'pivot'). Consider (1): the left conjunct (A) and the right conjunct (B, B′) both take the pivot (C) as argument. Note that an alternative analysis in which the conjuncts are A and B and the pivot C-B′ is not possible, as B′ is not a semantic argument of A. (In this and in other examples, conjuncts are shown in square brackets, discontinuous constituents underlined, and pivots in boldface.)

(1) John should [fetch] and [<u>give</u> **the book** <u>to Mary</u>]. (Wilder, 1999)
A B C B′

As I explore in §4, RNW is far less restricted than this single example suggests, and even richer than previously acknowledged in the literature. This paper defends the position that (nearly) all these new data can be gotten for free from adequate, independently motivated analyses of NCC and discontinuity.

2 Discontinuous CCG

Combinatory Categorial Grammars (CCGs) are extensions of the categorial systems of Ajdukiewicz (1935) and Bar-Hillel (1953) which postulate a number of primitive combinatory rules that operate on the phonology, syntax, and semantics of expressions. Following Jacobson (2014), all expressions, including lexical entries, take the form of triples of phonology, syntactic category, and semantics. In the following I notate an expression α with phonology $[\alpha]$, category A, and semantics α' as follows: $\alpha \ : \ \langle [\alpha] \ ; \ A \ ; \ \alpha' \rangle$. For expository purposes, I will refer to phonological strings with English orthography and omit angle brackets and the semantic dimension whenever possible.

The discontinuous CCG (DCCG) adopted in this paper pairs a new prosodic calculus with the categorial syntax using a set of combinatory rules. In the prosodic calculus there are four operations on strings O_i which build larger strings from their constituent parts. Each operation on strings is paired with a category constructor $/_i$ in the syntax that shares its subscript. As in many other CG approaches, the semantics is directly compositional, built up in parallel with the syntax.

The most basic of combinatory rules is 'function application' (**FA**), which corresponds to the slash elimination rules in TLG. Like the other combinatory rules, **FA** has effects in each dimension: in the syntactic dimension the main slash of the functor is eliminated, in the semantic dimension the functor is applied to the argument, and in the phonological dimension the functor and argument expressions are taken as first- and second-argument respectively to the operation on strings corresponding to the functor's main slash. The stipulation that the functor is always the *first* argument into the operation on strings becomes a central point of analysis to follow.

(2) **FA**
Given expressions $\alpha : \langle [\alpha] \ ; \ A/_i B \ ; \ \alpha' \rangle$ and $\beta : \langle [\beta] \ ; \ B \ ; \ \beta' \rangle$, infer an expression γ : $\langle [O_i(\alpha, \ \beta)] \ ; \ A \ ; \ \alpha'(\beta') \rangle$. (Jacobson, 2014a)

The prosodic calculus operates on strings of two sorts. The continuous sort L^0 includes strings with no infixation point (i.e. discontinuity), while the discontinuous sort L^1 includes strings with exactly one infixation point (denoted as in Jacobson (2014a) with the vertical bar '$|$'). It contains two modes of operations on strings: a continuous and a discontinuous mode, each of which includes two operations defined polymorphically over input strings of different sorts. This way, the operations of the continuous mode are still defined over discontinuous arguments.

The operations in the continuous mode, *left-* and *right-concatenation*—O_L and O_R—are identical (but with their arguments reversed), except in the $L^1 \times L^1$ condition. In this case the convention is that only the discontinuity in the first argument is preserved in the resulting string.

(3) For strings $w,\ x,\ y,\ z\ \in\ L^0$:

$$O_R : \begin{cases} O_R(x,\ y) = xy \\ O_R(x|y,\ z) = x|yz \\ O_R(x,\ y|z) = xy|z \\ O_R(w|x,\ y|z) = w|xyz \end{cases} \qquad O_L : \begin{cases} O_L(x,\ y) = yx & L^0 \times L^0 \to L^0 \\ O_L(x|y,\ z) = zx|y & L^1 \times L^0 \to L^1 \\ O_L(x,\ y|z) = y|zx & L^0 \times L^1 \to L^1 \\ O_L(w|x,\ y|z) = yzw|x & L^1 \times L^1 \to L^1 \end{cases}$$

The convention for 'passing up' infixation points is simple: all infixation points in the arguments are preserved in the output unless both arguments have an infixation point, in which case only the functor's remains.

The pair of operations in the discontinuous mode is *wrap*—O_W—and *infixation*—O_I. As with concatenation, they are defined polymorphically, though this time for all strings $x, /y$, it holds that $O_I(x,\ y) = O_W(y,\ x)$; for this reason I omit the O_I definitions. Put generally, the argument which ends up discontinuous in the resulting string must have an infixation point. In the resulting expression, the infix string occupies the place of the infixation point, so the number of infixation points in the output is always one less than that of the arguments together.

(4) For strings $w,\ x,\ y,\ z\ \in\ L^0$:

$$O_W : \begin{cases} O_W(x,\ y) = N/A & L^0 \times L^0 \to N/A \\ O_W(x|y,\ z) = xzy & L^1 \times L^0 \to L^0 \\ O_W(x,\ y|z) = N/A & L^0 \times L^1 \to N/A \\ O_W(w|x,\ y|z) = wy|zx & L^1 \times L^1 \to L^1 \end{cases}$$

2.1 introducing discontinuity

The operations on strings introduced so far only preserve discontinuities or eliminate them. For English, then, I propose an additional unary operation on strings O_{IR} which equips a continuous string with an infixation point on its right edge.

(5) For strings $x,\ y\ \in\ L^0$:

$$O_{IR} : \begin{cases} O_{IR}(x) = x| & L^0 \to L^1 \\ O_{IR}(x|y) = N/A & L^1 \to N/A \end{cases}$$

Accordingly there is a unary combinatory rule **I** (mnemonic for 'infixation' and 'identity') which is paired with O_{IR}. **I** applies O_{IR} to the phonology of the input, shifts the innermost $/_R$ of the input's category to a $/_W$, and applies the combinator 'I' (the identity function) to the semantics. Significantly, **I** is defined so that the introduction of infixation points is restricted to 'syntactic words' of certain categories.

Such a claim, of course, requires a well-defined notion of word. For the time being, I follow Hoeksema (1984), Zwicky (1992), and Moortgat and Oehrle (1994) in supposing that the prosodic sort of an expression should be marked in the expression's syntactic category.

In the notation of Hoeksema, X^0 contains all expressions in X of the 'word' sort, and X^1 those expressions of the 'phrase' sort. A property of the Hoeksema and the Moortgat and Oehrle accounts, and one which I adopt, is that any part of a complex category may be marked with its sort. For example, in a morphologically complex N^0 'electric organ player', the subexpression 'electric organ' can have the category $(N^0/_R N^0)^1$—i.e. it is a member of the phrase sort that is a function from a word to another word. To eliminate notational clutter, these details will be omitted when irrelevant.

This restriction is accomplished by defining **I** over members of the word sort alone. **I** is further restricted to functions which after taking some non-zero number of arguments return either an $S/_L NP$ or an N. Such categories include transitive verbs, ditransitive verbs, attributive adjectives, and predicative adjectives. (This is the meaning of the $X\$$, which is recursively defined as the set of expressions α such that $\alpha \in X$ or $\alpha \in B/_i C$ for all B and for all $C \in X\$$. $X\$_i$ is some particular member of $X\$$.)

(6) **I**
Given an expression α : $\langle[\alpha]\ ;\ (X/_R Y)\$^0_i\ ;\ \mathrm{a}\rangle$, infer an expression β : $\langle[O_{IR}(\alpha)]\ ;\ (X/_W Y)\$^0_i\ ;\ a\rangle$ where $X \in \{S/_L NP, N\}$.

2.2 some empirical motivation

So far, DCCG can already account for considerable discontinuity data. Ditransitives like *give* are stored in the lexicon with the category $(VP/_R NP)/_R PP$. By stipulating only the continuous category in the lexicon, we obtain the two word orders associated with the ditransitive by the optional application of **I**: the heavy-NP shift *V-PP-NP* order (7a) is gotten from the lexical category of *give*, and the canonical *V-NP-PP* order (7b) is gotten from applying **I** to *give*.

(7) a.

$$\dfrac{\dfrac{\overset{\text{gave}}{((VP/_R NP)/_R PP)^0} \quad \overset{\text{to Bach}}{PP}}{\text{gave to Bach: } VP/_R NP}\,\mathbf{FA} \quad \overset{\text{the oboe}}{NP}}{\text{gave to Bach the oboe: } VP}\,\mathbf{FA}$$

b.

$$\dfrac{\dfrac{\dfrac{\overset{\text{gave}}{((VP/_R NP)/_R PP)^0}}{\text{gave}|\text{: } ((VP/_W NP)/_R PP)^0}\,\mathbf{I} \quad \overset{\text{to Bach}}{PP}}{\text{gave}|\text{to Bach: } VP/_W NP}\,\mathbf{FA} \quad \overset{\text{the oboe}}{NP}}{\text{gave the oboe to Bach: } VP}\,\mathbf{FA}$$

Jacobson (2014a) also proposes this constituency for ditransitives to explain the weak-crossover effects in (8). In terms of Jacobson's (1999) variable-free account of pronoun binding, the aforementioned binding asymmetries are explained by virtue of the verb taking its direct object after its indirect object (the same asymmetry is observed in the heavy-NP shift version, suggesting the same constituency). Alternately, in a configurational account of binding (which is in many ways an epiphenomenon of the variable-free account), the direct object c-commands the indirect object.

(8) a. Bach gave no score$_i$ to its$_i$ owner after Friday.
b. *Bach gave her$_i$ score to no soprano$_i$ after Friday.

Note also that the combinator **I** is formalized such that it may apply to transitive verbs, though in the simplest case this step does not alter the relative order of the verb and its object (9). Such cases will henceforth be referred to as 'vacuous wrap'. It is not the case however that all applications of **I** to transitive verbs results in vacuous wrap. This mechanism is responsible for DCCG's account of the verb-particle alternation which productively modify and form both continuous and discontinuous constituents with transitive verbs (10), modulo some aspectual restrictions.

