Three kinds of transderivational constraint*

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1 Remarks

The status of *transderivational constraints* (TDCs) in syntactic theory has always been controversial. TDCs – informally definable as any that make syntactic well-formedness dependent upon *sets of sentences* – were proposed throughout the 1970s in various forms.[1] Most were quickly discovered to be factually or theoretically unsound. But this did not lead to a rejection of transderivational thinking. Quite the opposite; TDCs play a bigger role in syntactic theorizing today than ever before. The term itself is in disfavor, but the *blocking principles* of Di Sciullo and Williams (1987) meet the formal definition (see also Williams 1997; Hankamer and Mikkelsen 2001), as do the *economy conditions* of Chomsky 1995, Reinhart 1998, Fox 2000, and others working in the Minimalist Program.

Despite this current enthusiasm, little work has been done on the underlying logic of these constraints and their consequences for the design and complexity of syntactic theories.[2] As a result, all proposed TDC are stated informally, and sometimes their transderivational nature seems not even to be appreciated by their proponents.

This paper is a preliminary investigation of the formal properties of TDCs. I show that there are (at least) three logically and conceptually distinct classes of TDC. The tamest of the trio contains only those that can be cast as constraints on *grammars*, rather than constraints on natural language objects themselves. I call these *grammar constraints*. They include the metarules of GPSG (Gazdar et al. 1985) and its descendants, blocking principles, and others. Many are context-free definable; in section 3.1 I exemplify using the GPSG passive metarule and a blocking principle for Danish definite marking (Hankamer and Mikkelsen 2001).

From a model-theoretic vantage point, grammar constraints place limitations on the constraint set. But most TDCs constrain the constraints themselves, by setting their applicability relative to other sentences (sometimes even non-sentences). These are the *true TDCs* and the strategies for stating grammar constraints are of no use with them.

The true TDCs divide into two subclasses, which I call *optional TDCs* and *intrinsic TDCs*.[3] Optional TDCs enforce conditions that can be given non-transderivational statements within a more powerful formalism; in

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[1]There is no ideal name for these constraints. “Transderivational” is sometimes used for constraints on non-adjacent trees in a single derivation. This not the sense intended here. Rather, “transderivational” is reserved for constraints that reference sets of complete linguistic objects, whatever the nature of those objects is taken to be (single trees, attribute value matrices, ordered tuples of trees, etc.). “Interderivational” is better, but not theory neutral. “Comparative” is better still, but is easily confused with the comparative construction. Certainly, this name would make it hard to discuss Williams’s (1997) transderivational constraint on comparative marking, which would be a comparative comparative constraint.

[2]Jacobson 1974 is a pioneering work in this area. An outstanding recent contribution is Johnson and Lappin 1999. See also Pullum and Scholz 2001.

[3]The use of “intrinsic” is adapted from Johnson and Lappin’s (1999: §2.5.1) observation that Chomsky’s (1995) Smallest Derivation Principle “cannot, as far as we can see, be reformulated a local constraint on movement” (p. 31). The techniques offered in this paper permit assured omission of the hedge “as far as we can see”. Unfortunately, space precludes a discussion of this constraint.

section 3.1, I illustrate first with purely formal languages, and then with an example drawn from the recent linguistic literature: the Scope Economy condition of Fox (2000), which can be given a non-TD statement only if one assumes a *derivational* theory. Intrinsic TDCs are those that are transderivational no matter what formalism is assumed. I discuss one intrinsic TDC in detail – Rule H, again from Fox 2000 – and briefly mention many others that fall into this class.

This bifurcation in the class of true TDCs raises pressing theoretical issues. It is probable that a grammar incorporating TDCs is prohibitively complex. So a demonstrated need for an optional TDC could decide among formalisms (see Section 3.1.1). In particular, the validity of Fox's Scope Economy would be decisive for a derivational view over a representational one, as only the former can state this condition as a non-TDC.

In the interest of space, I do not here consider the linguistic motivation for the constraints I discuss. The focus is entirely on getting at their logical properties.

2 Constraints on possible grammars

Useful transderivational effects can be obtained by restricting the form of *grammars*. In this section, I show that many of these *grammar constraints* can be stated in the weak monadic second-order logic $L^2_{K,P}$ of the work of Rogers (1996, 1997, 1998). This logic is provably equivalent to a context-free formalism in the sense that a finite set of trees T is definable in it just in case T is generated by a context-free grammar. Moreover, the satisfaction question for $L^2_{K,P}$ is decidable. Thus, these grammar constraints are highly tractable.