(9) a.

$$\dfrac{\dfrac{\text{compose} : VP/_R NP \qquad \text{a fugue} : NP}{O_R(\text{compose, a fugue}) : VP}\,\mathbf{FA}}{\text{compose a fugue} : VP}\,O_R$$

b.

$$\dfrac{\dfrac{\dfrac{\text{compose} : VP/_R NP}{\text{compose}| : VP/_W NP}\,\mathbf{I} \qquad \text{a fugue} : NP}{O_W(\text{compose}|, \text{a fugue}) : VP}\,\mathbf{FA}}{\text{compose a fugue} : VP}\,O_W$$

Productive particles like *out* can be supposed to belong to $VP\$^0_i/_L VP\$^0_i$, i.e. they modify verbs with any argument structure as long as they are of the *word* sort, and give back a member of the *word* sort of the same category. Applying **I** to the verb-particle pair gives the continuous particle-verb alternate (10a), while applying **I** to the verb alone gives the discontinuous one (10b).[3]

(10) a. Bach copied/wrote/transcribed/distributed out the parts.
b. Bach copied/wrote/transcribed/distributed the parts out.

The ditransitive particle-verb data (11a)-(11b) discussed in Emonds (1976) falls out by the same mechanism,[4] while (11c) is not generated, as a discontinuous expression like a particle-verb pair can only *wrap* around one argument—O_W in (4) 'fills in' the infixation point.

(11) a. Bach sent out the parts to the singers.
b. Bach sent the parts out to the singers.
c. *Bach sent the parts to the singers out.

The interaction between heavy-NP shift and particle alternation (12) has not been discussed previously in the syntactic literature as far as I know. Strikingly, these data are entirely predicted by the present account.

(12) a. Bach sent out to the singers the parts (that he edited yesterday).
b. *Bach sent to the singers out the parts (that he edited yesterday).
c. *Bach sent to the singers the parts (that he edited yesterday) out.

Recall that the heavy-NP shift word order occurs only when **I** is never applied to the verb. Therefore, only the continuous particle-verb pair (12a) is possible, and the discontinuous ones (12b)-(12c) are correctly predicted ungrammatical.

[3] Idiosyncratic (i.e. non-productive) particle-verb pairs (e.g. look up, take on, throw out) show the same syntactic alternation as productive pairs. Under the assumption that such idiomatic expressions must be specified in the lexicon, it is necessary that each pair has two phonologies—e.g. *look*| *up* and *look up*|. Luckily, this assumption is flawed. Rather we can postulate idiomatic lexical entries $look_2$ and up_2 which have the syntax of non-idiomatic *look* and *up*—therefore the alternation in the syntax follows as with the productive pairs. The semantics of up_2, though, is partial function defined only over $look_2$. This analysis is supported by evidence noted by Jacobson (1987) which shows the semantics of even idiosyncratic particles must be partly compositional:

(i) John looked [this word up in the dictionary] and [that word up in the thesaurus].

[4] Emonds points out data similar to (11) concerning the interaction of ditransitives, particles, and the passive which do not clearly follow in the present analysis:

(i) a. The singers were sent out the parts.
b. *The singers were sent the parts out.

An analysis of (11b), however, requires an analysis of the passive, which is far outside the scope of this paper. I must, then, leave these data as an open question.

(13)

sent: $((VP/_R NP)/_R PP)^0$ out: $VP\$^0_i/_L VP\$^0_i$
————————————————— **FA**
sent out: $((VP/_R NP)/_R PP)^0$ to the singers PP
————————————————— **FA**
sent out to the singers: $VP/_R NP$ the parts NP
————————————————— **FA**
sent out to the singers the parts: VP

sent: $((VP/_R NP)/_R PP)^0$
————————————————— **I**
sent|: $((VP/_W NP)/_R PP)^0$ out $VP\$^0_i/_L VP\$^0_i$
————————————————— **FA**
sent| out:$((VP/_W NP)/_R PP)^0$ to the singers PP
————————————————— **FA**
sent| out to the singers: $VP/_W NP$ the parts NP
————————————————— **FA**
sent the parts out to the singers: VP

sent: $((VP/_R NP)/_R PP)^0$ out: $VP\$^0_i/_L VP\$^0_i$
————————————————— **FA**
sent out:$((VP/_R NP)/_R PP)^0$
————————————————— **I**
sent out|: $((VP/_W NP)/_R PP)^0$ to the singers PP
————————————————— **FA**
sent out| to the singers: $VP/_W NP$ the parts NP
————————————————— **FA**
sent out the parts to the singers: VP

Additionally, **I** predicts the existence of attributive adjectives which take their arguments by *wrap*. Certainly, this is necessary for the description of 'tough'-adjectives (14a), for which a *wrap* analysis dates back to Bach (1979). Considering adjectives which take no additional arguments, however, at first blush the application of **I** appears to do no more than license vacuous *wrap*. As with transitive verbs though, there is empirical evidence that prenominal adjectives productively form discontinuous constituents, in this case with comparatives (14b).

(14) a. Bach is a tough composer to please.
(*cf. Bach is tough to please*)
b. Bach is a more creative composer than Telemann.
(*cf. Bach is more creative than Telemann*)

As we will see in §4, this particular formalization of **I**, in particular extension to cases which lead to vacuous *wrap*, makes important and empirically successful predictions in the domain of coordination.

2.3 cross-serial dependencies in Swiss German

Since Pollard (1984) showed that a simple head-wrapping mechanism can successfully generate them, cross-serial dependencies in Dutch and Swiss German (15) have rightfully become a rite of passage for discontinuity calculi. Proven non-context-free (Shieber, 1985), the Swiss German construction is powerful evidence for including non-context-free operations like *wrap* in the grammar.

(15)

...	mer	d'chind	em	Hans	es huus	lönd	hälfed	aastriiche.
...	we	the children.ACC	DAT	Hans	the house.ACC	let	help	paint.

'...we let the children help Hans paint the house.'

Though a complete analysis in DCCG is outside the scope of this paper, (16) is something of a proof-of-concept. Of course, Swiss German's prosodic calculus need not be identical to English's—instead of the O_{IR} operation which provides a word with an infixation point to its right, Swiss German makes use of the O_{IL} which adds the infixation point on the left.

The general pattern is that embedded verbs are given infixation points on the left, while they are infixed into by the functors which take them. A similar analysis is proposed by Calcagno (1995).

(16)

$$\dfrac{\dfrac{\text{mer}}{NP_{\text{NOM}}} \quad \dfrac{\dfrac{\text{d'chind}}{NP_{\text{ACC}}} \quad \dfrac{\dfrac{\dfrac{\text{em-Hans}}{NP_{\text{DAT}}} \quad \dfrac{\dfrac{\dfrac{\text{es-huus}}{NP_{\text{ACC}}} \quad \dfrac{|\text{aastriiche}}{VP/_{L}NP_{\text{ACC}}}}{\text{es-huus }|\text{aastriiche} : VP}\,\textbf{FA} \quad \dfrac{|\text{hälfed}}{(VP/_{L}NP_{\text{DAT}})/_{I}VP}}{\text{es-huus }|\text{hälfed aastriiche} : VP/_{L}NP_{\text{DAT}}}\,\textbf{FA}}{\text{em-Hans es-huus }|\text{hälfed aastriiche} : VP}\,\textbf{FA} \quad \dfrac{\text{lönd}}{(VP/_{L}NP_{\text{ACC}})/_{I}VP}}{\text{em-Hans es-huus }|\text{lönd hälfed aastriiche} : VP/_{L}NP_{\text{ACC}}}\,\textbf{FA}}{\text{d'chind em-Hans es-huus lönd hälfed aastriiche} : VP}\,\textbf{FA}}{\text{mer d'chind em-Hans es-huus lönd hälfed aastriiche} : S}\,\textbf{FA}$$

While it may well be that Swiss German uses something like the **I** combinator, it does not appear relevant to cross-serial dependencies. Recall that **I** equips a functor with a *wrap* category and an infixation point, while in (16) it is the argument verb which requires the infixation point (*aastriiche* 'paint' has an infixation point while *lönd* 'let' does not).

Whatever the combinatory details, it is clear that with the natural addition of O_{IL}, DCCG's set of operations on strings is adequate for describing cross-serial dependencies.

3 NCC with discontinuity

3.1 the combinatory approach

Dowty's (1988) landmark account of non-constituent coordination (NCC) in a continuous CCG is among the greatest empirical successes of the CCG approach. The account relies on a syntactic use of the type-raising combinator of Partee and Rooth (1983) (henceforth **L** for 'lift') and function composition (which, following (17) Jacobson (2014a), the present account eschews in favor of its Curry-ed version—the unary Geach/Division combinator (18), henceforth **G**). However, Dowty (1997) notes that the account fails upon the introduction of canonical discontinuous constituents, as his combinators are not defined in such cases.

(17) **L** $\quad A \Rightarrow B/_{L}(B/_{R}A) \qquad A \Rightarrow B/_{R}(B/_{L}A)$

(18) **G** $\quad A/_{R}B \Rightarrow (A/_{R}C)/_{R}(B/_{R}C) \qquad A/_{L}B \Rightarrow (A/_{L}C)/_{L}(B/_{L}C)$

It is sentences like (19) which do not follow under the new set of assumptions in DCCG. In both systems, these sentences involve coordination of non-canonical constituents, however DCCG introduces the complication that part or all of the pivot canonically forms a discontinuous constituent with some of the conjunct.

(19) a. Bach **gives** [melismas to oboes] and [chorales to bassoons].
b. [Bach copied] and [Anna Magdalena sent] **the parts out**.

Considering the proof from Dowty (1988) (20), it is clear that a comparable proof is not possible yet in DCCG. The first argument into the verb must be lifted over the TV category and the second argument over the VP category (so that it takes a TV as argument). A comparable proof in DCCG would aim to *lift* the NP argument to VP/TV. However, recall that in DCCG, TV abbreviates $VP/_{W}NP$: Dowty's (1988) continuous version of **L** cannot produce this $/_{W}$.

(20) Where $TV = VP/_{R}PP$ and $DV = (VP/_{R}PP)/_{R}NP$:

$$
\dfrac{\text{gave} : DV \qquad \dfrac{\dfrac{\text{melismas} : NP}{TV/_L DV}\,\mathbf{L} \qquad \dfrac{\dfrac{\dfrac{\text{to oboes} : PP}{VP/_L TV}\,\mathbf{L}}{(VP/_L DV)/_L(TV/_L DV)}\,\mathbf{G}}{}}{VP/_L DV}\,\mathbf{FA}}{VP}\,\mathbf{FA}
$$

To give **L** and **G** for the discontinuous mode, we need only adopt the intuition underlying Lambek's (1958) calculus: that the definitions of these combinators preserve word order. **L** must in effect 'switch' a functor and argument pair, while preserving their relative orders. This is accomplished by making the main slash of the *lifted* category the reverse of the original functor's, and making the two slashes of the *lifted* categories reverses of each other. So just as in Dowty's (1988) CCG where the two ways to *lift* A over B were $B/_L(B/_R A)$ and $B/_R(B/_L A)$, the new *lifts* introduced in DCCG by the discontinuous mode are $B/_I(B/_W A)$ and $B/_W(B/_I A)$.

As such, however, **L** is not guaranteed to be word-order preserving. Recall that a crucial feature of DCCG is that the pair of operations on strings in a mode is not symmetric: i.e. it is not necessarily the case that $O_R(a,\ b) = O_L(b,\ a)$

$$
O_R(a\big|b,\ c\big|d) \stackrel{?}{=} O_L(c\big|d,\ a\big|b)
$$
$$
a\big|bcd \neq abc\big|b
$$

Therefore, simply assuring that the slashes 'disagree' is not sufficient to ensure word-order preservation. An order preserving convention is easy, though, with the introduction of a new (cross-modal) feature on slashes: for all modes i, $/_i^A$ will denote a functor expression whose phonology, upon taking its argument by **FA** , is the *second* argument to the operation on strings *opposite* to i. This mechanism simply ensures that the same operation on strings combines functor and argument whether or not **L** applies. In most cases, this detail is irrelevant and omitted.

(21) **FA**
Given expressions $\alpha : \big\langle[\alpha]\ ;\ A/_i^A B\ ;\ \alpha'\big\rangle$ and $\beta : \big\langle[\beta]\ ;\ B\ ;\ \beta'\big\rangle$, infer an expression $\gamma : \big\langle[O_j(\beta,\ \alpha)]\ ;\ A\ ;\ \alpha'(\beta')\big\rangle$ where $i \neq j$ and $i, j \in \{R, L\}$ or $\{W, I\}$.

Now an order preserving **L** is possible. In addition to the modes on the slashes 'disagreeing', the superscripts must not match either.

(22) **L**
For all categories A, B with semantic types a, b respectively, given an expression $\langle[\alpha]\ ;A\ ;x\rangle$, infer an expression $\big\langle[\alpha]\ \ ;B/_i^M(B/_j^N A)\ \ ;\lambda F_{a\to b}[Fx]\big\rangle$ where $i \neq j$ and $i, j \in \{R, L\}$ or $\{W, I\}$; and $M \neq N$ and $M, N \in \{A, \emptyset\}$.

Discontinuous **G** also requires a bit of additional detail. **G** 'divides' both sides of a functor category by the same category—the first step of Curry-ed function composition. Continuous **G** ensures word-order preservation by stipulating that the introduced slashes 'agree' with the main slash of the original expression. In the discontinuous mode, however, we no longer find that it is necessary to make all the slashes' subscripts 'agree' as in the continuous version. (23)[5] shows a pair of proofs which both prove the same string from the same initial expressions, but differ in their internal details. Crucially, in (23b) *none* of the slashes following the **G** operation 'agree'. Despite this (or rather *because* of this), the same result is gotten as in (23a) which uses only **FA**.

[5]Note that operations on strings are not rules of inference in the grammar—their appearance in these proofs is purely expositional.

(23) a.

$$\dfrac{\dfrac{\mathrm{x|x} : A/_{W}B \qquad \dfrac{\mathrm{z} : C \qquad \mathrm{y} : B/_{L}C}{O_L(\mathrm{y},\,\mathrm{z}) : B}\,\mathbf{FA}}{\dfrac{O_W(\mathrm{x|x},\ O_L(\mathrm{y},\,\mathrm{z})) : A}{O_W(\mathrm{x|x},\ \mathrm{zy}) : A}\,O_L}\,\mathbf{FA}}{\mathrm{xzyx} : A}\,O_W$$

b.

$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\mathrm{x|x} : A/_{W}B}{\mathrm{x|x} : (A/_{W}C)/_{R}(B/_{L}C)}\,\mathbf{G} \qquad \mathrm{y} : B/_{L}C}{O_R(\mathrm{x|x},\,\mathrm{y}) : A/_{W}C}\,\mathbf{FA} \qquad \mathrm{z} : C}{O_W(O_R(\mathrm{x|x},\,\mathrm{y}),\,\mathrm{z}) : A}\,\mathbf{FA}}{O_W(\mathrm{x|xy},\,\mathrm{z}) : A}\,O_R}{\mathrm{xzyx} : A}\,O_W$$

If **G** is to continue to license all and only those divisions which are order-preserving, its new definition must make this detail explicit, as this result can no longer be accomplished by stipulating that the slashes must agree. The pair of proofs in (23) suggests a new formalization. Note that they show the following:

$$O_W(x|x,\ O_L(y,\ z)) = O_W(\,O_R(x|x,\ y),\ z)\ .$$

Similarly, for any four (not necessarily distinct) operations O_i, O_j, O_k, O_l, if:

$$O_i(x,\ O_l(y,\ z)) = O_j(O_k(x,\ y),\ z)\ ,$$

then it must be the case that if $x \in A/_{i}B$, $y \in B/_{l}C$, and $z \in C$, then the type shift $A/_{i}B \Rightarrow (A/_{j}C)/_{k}(B/_{l}C)$ is order preserving. The new statement of **G** follows from this insight:

(24) **G**
For all categories A, B, C with respective semantic types a, b, c, given an expression $\langle [x]\ ;\ A/_{i}B\ ;\ F\rangle$, infer an expression $\Big\langle [x]\ ;\ (A/_{j}C)/_{k}(B/_{l}C)\ ;\ \lambda G_{c\to b}[\lambda u_c[F(Gu)]]\Big\rangle$, for all operations O_i, O_j, O_k, O_l such that for all strings $x \in A/_{i}B$, $y \in B/_{l}C$, $z \in C$, $O_i(x,\ O_l(y,\ z)) = O_j(O_k(x,\ y),\ z)$.

Having updated the combinators, NCC follows from DCCG just as before:

(25) Where $TV = VP/_{W}NP$ and $DV = (VP/_{W}NP)/_{R}PP$:

$$\dfrac{\dfrac{\dfrac{\dfrac{\text{melismas} : NP}{\text{melismas} : VP/_{I}TV}\,\mathbf{L}}{\text{melismas} : (VP/_{I}DV)/_{R}(TV/_{L}DV)}\,\mathbf{G} \qquad \dfrac{\text{to oboes} : PP}{\text{to oboes} : TV/_{L}DV}\,\mathbf{L}}{\text{melismas to oboes} : VP/_{I}DV}\,\mathbf{FA}}{}$$

$$\dfrac{\dfrac{\text{give} : (VP/_{R}NP)/_{R}PP}{\text{give}| : DV}\,\mathbf{I} \qquad \dfrac{\begin{array}{c}\vdots\\ \text{melismas to oboes}\\ VP/_{I}DV\end{array} \qquad \begin{array}{c}\vdots\\ \text{and chorales to bassoons}\\ (VP/_{I}DV)/_{L}(VP/_{I}DV)\end{array}}{\text{melismas to oboes and chorales to bassoons} : VP/_{I}DV}\,\mathbf{FA}}{\text{give melismas to oboes and chorales to bassoons} : VP}\,\mathbf{FA}$$

3.2 the multimodal TLG approach

Discontinuity calculi in TLG are generally flexible enough to account for these data as well. Consider, for instance, Morrill's (1995) multimodal logic in which for each mode of adjunction $+_i$ (corresponding to my operations on strings), there is a corresponding pair of connectives such that:

$$s \in A/_{i}B \text{ iff } \forall\ s'_{\in B}[s +_i s' \in A] \qquad\qquad s \in B\backslash_i A \text{ iff } \forall\ s'_{\in B}[s' +_i s \in A].$$

Among the modes of adunction are concatenation and wrap. Therefore, this calculus effectively employs wrap while maintaining closure under all continuous non-canonical coordinations.

Dowty (1997) is of particular interest here for his use of Moortgat and Oehrle's (1994) logic to account for the same phenomena from his (1988) account in a continuous CCG. Moortgat and Oehrle (1994) achieve flexible constituency from both structural associativity rules and from slash introduction, and simulate *wrap* with structural commutativity. Moortgat and Oehrle (1994) propose a head-wrapping calculus (henceforth M&O94) in TLG which Dowty (1997) adopts to account for discontinuity in English and Dutch.

Dowty summarizes the intuition of the system in prose:

1. wrapping/infixing types (e.g. $VP/_W VP$; $(VP/_W NP)/VP$, etc.) combine with an argument via an abstract discontinuous mode of combination, $\bullet_w$.
2. A structual axiom (Mixed Commutativity) may then "commute" the $\bullet_w$ operation with respect to $\bullet$, and in doing so it "permutes" one of the operands of the first with an operand of the second [...]. By recursive use of this rule (and possibly Mixed Associativity), the original operand may 'move' some distance away from its position of origin.
3. All infxing/wrapping verbs are also assigned to a specific infixing sort, denoted $(A)_i$ for a verbal type A. As such they serve as a "trigger" for a sort inclusion rule: when the "permuting" element has become adjacent to the desired goal (a trigger sort or cluster) by 2., the sort interaction axiom can then eliminate the abstract mode $\bullet_w$ in favor of ordinary concatenation, simultaneously converting the wrapped/infixed element plus its verbal argument into a cluster sort. Once the linear concatenation operation has replaced $\bullet_w$, its operands are of course no longer subject to the Commutativity axiom.
4. A derivation is "complete" only when $\bullet_w$ modes have been eliminated, i.e. when the expression is completely linear. (In terms of Gentzen sequent derivations, only fully linear strings may be the input to analysis.)

Formally, 'Slash Elimination' and 'Slash Introduction' are paired with a prosodic calculus. In the phonological dimension, strings are fully bracketed and labeled with their prosodic sort, and every adjacent bracketing is joined with a modalized connective. The concatenation connective is simply '$\circ$'.