I begin, in section 2.1, with a brief overview of $L^2_{K,P}$ and the kinds of relations we can define within it. I then state the GPSG passive metarule and the blocking principle of Hankamer and Mikkelsen (2001) using the tools developed in 2.1.[4]

2.1 The basics of the logic $L^2_{K,P}$

As Rogers (1997: p. 723) notes, $L^2_{K,P}$ is powerful. Since it is second-order (hence the ^{2}), it allows quantification over both nodes (its individuals) and sets of nodes. This makes it possible to place conditions on arbitrarily large trees, since trees are just sets of nodes meeting certain properties (see (3) below).

However, because it is a monadic logic, all binary predicates are either members of the set of relations in (1), or else defined in terms of these relations and unary predicates (members of the class K).[5]

(1)
a. The usual predicate logic connectives: $\wedge, \vee, \rightarrow, \leftrightarrow, \neg$
b. $\triangleleft$ = *immediate domination* $\quad$ $\prec$ = *left-of*
$\approx$ = *equality*

Thus, one can ensure that every sentence has both a subject and a predicate by imposing the following condition on models:

(2)
$$\forall x[\mathrm{S}(x) \rightarrow \exists y, z[x \triangleleft y \wedge \mathrm{NP}(y) \wedge x \triangleleft z \wedge \mathrm{VP}(z) \wedge y \prec z \wedge \forall v[x \triangleleft v \rightarrow y \approx v \vee x \approx v]]]$$

—every node x labelled S has a daughter y labelled NP and a daughter z labelled VP and y precedes z and x has no daughters distinct from y and z

[4]These ideas are inspired by Rogers's (1997) proposals, though my interpretation is much different than his.

[5]I use in addition the meta-logical symbol '$\equiv$' (strict equivalence), and abbreviations like

$$\bigvee_{x_i : i \leqslant 3} \varphi(x_i) \equiv \varphi(x_1) \vee \varphi(x_2) \vee \varphi(x_3)$$

The power of second-order quantification permits complex conditions such as (3), which says that every chain contains exactly one node that is case marked ((3) takes for granted the explicitly defined relation CHAIN from Rogers 1998 (§13.5).)

(3) $\forall X[\text{CHAIN}(X) \rightarrow \exists x[X(x) \wedge \text{CASE}(x) \wedge \forall y[X(y) \wedge \text{CASE}(y) \rightarrow x \approx y]]]$

—every set of nodes that forms a chain contains exactly one node that bears case

2.2 Defining local trees in $L^2_{K,P}$

Rogers (1997) provides the tools for translating context-free rewrite rules (tree admissability constraints) into statements of $L^2_{K,P}$. We begin by defining local trees using the predicate CHILDREN (Rogers 1996, 1997).

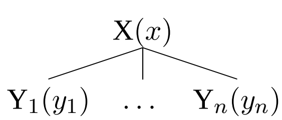
(4) $\text{CHILDREN}(x, y_1, \ldots, y_n) \equiv$

$$\bigwedge_{y_i:1\leqslant i\leqslant n} [x \lhd y_i] \wedge \bigwedge_{i\neq j} [y_i \not\approx y_j] \wedge \forall z[x \lhd z \rightarrow \bigvee_{y_i:1\leqslant i\leqslant n} [z \approx y_i]]$$

—x immediately dominates all and only the nodes in $y_1, \ldots, y_n$, which are all distinct

Using CHILDREN, we can actually treat local trees as predicates of variable arity. Symbolically, this is most perspicuously done by including tree diagrams in formulae, decorated with predicates and variables. The result is rather Fregean in its embrace of complex graphemes:

(5)

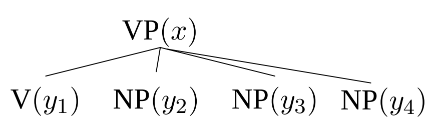


$$\equiv \text{CHILDREN}(x, y_1, \ldots, y_n) \wedge X(x) \wedge \bigwedge_{y_i:1\leqslant i\leqslant n} [Y_i(y_i)]$$

—the mother node x in the local tree is labelled X and each daughter y_i is labelled by Y_i

These defined predicates provide a neat shorthand, allowing, for instance, a perspicuous statement of a constraint blocking tri-transitive verbs; the following are equivalent:

(6) a. $\neg\exists x, y_1, y_2, y_3, y_4$ [

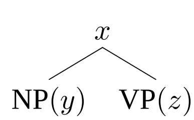


]

b. $\neg\exists x, y_1, y_2, y_3, y_4[\text{CHILDREN}(x, y_1, y_2, y_3) \wedge \text{VP}(x) \wedge \text{V}(y_1) \wedge \text{NP}(y_2) \wedge \text{NP}(y_3) \wedge \text{NP}(y_4)]$

Similarly, the cumbersome statement in (2) can now take the form (7).