(26) a.
$$\dfrac{\dfrac{\overline{\big\langle (a \circ_i b)\ ;\ A\ ;\ \alpha' \big\rangle^n}}{\vdots}\qquad}{\dfrac{\big\langle b\ ;\ B\ ;\ \beta' \big\rangle}{\big\langle a\ ;\ A/_i B\ ;\ \lambda\alpha'[\beta'] \big\rangle}\ /_i\mathrm{I}^n}$$

b.
$$\dfrac{\dfrac{\overline{\big\langle (b \circ_i a)\ ;\ A\ ;\ \alpha' \big\rangle^n}}{\vdots}\qquad}{\dfrac{\big\langle b\ ;\ B\ ;\ \beta' \big\rangle}{\big\langle a\ ;\ B\backslash_i A\ ;\ \lambda\alpha'[\beta'] \big\rangle}\ \backslash_i\mathrm{I}^n}$$

In addition to the concatenation mode there is a *wrap* mode, with connective '$\circ_w$':

(27) a.
$$\dfrac{\big\langle a\ ;\ A/_i B\ ;\ \alpha' \big\rangle \quad \big\langle b\ ;\ B\ ;\ \beta' \big\rangle}{\big\langle (a \circ_i b)\ ;\ A\ ;\ \alpha'(\beta') \big\rangle}\ /_i\mathrm{E}$$

b.
$$\dfrac{\big\langle b\ ;\ B\ ;\ \beta' \big\rangle \quad \big\langle a\ ;\ B\backslash_i A\ ;\ \alpha' \big\rangle}{\big\langle (b \circ_i a)\ ;\ A\ ;\ \alpha'(\beta') \big\rangle}\ \backslash_i\ \mathrm{E}$$

A number of interaction axioms relate the concatenation and wrap modes. 'Mixed Associativity 2' allows for the rearranging of bracketings, while 'Mixed Communtativity 2' simulates the *wrap* operation by commuting two elements.[6] Finally, the 'Inclusion' axiom eliminates the *wrap* connective when it is adjacent to an infixing word, shifting its phrasal bracketing '$(\dots)_{ph}$' to a phonological cluster bracketing '$(\dots)_c$'. These axioms have no semantic or syntactic effects, so these components are left out of their definitions.

(28) a. b. c.

$$\frac{(a \circ b) \circ_w c}{a \circ (b \circ_w c)}\text{M-Assoc-2} \qquad \frac{(a \circ b) \circ_w c}{(a \circ_w c) \circ b}\text{M-Comm-2} \qquad \frac{(a_i \circ_w b)_{ph}}{(a_i \circ b)_c}\text{Incl}$$

With these rules, the discontinuous ditransitive is highly natural. Verbs like *give* are of the infixing sort (i.e. are stored in the lexicon as, e.g. $give_i$) with category $(VP/_W NP)/_R PP$. Note that the heavy-NP shift version does not follow immediately in this system as in DCCG, though a rule like **I** is conceivable.

(29)

$$\cfrac{\cfrac{\text{give}_i : (VP/_W NP)/_R PP \qquad \text{to Telemann} : PP}{(\text{give}_i \circ \text{to Telemann}) : VP/_W NP}/_R\text{E} \qquad \text{the oboe} : NP}{\cfrac{((\text{give}_i \circ \text{to Telemann}) \circ_w \text{the oboe}) : VP}{\cfrac{((\text{give}_i \circ_w \text{the oboe}) \circ \text{to Telemann}) : VP}{((\text{give}_i \circ \text{the oboe})_c \circ \text{to Telemann}) : VP}\text{Incl}}\text{M-Comm-2}}/_W\text{E}$$

Dowty, unwittingly it seems, introduces a new mixed associaitivity axiom which I will call 'Mixed Associativity 4' ('Mixed Associativity 3' is already used by Whitman (2009)):

(30)

$$\frac{(\text{a} \circ_w \text{b}) \circ \text{c}}{\text{a} \circ_w (\text{b} \circ \text{c})}\text{M-Assoc-4}$$

This new rule allows for the bracketing of the non-canonical constituent *melismas to oboes*, which feeds into 'Infix-Slash Introduction'. (For notational consistency, I will continue to use $/_L$ and $/_I$ instead of $\backslash$ and $\backslash_W$. Note that in this system, $/_I$ is distinguished from $/_W$ only in that it introduces a *wrap* connective $\circ_w$ to the *left* of the functor.)

(31)

$$\cfrac{\cfrac{\cfrac{[\ ]^a_i : (VP/_W NP)/_R PP \qquad \text{to oboes} : PP}{[\ ]^a_i \circ \text{to oboes} : VP/_W NP}/_R\text{E} \qquad \text{melismas} : NP}{\cfrac{([\ ]^a_i \circ \text{to oboes}) \circ_w \text{melismas} : VP}{\cfrac{([\ ]^a_i \circ_w \text{melismas}) \circ \text{to oboes} : VP}{[\ ]^a_i \circ_w (\text{melismas} \circ \text{to oboes}) : VP}\text{M-Assoc-4}}\text{M-Comm-2}}/_W\text{E}}{\text{melismas} \circ \text{to oboes} : VP/_I((VP/_W NP)/_R PP)}/_I\text{I}^a$$

We have seen then that the introduction of discontinuous constituency has a number of empirical benefits. In most cases, it does not significantly impact existing accounts of phenomena like NCC involving unbounded dependencies. As such, the proliferation of—mostly empirically successful—proposals for discontinuity calculi in CG has made it difficult to settle on a particular analysis best suited to natural language. The following section presents coordination data which suggest, at least by one metric, that DCCG most naturally and successfully describes discontinuous constituency in English.

[6]'Mixed Associativity 1' and 'Mixed Commutativity 1' are proposed only for Dutch by Dowty (1997).

4 Right-Node Wrapping

This paper will now provide an account of a coordination phenomenon discovered independently by Wilder (1999) and Whitman (2009), known in Whitman's work under the rubric 'Right-Node Wrapping' (RNW)[7]. While terminology might suggest that RNW should be considered a separate phenomenon from RNR and NCC in general, I now presents evidence that RNW is simply a special case of NCC. Accordingly, the proposed analysis which follows requires no additional apparatus other than what is already proposed for ordinary NCC and discontinuity.

In the literature up to this point, NCC names those coordinations in which the pivot is on the periphery of the coordination (Dowty, 1988, 1997). By contrast, RNW is defined as those coordinations in which the pivot (shown in bold) is not peripheral, but rather internal to the rightmost conjunct (thus Kubota's (2014, Ms.) name 'Medial RNR'). Crucially, the material following the pivot is (by definition) a semantic argument not of both the conjuncts but rather of the right conjunct alone. Therefore, the right conjunct must be understood, at least if the correct semantics is to be gotten, as a discontinuous expression.

The discontinuous right conjunct is frequently a ditransitive verb and argument (32a)-(32b), or some sort of phrasal verb (32c)-(32d) and argument.

(32) a. [Bach fetched] and [Anna Magdalena gave **the oboe** to Telemann].
b. Bach [met] and [persuaded **Telemann** to write more fugues].
c. Bach [fetched] and [wiped **the oboe** clean].
d. [Bach edited] and [Anna Magdalena sent **the scores** out].

Indeed, Whitman (2009) cites many additional such attested sentences. Note that unequivocal cases of non-canonical constituent conjuncts as in continuous RNR/NCC are possible, e.g. (32a),(32d), where the subject and verb form a conjunct without the object.

Notably, however, the discontinuous conjunct may also consist of a verb and an optional element such as an adjunct. This case is of interest because even in a theory with discontinuous constituency, it is implausible that the discontinuous elements in (33) form canonical discontinuous constituents.

(33) a. Several years ago, in a Washington, D.C. suburb, and undercover police officer [followed] and then [shot **a young motorist** eight times]. (Whitman, 2009)
b. John [scolded] and then [eyed **his misbehaving puppy** silently].

Also consistent with NCC, RNW permits unbounded dependencies:

(34) [Bach thinks that Buxtehude speculated that Schütz fetched] and [Anna Magdalena knows that Monteverdi persuaded Lully to give **the oboe** to Telemann]

Finally, RNW appears to be generally scopally ambiguous—at least under the right context. Similarly, Kubota and Levine (forthcoming) show that (continuous) NCC is systematically scopally ambiguous for conjunction and disjunction, and for upward and downward entailing quantifiers.

(35) a. The lieutenant will either [arrest] or [shoot **every suspected arsonist** with his rifle]. (Sabbagh, 2014)

[7] Much in the way that the name 'Right-Node Raising' is still used in analyses lacking transformations such as raising, 'Right-Node Wrapping' is not intended to presuppose a *wrap* analysis (though indeed this paper advances such an analysis).

b. Carl Philip Emmanuel Bach [secretly hid] or [donated **every manuscript in his father's collection** to the library]. (Many of the former type remain lost, while the latter are well preserved.)

The $\vee > \forall$ reading in which the coordination obtains wide scope (35a) is acknowledged by all authors on RNW (Chaves, 2014; Sabbagh, 2014; Kubota, 2014, Ms.). However, the $\forall > \vee$ reading in which the pivot scopes over the coordination is judged unavailable for that same sentence by Sabbagh, and for all RNW sentences by Chaves. The judgments in cases like (35a) remain quite delicate, but Chaves's strong position does not hold up in light of cases like (35b), in which the *preferred* reading is the disputed one.

The essential conclusion from this discussion is that RNW is no more than a special case of NCC. Aside from discontinuity and its various complications, no empirical differences between RNW and NCC can be found. It follows then that RNW should fall out from adequate, independently motivated accounts of coordination and discontinuity. Indeed, this paper aims to show that just such an analysis is possible.

At this point, it is important to acknowledge that RNW is marginal for many English speakers. Such speakers, however, consistently acknowledge a marked contrast between RNW and a similar pattern—call it 'LNW'—in which the pivot *wraps* into the left conjunct (36).

(36) *[Anna Magdalena gave **the oboe** to Telemann] and [Bach tuned].

Such a sharp contrast should be taken as evidence that RNW is at the very least consistent with English grammar, while LNW is higly non-English-like. Therefore, it is a worthy enterprise to pursue a grammar which generates RNW without overgenerating LNW.[8]

4.1 RNW in DCCG

The attentive reader may have already noted that RNW follows completely for free from the version of DCCG already motivated in §2.2. While this result in itself is striking, just as significantly, the DCCG account of RNW demands a grammar with only a very limited set of available operations.

With only this mechanism in place, most cases of RNW are trivially good, as in (37). The transitive *fetched* and ditransitive *gave* are both equipped with their own infixation points by the combinatory rule **I**. The discontinuity is passed up to the constituent *and gave*| *to Mary* through two concatenation operations. Each of these operations is performed on exactly one discontinuous string and one continuous string, so the infixation point is always preserved. Then, crucially, the concatenation of *fetched*| with *and gave*| *to Mary* preserves only the second of those discontinuities because it is contained within the string with the functor category. This is due to the definition of O_L (see the steps in (37) shown in bold). This is how DCCG ensures the correct placement of the discontinuity, so that the object always infixes into the rightmost conjunct.

[8]This contrast may also be construed as evidence against including RNR, left-sided NCC, and RNW all under one rubric, as leftward sharing appears to be restricted in discontinuous coordination only. However, in the next section I show that this need not be the case: the badness of LNW may follow from the formalization of *discontinuity*, not coordination.

(37)

$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\text{Bach} : NP}{\text{Bach} : S/_R VP}\,\mathbf{L}}{\begin{array}{c}\text{Bach}\\ (S/_W NP)/_R(VP/_W NP)\end{array}}\,\mathbf{G} \quad \dfrac{\begin{array}{c}\text{fetched}\\ VP/_R NP\end{array}}{\begin{array}{c}\text{fetched}|\\ VP/_W NP\end{array}}\,\mathbf{I}}{O_R(\text{Bach, fetched}|) : S/_W NP}\,\mathbf{FA}}{\text{Bach fetched}| : S/_W NP}\,O_R \quad \dfrac{\dfrac{\begin{array}{c}\text{and}\\ (X/_L X)/_R X\end{array} \quad \dfrac{\dfrac{\dfrac{\dfrac{\text{Anna} : NP}{\text{Anna} : S/_R VP}\,\mathbf{L}}{\begin{array}{c}\text{Anna}\\ (S/_W NP)/_R(VP/_W NP)\end{array}}\,\mathbf{G} \quad \dfrac{\dfrac{\dfrac{\begin{array}{c}\text{gave}\\ (VP/_R NP)/_R PP\end{array}}{\begin{array}{c}\text{gave}|\\ (VP/_W NP)/_R PP\end{array}}\,\mathbf{I} \quad \begin{array}{c}\text{to Telemann}\\ PP\end{array}}{O_R(\text{gave}|, \text{to Telemann}) : VP/_W NP}\,\mathbf{FA}}{\text{gave}|\text{to Telemann} : VP/_W NP}\,O_R}{O_R(\text{Anna, gave}|\text{to Telemann}) : VP}\,\mathbf{FA}}{\text{Anna gave}|\text{to Telemann} : VP}\,O_R}{O_R(\text{and, Anna gave}|\text{to Telemann}) : (S/_W NP)/_L(S/_W NP)}\,\mathbf{FA}}{\text{and Anna gave}|\text{to Telemann} : (S/_W NP)/_L(S/_W NP)}\,O_R}{\boldsymbol{O_L}(\textbf{and Anna gave}|\textbf{to Telemann, Bach fetched}|) : \boldsymbol{S/_W NP}}\,\mathbf{FA}}{\textbf{Bach fetched and Anna gave}|\textbf{to Telemann} : \boldsymbol{S/_W NP}}\,\boldsymbol{O_L} \quad \begin{array}{c}\text{the book}\\ NP\end{array}}{O_W(\text{Bach fetched and Anna gave}|\text{to Telemann, the book}) : S}\,\mathbf{FA}}{\text{Bach fetched and Anna gave the book to Telemann} : S}\,O_W$$

Cases like (33) in which the discontinuous conjunct is a verb and its modifier which *wrap* around the object are easy to prove as well. (38) shows the proof of the right conjunct.

(38)

$$\dfrac{\dfrac{\dfrac{\text{shot} ;\ VP/_R NP;\ \mathbf{shot'}}{\text{shot}|;\ VP/_W NP;\ \mathbf{shot'}}\,\mathbf{I} \quad \dfrac{\text{eight times} ;\ VP/_L VP;\ 8\times}{\begin{array}{c}\text{eight times} ;\ (VP/_W NP)/_L(VP/_W NP)\\ \lambda R[\lambda x[8\times(Rx)]]\end{array}}\,\mathbf{G}}{\text{shot}|\ \text{eight times} ;\ VP/_W NP;\ \lambda x[8\times(\mathbf{shot'}x)]}\,\mathbf{FA} \quad \begin{array}{c}\text{the victim}\\ NP;\ \mathbf{v}\end{array}}{\text{shot the victim eight times} ;\ VP;\ 8\times(\mathbf{shot'v})}\,\mathbf{FA}$$

So RNW in DCCG appears to be no more than the interaction of the already motivated coordination and discontinuity accounts. It is no surprise then that, like (continuous) NCC, RNW is scopally ambiguous, as shown in (35). Hendriks (1993) proposes an argument lift combinator which successfully accounts for such ambiguities in canonical coordination. Such a combinator allows any part of a complex category to be 'lifted' (with an accompanying semantic lift), easily providing the desired readings for both the continuous and discontinuous non-canonical coordinations.[9]

Hudson (1976) notes cases in which RNR is possible without coordination (39).

(39) [Those who like] [outnumber those who dislike] **Bach cantatas**.

This phenomenon can be accounted for with the addition of a new combinator: Substitution (**S**), which was proposed by Steedman (1987) in his analysis of Parasitic Gaps. The syntax of the combinator comes in various forms—the 'Backwards Crossed' ($<\times$**S**) version (40) relevant for both parasitic gaps and non-coordination RNR:

(40) $<\times\mathbf{S}$ $\qquad B/_R C \quad (A/_L B)/_R C \quad \Rightarrow \quad A/_R B$

[9] In fact, such a combinator is already motivated in DCCG by scopal ambiguities outside of coordination:

(i) Every organ prelude is based on some chorale.

In a number of discontinuous logics in TLG (Kubota, 2010; Moortgat, 1996), the reading in which the object scopes over the subject is obtained by way of discontinuous constituency—quantifiers can be analyzed as infixes which scope over the surrounding expression.

DCCG eschews this strategy, preferring the argument lift combinator for this reading as it is necessary for generating certain coordinations (along with a similar generalized **G**). The interested reader can verify that (ii) can be gotten by applying argument lift and then generalized **G** to the first coordination.

(ii) [Bach composed] and [Leipzig adored] [cantatas on Sunday] and [passions on Easter].

In the case of (39) $<\!\times\mathbf{S}$ applies to *those who like* with category $NP/_R NP$ and *outnumber those who dislike* with category $(S/_L NP)/_R NP$.

Since under the present treatment RNW is just a special case of NCC, we should expect it as well to be possible without coordination. In fact, this is a good prediction, as (41) are about as acceptable as RNW with coordination.

(41) a. [If Bach fetches], [then Anna Magdalena will give, **the oboe** to Telemann].
b. [The organist who composed], [also performed, **the prelude** eight times].

Such sentences can be gotten by adding a new syntactic variant of **S**—'Wrap Crossed Substitution' ($W\times\mathbf{S}$) (the semantics given is just the semantics of **S**).

(42) $W\times\mathbf{S}$
Given expressions $\alpha : \langle[\alpha]\ ;\ (A/_L B)/_W C\ ;\ \alpha'\rangle$ and $\beta : \langle[\beta]\ ;\ B/_W C\ ;\ \beta'\rangle$, infer an expression $\gamma : \langle[O_L(\alpha,\ \beta)]\ ;\ A/_W C\ ;\ \lambda c[\alpha'(c)(\beta'(c))]\rangle$.

Crucially, the functor expression α is on the right, so upon the *left-concatenation* (O_L) of the two discontinuous premises of $W\times\mathbf{S}$, it is the one which keeps its infixation point, giving the correct RNW pattern (43). As in the coordination case of RNW, it is the particular definition of O_L which ensures that the pivot wraps into the right side.

(43)
$$\dfrac{\dfrac{\dfrac{\text{the organist who composed}\mid : NP/_W NP \qquad \text{performed}\mid \text{eight times} : (S/_L NP)/_W NP}{O_L(\text{performed}\mid \text{eight times, the organist who composed}\mid) : S/_W NP}\,W\times\mathbf{S}}{\text{the organist who composed performed}\mid \text{eight times} : S/_W NP}\,O_L \qquad \text{the prelude} : NP}{\text{the organist who composed performed the prelude eight times} : S}\,\mathbf{FA}$$

Another successful prediction of the DCCG account is that discontinuous adjectives, like the *tough*-adjectives and adjective-comparative pairs, should be found in RNW coordinations. The existence of sentences like (44c) corroborate the extension of **I** to transitive predicative adjectives. It is this mechanism that allows adjectives beyond canonically discontinuous ones to form discontinuous constituents with modifiers in RNW, just as do transitive verbs.

(44) a. Bach is a [prickly] and [tough **man** to love].
b. Bach is a [prickly] but [more clever **composer** than Telemann].
c. Please move from the exit rows if you are [unwilling] or [unable **to perform the necessary actions** without injury]. (Whitman, 2009)

4.2 comparison with alternative accounts of RNW

The account of RNW in DCCG compares favorably with previous proposals (eg. Whitman, 2009; Chaves, 2014; Kubota, 2014, Ms.). In general, these accounts easily give the basic word order of the canonical case, but fail on cases with less canonical syntax or semantics. Furthermore, both previous CG accounts of RNW introduce operations far more complex than DCCG's *wrap* operation. As we shall see, then, the DCCG account is preferable both on theoretical and empirical grounds.

4.2.1 *wrap* in multimodal TLG

Whitman (2009) gives the first detailed discussion and account of RNW. His account is actually a very limited extension of Moortgat and Oehrle's (1994) logic (M&O94), i.e. the system used in Dowty's (1997) multimodal TLG account of NCC. In addition to the associative and commutative rules of Dowty's system, Whitman proposes an additional inference rule: 'Mixed Association 3'—repeated in (45). In effect, this association rule allows for the formation of a non-canonical conjunct which takes its pivot by *wrap*.[10]

(45)

$$\dfrac{\mathrm{a} \circ (\mathrm{b} \circ_w \mathrm{c})}{(\mathrm{a} \circ \mathrm{b}) \circ_w \mathrm{c}}\,\text{M-Assoc-3}$$

The canonical case of RNW (32) is easy to show in this system. The left and right conjuncts both require a single appeal to Mixed Association 3 (see the steps in bold).

(46)

$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\text{Bach} \atop NP \quad \dfrac{\text{fetched}_i \atop VP/_W NP \quad [\;]^a \atop NP}{\text{fetched}_i \circ_w [\;]^a : VP}\,/_W\text{E}}{\mathbf{Bach \circ (fetched_\mathit{i} \circ_w [\;]^a) : \mathit{S}}}\,/_L\text{E}}{\mathbf{(Bach \circ fetched_\mathit{i}) \circ_w [\;]^a : \mathit{S}}}\,\textbf{M-Assoc-3}}{\text{Bach} \circ \text{fetched}_i : S/_W NP}\,/_W\text{I}^a \quad \dfrac{\text{and} \atop (X/_L X)/_R X \quad \dfrac{\dfrac{\dfrac{\text{Anna} \atop NP \quad \dfrac{\dfrac{\text{gave}_i : (VP/_W NP)/_R PP \quad \text{to Telemann} : PP}{\text{gave}_i \circ \text{to Telemann} : VP/_W NP}\,/_R\text{E} \quad [\;]^b \atop NP}{(\text{gave}_i \circ \text{to Telemann}) \circ_w [\;]^b : VP}\,/_W\text{E}}{\mathbf{Anna \circ ((gave_\mathit{i} \circ to\ Telemann) \circ_w [\;]^b) : \mathit{S}}}\,/_W\text{E}}{\mathbf{(Anna \circ (gave_\mathit{i} \circ to\ Telemann)) \circ_w [\;]^b : \mathit{S}}}\,\textbf{M-Assoc-3}}{\text{Anna} \circ (\text{gave}_i \circ \text{to Telemann}) : S/_W NP}\,/_W\text{I}^b}{\text{and} \circ (\text{Anna (gave}_i \circ \text{to Telemann)}) : (S/_W NP)/_L(S/_W NP)}\,/_R\text{E}}{(\text{Bach} \circ \text{fetched}_i)\circ(\text{and} \circ (\text{Anna (gave}_i \circ \text{to Telemann)})) : S/_W NP}\,/_L\text{E} \quad \text{the oboe} \atop NP}{((\text{Bach} \circ \text{fetched}_i) \circ(\text{and} \circ (\text{Anna (gave}_i \circ \text{to Telemann)}))) \circ_w \text{the oboe} : S}\,/_W\text{E}$$

$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{((\text{Bach} \circ \text{fetched}_i) \circ(\text{and} \circ (\text{Anna (gave}_i \circ \text{to Telemann)}))) \circ_w \text{the oboe} : S}{(\text{Bach} \circ \text{fetched}_i) \circ ((\text{and} \circ (\text{Anna (gave}_i \circ \text{to Telemann)}))\circ_w \text{the oboe}) : S}\,\text{M-Assoc-2}}{(\text{Bach} \circ \text{fetched}_i) \circ (\text{and} \circ ((\text{Anna (gave}_i \circ \text{to Telemann)})\circ_w \text{the oboe})) : S}\,\text{M-Assoc-2}}{(\text{Bach} \circ \text{fetched}_i) \circ (\text{and} \circ (\text{Anna ((gave}_i \circ \text{to Telemann)}\circ_w \text{the oboe}))) : S}\,\text{M-Assoc-2}}{(\text{Bach} \circ \text{fetched}_i) \circ (\text{and} \circ (\text{Anna ((gave}_i \circ_w \text{the oboe)}\circ \text{to Telemann}))) : S}\,\text{M-Comm-2}}{(\text{Bach} \circ \text{fetched}_i) \circ (\text{and} \circ (\text{Anna ((gave}_i \circ \text{the oboe)}_c \circ \text{to Telemann}))) : S}\,\text{Incl}$$

So the basic pattern of RNW is easy to obtain when the discontinuous element is a ditransitive verb and its indirect object. A transitive verb and particle is similarly straightforward; the proofs converge by the Mixed Association 3 steps. The relevant detail is that the particle rather than the verb is the functor, with category $TV/_L TV$.

Whitman himself notes a number of problems with his account. First, he points out that attested examples like (47) cannot be generated because the discontinuous conjunct *unable without injury* does not form a semantic unit. Rather, the rightmost modifier in that sentence modifies the pivot.

(47) Please move from the exit rows if you are [unwilling] or [unable **to perform the necessary actions** without injury].

The problem in M&O94 is with the slash-introduction inference rule, which requires the extracted element to be peripheral to the expression. The presentation of this rule results in another undergeneration not noted by Whitman. Under the usual assumption that non-particle verbal adjuncts belong to the category $VP/_L VP$ (i.e. they modify verb-*phrases*, not verbs themselves), discontinuous verb-adjunct conjuncts as found in (33) are not generated.

(48)

$$\dfrac{\dfrac{\text{shot}_i : VP/_W NP \quad \text{the victim} : NP}{\text{shot}_i \circ_w \text{the victim} : VP}\,/_W\text{E} \quad \text{eight times} : VP/_L VP}{(\text{shot}_i \circ_w \text{the victim}) \circ \text{eight times}}\,/_L\text{E}$$

By the end of this proof, there is no structural rule in M&O94 or Dowty's (1997) and Whitman's (2009) extensions which may apply, leaving no way to prove the discontinuous conjunct *shot eight times* to be of category $S/_W NP$. What is required for this inference is

[10] In fact, Dowty's (1997) analysis predicts the existence of RNW in the case where the conjuncts are canonical constituents, e.g. (32b), (32c), though Dowty himself does not acknowledge it (indeed RNW does not appear to have been known at the time).

a new rule we will call 'Inverse Mixed Commutativity 2', which, unsurprisingly, is simply the inverse of 'Mixed Commutativity 2'.[11]

(49)

$$\dfrac{(\mathrm{a} \circ_w \mathrm{b}) \circ \mathrm{c}}{(\mathrm{a} \circ \mathrm{c}) \circ_w \mathrm{b}}\ \text{Inv-M-Comm-2}$$

With the addition of this rule, a discontinuous non-canonical constituent consisting of verb and adjunct may be proven:

(50)

$$\dfrac{\dfrac{(\text{shot}_i \circ_w \text{the victim}) \circ \text{eight times}}{(\text{shot}_i \circ \text{eight times}) \circ_w \text{the victim}}\ \text{Inv-M-Comm-2}}{\text{shot}_i \circ \text{eight times}}\ /_W\mathrm{I}$$

Whitman does not postulate this rule, as he does not recognize this undergeneration. It is possible, though he does not make this explicit, that he assumes all verb modifiers, like *eight times*, select the lexical verb itself, making the proof of (33) identical to that of particle-verb RNW. [12]

A similar proof exists for (47), requiring 'Mixed Associativity 1', a rule which Dowty and Whitman both assume is not available to English.

(51)

$$\dfrac{\dfrac{\dfrac{\dfrac{\text{unable}_i : (S[\mathrm{A}]/_L NP)/_W VP \qquad \dfrac{[\ ]^a : VP \qquad \text{without injury} : VP/_L VP}{[\ ]^a \circ \text{without injury} : VP}\ /_L\mathrm{E}}{\text{unable}_i \circ_w ([\ ]^a \circ \text{without injury}) : S[\mathrm{A}]/_L NP}\ /_W\mathrm{E}}{(\text{unable}_i \circ_w [\ ]^a) \circ \text{without injury} : S[\mathrm{A}]/_L NP}\ \text{M-Assoc-1}}{(\text{unable}_i \circ \text{without injury}) \circ_w [\ ]^a : S[\mathrm{A}]/_L NP}\ \text{Inv-M-Comm-2}}{\text{unable}_i \circ \text{without injury} : (S[\mathrm{A}]/_L NP)/_W VP}\ /_W\mathrm{I}^a$$

The RNW analysis in DCCG also addresses this shortcoming of the M&O94 account. While (51) requires the addition of two new structural rules not previously considered for English, a comparable proof in DCCG can obtain such constituents with no additional apparatus (52). These proofs differ from ones like (38)—in which the rightmost part of the discontinuous constituent modifies the leftmost part as opposed to the pivot—only in that **G** applies to the functor rather than the adjunct.

(52)

$$\dfrac{\dfrac{\dfrac{\dfrac{\text{unable} ; (S[\mathrm{A}]/_L NP)/_R VP; \neg\Diamond}{\text{unable}| ; (S[\mathrm{A}]/_L NP)/_W VP; \neg\Diamond}\ \mathbf{I}}{\text{unable}| ; ((S[\mathrm{A}]/_L NP)/_W VP)/_R(VP/_L VP) ; \lambda F[\lambda P[\neg\Diamond(F(P))]]}\ \mathbf{G} \quad \begin{array}{c}\text{without injury} ;\\ VP/_L VP; \neg\mathbf{injury'}\end{array}}{\text{unable}|\text{without injury} ; (S[\mathrm{A}]/_L NP)/_W VP; \lambda P[\neg\Diamond(\neg\mathbf{injury'}(P))]}\ \mathbf{FA} \quad \begin{array}{c}\text{to perform} ;\\ VP ; \mathbf{perform'}\end{array}}{\text{unable to perform without injury} ; (S[\mathrm{A}]/_L NP) ; \neg\Diamond(\neg\mathbf{injury'}(\mathbf{perform'}))}\ \mathbf{FA}$$

[11] Significantly, all the rules of M&O94—including this newest one—uphold the invariant that the argument taken by the functor with a '$/_W$' remains immediately to the right of the $\circ_w$, and therefore always ends up adjacent to the functor.

[12] Such an assumption may not be entirely unmotivated. One of the primary arguments for discontinuous ditransitives comes from weak crossover, e.g. (8). Similar data exist for transitive verbs with adjuncts:

(i) a. Bach composed every chorale$_i$ for its$_i$ own occasion.
b. *Bach composed it$_i$ for every chorale's$_i$ own occasion.

If the same analysis used to account for (8) is to apply here, transitive verbs must first combine with their adjuncts, and then with their objects.

Most concerning, Whitman overgenerates precisely that undesirable LNW pattern (36) which is markedly worse than RNW. Rather than appealing to M-Assoc-2 to embed the pivot deeper into the right conjunct as in (53), M-Comm-2 may apply earlier to bring the pivot adjacent to the left conjunct. There it can form a cluster next to the left verb.

(53)

$$
\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\begin{array}{c}\vdots\\ \text{Bach} \circ \text{fetched}_i\\ S/_W NP\end{array} \qquad \dfrac{\begin{array}{c}\text{and}\\ (X/_L X)/_R X\end{array} \qquad \begin{array}{c}\vdots\\ \text{Anna (gave}_i \circ \text{to Telemann)}\\ S/_W NP\end{array}}{\text{and} \circ (\text{Anna (gave}_i \circ \text{to Telemann)}) : (S/_W NP)/_L(S/_W NP)}\,/_R\text{E}}{(\text{Bach} \circ \text{fetched}_i) \circ (\text{and} \circ (\text{Anna (gave}_i \circ \text{to Telemann)})) : S/_W NP}\,/_L\text{E} \qquad \begin{array}{c}\text{the oboe}\\ NP\end{array}}{((\text{Bach} \circ \text{fetched}_i) \circ (\text{and} \circ (\text{Anna (gave}_i \circ \text{to Telemann)}))) \circ_w \text{the oboe} : S}\,/_W\text{E}}{((\text{Bach} \circ \text{fetched}_i) \circ_w \text{the oboe}) \circ (\text{and} \circ (\text{Anna (gave}_i \circ \text{to Telemann)}))}\,\text{M-Comm-2}}{((\text{Bach} \circ (\text{fetched}_i \circ_w \text{the oboe})) \circ (\text{and} \circ (\text{Anna (gave}_i \circ \text{to Telemann)}))}\,\text{M-Assoc-2}}{{}^*((\text{Bach} \circ (\text{fetched}_i \circ \text{the oboe})_c) \circ (\text{and} \circ (\text{Anna (gave}_i \circ \text{to Telemann)}))}\,\text{Incl}
$$

DCCG fares better than M&O94 on this front, too. As mentioned previously, DCCG rules out such sentences by the definitions of the concatenation operations and the category of *and* which together ensure that the infixation point is inherited on the right side. Therefore, the pivot always *wrap*s into the right conjunct, never the left one.[13]

Finally, Whitman notes so-called 'RNW Sandwiches' in which multiple conjuncts take as argument the expression following the pivot (i.e. are discontinuous) and surround a conjunct which does not (54). Whitman considers these a problem for his account. However, they are closely related to better-known violations of the Coordinate Structure Constraint due to Lakoff (1986) in which a conjunct-part need not be extracted 'across the board'.

(54) Led by France and Canada, a majority of countries are asserting the right of governments to [safeguard], [promote] and even [protect **their cultures** from outside competition]. (Whitman, 2009)

In an unpublished handout, Jacobson (2014b) notes that just the same phenomenon is possible in RNR—the pivot may belong to any subset of conjuncts which includes the final conjunct (55). She shows that in a CCG closely related to the present one, all of these facts are predicted.

(55) a. John went to the store, bought, and drank those 100 bottles of beer whose cans you see stacked on the wall.

b. *John (went to the store,) bought, drank, and fell asleep the 100 bottles of beer whose cans you see stacked on the wall.

Jacobson's analysis works for RNW sandwiches as well—i.e. they are gotten entirely for free. First, to account for iterated conjunction, the category of *and* is adjusted to $(X_\&/_L X)/_R X$, and a silent conjunction ~~and~~ with category $(X_\&/_L X)/_R X_\&$ is proposed. RNW (and RNR) sandwiches are gotten by instantiating X with the category of the 'fullest' conjunct, and appealing to **L** and **G**.

[13] Note that without the superscript A feature on slashes produced by **L**, the same overgeneration would be possible in DCCG. Since **L** shifts an argument into a functor, application of **L** to the left conjunct without adding the superscript A would cause only the left infixation point to remain in the coordination, giving LNW.

(56)

$$\dfrac{\dfrac{\dfrac{\dfrac{\text{safeguard}| \quad DV \qquad \dfrac{\dfrac{\cancel{\text{and}} \quad (DV_{\&}/_{L}DV)/_{R}DV_{\&} \qquad \dfrac{\dfrac{\dfrac{\dfrac{\text{promote}|:\ TV}{\text{promote}|\ \ TV_{\&}/_{R}(TV_{\&}/_{L}TV)}\,\mathbf{L}}{\text{promote}|\ \ DV_{\&}/_{R}((TV_{\&}/_{L}TV)/_{R}PP)}\,\mathbf{G} \qquad \dfrac{\dfrac{\text{and} : (TV_{\&}/_{L}TV)/_{R}TV}{\text{and}\ \ ((TV_{\&}/_{L}TV)/_{R}PP)/_{R}DV}\,\mathbf{G} \qquad \text{protect}|\ \ DV}{\text{and protect}| : (TV_{\&}/_{L}TV)/_{R}PP}\,\mathbf{FA}}{\text{promote and protect}| : DV_{\&}}\,\mathbf{FA}}{}}{\cancel{\text{and}}\text{ promote and protect}| : DV_{\&}/_{L}DV}\,\mathbf{FA}}{}}{\text{safeguard }\cancel{\text{and}}\text{ promote and protect}| : DV}\,\mathbf{FA} \qquad \text{from competition}\ \ PP}{\text{safeguard }\cancel{\text{and}}\text{ promote and protect}|\text{from competition} : TV}\,\mathbf{FA} \qquad \text{their cultures}\ \ NP}{\text{safeguard }\cancel{\text{and}}\text{ promote and protect their cultures from competition} : S}\,\mathbf{FA}$$

4.2.2 Linearization-Based Ellipsis in HPSG

Chaves (2014) gives an elliptical account of RNW without appealing to discontinuous constituency. Working under the rubric of Linearization-Based Ellipsis, a morpho-phonological deletion approach to NCC, Chaves proposes a new rule—'Backward Periphery Deletion' (BPD). Informally stated, this rule licenses the deletion of a prosodic phrase upon identity with a near-peripheral phrase:

(57) **BPD** $\quad \alpha_1\ \alpha_2\ \alpha_3\ \alpha_4\ \alpha_5 \ \Rightarrow\ \alpha_1\ \alpha_3\ \alpha_4\ \alpha_5$
for prosodic phrases $\alpha_1 - \alpha_5$ of the same prosodic sort, where $\alpha_2 = \alpha_4$.

Some cases of RNW—including non-coordination cases like (41)—follow from BPD when α_2 and α_4 are the pivot. Kubota and Levine (forthcoming) launch a detailed criticism of this elliptical approach, however. Not only does BPD fail to license cases of RNW in which the pivot scopes over the coordination (e.g. (35)), they note that it fails to do so for all NCC (barring certain *ad hoc* workarounds).

Furthermore, BPD is little more than a stipulation. Note that although LNW does not follow, a version of BPD which licenses it would be just as easy to state. By contrast, the relative badness of LNW follows deeply in DCCG from the proposed prosodic calculus for English.

4.2.3 reordering in multimodal TLCG

Kubota (2014, Ms.) provides another multimodal TLG account. Though space does not permit a detailed recounting, the essential proposal is for a 'reordering' mode with a single commutativity axiom:

(58) Reordering $\quad A \circ_r (B \circ_r C) \Rightarrow A \circ_r (C \circ_r B)$

Generally, the A expression is a functor (or head) and the B and C expressions arguments or modifiers. So transitive and ditransitives take their arguments by the reordering mode, as do modifiers. There are additional associativity axioms. From a continuous RNR syntax (e.g. *Bach fetched and gave to Telemann the oboe*), an appeal to 'reordering' can give the RNW surface order.

Kubota blocks LNW with the addition of a 'coordination' mode which constrains association, allowing only the axioms in (59). It is the absence of cases like $(A \circ_i B) \circ_i C \Rightarrow A \circ_i (B \circ_i C)$ (call this fake rule '*M-Assoc') which makes derivations like (60), and therefore LNW, impossible.

(59) R-M-Assoc $\quad A \circ_i (B \circ_c C) \Rightarrow (A \circ_i B) \circ_c C \qquad i \neq c$
L-M-Assoc $\quad (A \circ_c B) \circ_i C \Rightarrow A \circ_c (B \circ_i C)$

(60)

$$\dfrac{\dfrac{((\text{gave} \circ_r \text{to Telemann}) \circ_c (\text{and} \circ_c \text{tuned})) \circ_r \text{the oboe}}{{*}(\text{gave} \circ_r (\text{to Telemann} \circ_c (\text{and} \circ_c \text{tuned}))) \circ_r \text{the oboe}}\,\text{*M-Assoc}}{{*}(\text{gave} \circ_r \text{the oboe}) \circ_r (\text{to Telemann} \circ_c (\text{and} \circ_c \text{tuned}))}\,\text{Reordering}$$

The problem with this analysis is that it crucially relies on coordination to rule out LNW, while in fact we have seen RNW is not limited to coordination alone, e.g. (41). Assuming some mechanism can be added to Kubota's system to give these non-coordination sentences, it must also constrain association like the coordination mode. On the other hand, DCCG naturally rules out in both the coordination and non-coordination cases due to the details of the prosodic calculus.

One more possible overgeneration warrants discussion: Whitman (2009), Kubota (2014, Ms.), and DCCG all predict the goodness of RNW sentences in which both conjuncts are discontinuous, e.g. (61). Such cases appear to be a problem in general for the CG analysis of RNW. Supposing that RNW is licensed by virtue of both conjuncts having *wrap* or reordering categories, it would be difficult (in the syntax) to also prevent cases in which the left conjunct is not a vacuous *wrap*-per. However, it is not clear that these sentences are strictly ungrammatical: a few informants accepted them with reservations.

(61) a. ?Bach [took from Anna Magdalena] and [<u>gave</u> **the oboe** <u>to Telemann</u>].
b. ?Bach [copied out] and [<u>sent</u> **the scores** <u>off</u>].

Even an elliptical account like Chaves's (2014) is subject to the same problem, as his ellipsis operation would apply in cases like (62):

(62) Bach [took from Anna Magdalena ~~the oboe~~] and [<u>gave</u> **the oboe** <u>to Telemann</u>].

4.3 other discontinuity calculi and RNW

Here I consider a taxonomy for discontinuous logics, which makes four binary distinctions—whether or not the logic:

1) allows discontinuity anywhere inside a string,

2) assigns discontinuous categories to certain words,

3) permits multiple discontinuities within a single string, or

4) associates certain phonological effects with discontinuity.

I argue now that the particular features possessed by the proposed calculus in this paper, DCCG, conspire to allow it to account for RNW.

DCCG does not allow discontinuity freely; it only assigns discontinuity via the combinatory rule **I** to a very limited set of categories. Other systems like Moortgat's (1988) extension of the Lambek calculus, Kubota's (2010) Hybrid Type-Logical Grammar, and Morrill and Valentín's (2012) Displacement Calculus do allow discontinuity freely—i.e. they have the property that for $i = W$ or the relevant modality, a string $s \in A{/_i}B$ iff $\exists s_1, s_2[s = s_1 + s_2 \ \wedge \ \forall s'_{\in B}[s_1 + s' + s_2 \in A]]$. I will show that such generality leads to serious overgeneration.

Any account of RNW in such a system—that is the proposal of some mechanism to rule out the ungrammatical LNW case—must necessarily advance a very strong version of the Lambek Coordination Closure Hypothesis discussed by Dowty (1997). This hypothesis originally conjectures that any continuous substring of a well-formed string may appear as a conjunct in NCC, a position which follows from most TLG accounts of NCC. This stance becomes highly suspect when extended to a general discontinuous logic. Such systems must also predict that the discontinuous rightmost conjunct may be any substring of a sentence with a single discontinuity. Contrary to this prediction, some discontinuous strings clearly do not appear to make well-formed conjuncts (i.e. constituents):

(63) *[Bach wrote the fugue that], and [Herreweghe thinks that **Harnoncourt performed** the prelude, too].
(*cf.* [*Bach wrote the fugue that Harnoncourt performed*] *and* [*Herreweghe thinks that Harnoncourt performed the prelude, too*].)

On the basis of such evidence, such general discontinuity must be dismissed under the assumption that all discontinuous constituency can be subsumed under a single mechanism.

DCCG advances a weaker version of the Coordination Closure Hypothesis: namely that all discontinuous constituents can appear as discontinuous right conjuncts so long as the infixation point is directly following a word of a category that **I** is defined over. Since **I** does not apply to complementizers like *that*, (63) is correctly predicted ungrammatical.

This same evidence supports the position taken by DCCG that discontinuity is assigned at the word level. We have only seen discontinuity in RNW at the locus of transitive verbs, ditransitive verbs, and adjectives. Furthermore, we surveyed considerable evidence in §2.2 that words—though not necessarily just lexical items, as we saw with particle/verb pairs—of some categories appear to 'trigger' discontinuity, a fact which seems to demand a lexical rule like **I** or a property of lexical organization which manages discontinuity.

Third, DCCG permits only a single discontinuity within a string. This feature is motivated by RNW as well. We saw that systems which allows multiple discontinuities like M&O94 as extended by Whitman (2009), are prone to overgenerating the LNW case. This restriction of DCCG is precisely the feature which allows it to avoid LNW, as the conventions for passing up infixation points guarantees that the infixation point in a coordination will end up in the rightmost conjunct.[14]

It is not clear how a calculus which allows multiple discontinuities like Hybrid Type-Logical Categorial Grammar would avoid LNW. It seems that any such analysis would require the concatenation of two lambda expressions, which is not necessarily a well-defined operation. Morrill and Valentín's (2012) Displacement Calculus **D** defines a right-*wrap* operation on strings with any number $k > 0$ of discontinuities which replaces the k^{th} discontinuity, i.e. the rightmost one, in a string with an infix expression. Such an operation would allow multiple discontinuous conjuncts (vacuously or otherwise) to wrap around the pivot at the rightmost conjuct—just what is needed to get RNW without LNW. However, this logic is still too general, overgenerating strings like (63).

Finally, DCCG associates no strong phonological effects with discontinuity. It is possible that wrap is associated with some sort of encliticization process, as suggested by Moortgat and Oehrle (1994) and Dowty (1997), however this is not an essential feature of DCCG.

Certainly, a strongly phonological system like Hoeksema and Janda's (1988) is inade-

[14]A strikingly similar convention is settled on by Calcagno (1995), who considers a large set of possible concatenation and head-*wrap* operations. Instead of infixation points assigned to words, this logic distinguishes a *word* as the *head* of an expression. Left and right concatenation of two headed strings can preserve the head of the first or the second argument of the operation. DCCG uniformly preserves the first argument's. An expression may *wrap* to the left of the head or the right of the head in much the same way that O_{IR} and O_{IL} place infixation points to the right and left of words. Calcagno also considers that either the functor's head or the argument's head may become the head of the string following *wrap*. All *wrap* operations in DCCG are simply right-*wrap* in which the infix's infixation point (if it has one) is preserved. A calculus like Calcagno's could presumably give a natural account of RNW.

quate to describe RNW. Their *wrap* operations always split a prosodic structure after its first element or before its last one. Inconsistent with such an operation, we have found numerous counterexamples, e.g. (32a), showing that infixation points in discontinuous constituents need not be next to the left periphery.

In order to account for RNW (and other discontinuity phenomena), then, it seems that a discontinuity calculus must at least share many of the properties of DCCG. It remains to be seen whether more general systems like Morrill and Valentín's (2012) and Kubota and Levine's (forthcoming) can effectively unify their particular notions of discontinuity with that found in RNW.

4.4 Discussion on complexity

M&O94 and Kubota's (2014, Ms.) multimodal logic rely on structural commutativity and associativity rules to simulate wrap and to generate RNW. These inference rules map one structured string to another structured string based on details of those those structures. In this way, structural rules are closely related to some kinds of movement operations in, e.g. the GB framework, which map an input tree to an output tree.[15]

Unlike these approaches, DCCG is still able to achieve discontinuity via the relatively simple *wrap* operation. Crucially, *wrap* requires the grammar to keep track of at most one internal detail of a string: the location of its single infixation point. This operations compares favorably with both M&O94's structural rules and systems which permit multiple discontinuities (e.g. Kubota, 2010; Morrill and Valentín, 2012), all of which demand an indefinite number of details to be 'remembered'. Particularly, the structural commutativity and associativity rules which M&O94 uses to simulate *wrap* (as well as the associativity rules) requires every string in the proof to be fully bracketed—i.e. a completely hierarchical structure like a tree (but with only the root category label). Therefore, structural rules, just like movement, are really mappings from one tree structure to another. In this regard, *wrap* in M&O94 entirely misses one of the great advantages of Bach's (1979) original *wrap* operation—namely that it achieved discontinuous constituencies without appealing to movement. DCCG preserves this original property of *wrap*, representing a much simpler conception of the grammar.

4.5 Gapping

So far, there has been no mention in this paper of Gapping (64a) and Psuedogapping (64b)—surely the most well-studied cases of the interaction of discontinuity with coordination.

(64) a. [<u>Bach</u> **likes** <u>oboes</u>] and [Telemann recorders].
b. [<u>Bach has</u> **written** <u>more cantatas</u>] than [Telemann has Passions].

Gapping's most concerning detail is that it appears to be exactly the LNW pattern in which the 'pivot' is found only in the left conjunct, and the avoidance of which was such

[15] M&O94 could actually be weakly equivalent to a wrap grammar. Four features of this calculus limit the kinds of strings it can generate: 1) The commutativity axioms are licensed only when there is a wrap connective, 2) commutativity is designed such that an infix always stays on the same side of the wrap connective it introduces, 3) no 'derivation' is complete until all wrap connectives are eliminated, and 4) wrap connectives are only eliminated by heads, so commutativity will never have any effect but 'transporting' the infixed argument to the head. Nonetheless, the intermediate stages in licensing a string may be quite different from those of a grammar with true *wrap*.

an essential part of the analysis of RNW in DCCG. In fact, this is not a concern, I believe, since there is good evidence that Gapping is a distinct phenomenon from NCC.

The elegance of the CG approach to NCC lies in the fact that it reduces the phenomenon simply to a case of coordination of like-categories. The same is true of DCCG's account of RNW. However, Gapping is considerably more restricted than we would expect were it like-category coordination. Gapping gaps always begin with verbs, never with objects (65) as we see in RNW.

(65) *[John told **Mary** that he loved her] and [Bill told that he would die for her]. (Hudson, 1976)

In order for DCCG as currently formulated to generate the discontinuous right conjunct of a Gapping coordination, **I** would have to be extended to apply to subjects (of category $S/_{R}VP$) in order to give them the necessary infixation point. Unlike all previously discussed cases in which **I** introduces discontinuity, such an extension has no external motivation.

Even stronger empirical evidence against considering Gapping a part of RNW is that Gapping allows mismatches in number agreement, while NCC does not:

(66) a. [Bach **composes** fugues] and [his sons symphonies].
b. *[On Sundays Bach's sons] and [on Tuesdays Bach] **composes fugues**.

Similarly, Pseudogapping permits mismatches in tense/aspect (67b), while Chaves (2014) argues that similar data like (67b) are cases of cataphoric VP-ellipsis, not of true RNR.

(67) a. [Bach **wrote** more cantatas] than [Telemann has Passions].
b. [Bach will] and [Telemann has] **composed a fugue**.

This is not a paper on Gapping, so I will not propose an analysis within the system. However, it is not a concern that gapping does not follow from the same mechanism as RNW. In the latter case, the pivot is taken as a syntactic (and semantic) argument by the coordinated expressions. In Gapping, on the other hand, the above inflectional mismatch data suggest that the pivot may not be a syntactic argument of the entire coordination. Hopefully, it is possible to advance an analysis for VP-ellipsis, Pseudogapping, and Gapping alike in which the semantics of the gapped or elided element is applied to the reduced conjunct anaphorically.

5 Conclusion

Strikingly, DCCG—simple though it is—straightforwardly accounts for nearly the full range of RNW data surveyed in this paper. In fact, the empirical successes of DCCG pertaining to RNW are even greater than those of more complex systems surveyed. In addition to this, it successfully accounts for binding asymmetries, particle verbs, heavy-NP shift, *tough*-adjectives, continuous NCC, and cross-serial dependencies all under a single discontinuity calculus. While ultimately it is possible that not all the proposed cases of discontinuous constituency to be found in the literature can be described with a unified notion of discontinuous constituency, the tentative success of the present approach supports the position that DCCG's particular notion of constituency is indeed much like that of natural language.

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