(7) $\forall x \left[\text{S}(x) \rightarrow \exists y, z \right.$ [



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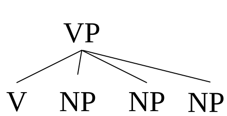
I stress that the tree predicate makes statements in the *object* language. It has exactly the status of, e.g., $\rightarrow$. It is a defined predicate adopted to make the system easier to work with. Linguistically speaking, this means that the tree predicate is interpreted over natural language objects. So (6) defines a set of trees that excludes all subtrees of the form (8b), properly blocking (8a).

(8) a. *Willie bet Fats five-thousand bucks the game.

b. *



2.3 Why there cannot be object language TDCs

The goals of this section are two. Using the GPSG passive metarule as an example, I show that we can state grammar constraints in $L^2_{K,P}$, which amounts to showing that they are strongly context-free. But equally important is my illustration that these constraints *must* be grammar constraints if our class of models includes individual sentences. Attempting to use them to restrict natural language objects directly has laughably false consequences.

2.3.1 The GPSG Passive metarule

Metarules play a key role in the GPSG grammar formalism and the frameworks it has influenced. As the name indicates, these are metagrammatical principles, closure properties on the set of rules in the grammar. As Gazdar et al. (1985) write "Metarules map lexical ID rules to lexical ID rules" (p. 59). For instance, the *passive metarule* says, roughly, that every transitive verb has a passive counterpart – that is, for every rule licensing a transitive verb phrase based on a verb V there is a rule licensing the passive counterpart of V.

The metagrammatical status of this rule becomes evident when one states it in the object language, i.e., as a direct constraint on natural language objects; see (9).[6,7]

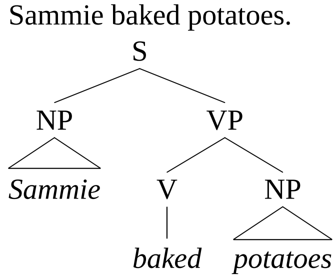
(9) *Passive meta-rule in the object language (with disastrous results)*:

$$\forall X \forall (x, y_1, y_2)\left[\left[\mathcal{V}(X) \wedge \begin{array}{c} XP(x) \\ \diagup \qquad \diagdown \\ X(y_1) \quad \mathrm{NP}(y_2)\end{array}\right] \rightarrow \exists z, w \left[\begin{array}{c} XP(z) \\ | \\ X_{[\mathrm{PAS}]}(w)\end{array}\right]\right]$$

—every transitive verb phrase has a passive counterpart

But this is not the intended statement; quite probably, (9) is not a rule in any natural language. It has the unfortunate effect of blocking (10).

(10) Sammie baked potatoes.



It is *false* of this tree (hopeful model) that for every subtree meeting the antecedent condition of (9) there is one meeting its consequent condition. There is just one VP. It is a transitive verb phrase. Hence it does not validate the consequent —

$$\begin{array}{c} XP(z) \\ | \\ X_{[\mathrm{PAS}]}(w)\end{array}$$

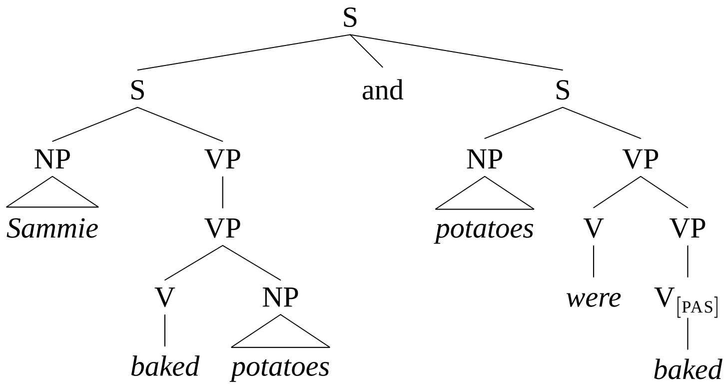
— for two reasons: (i) it has just one daughter node; and (ii) its head, w, is not a member of $[\mathrm{PAS}]$.

However, this tree does satisfy (9):

[6] I use $\mathcal{V}$ to denote the set of verbal predicates. This third-order set is legitimate in the second-order only $L^2_{K,P}$ because it is merely an abbreviation: $\mathcal{V}(X) \equiv [X = V_1 \vee V_2 \ldots]$. That is, $\mathcal{V}$ abbreviates a finite disjunction of predicates and is thus eliminable. I also use $XP(x)$ as an abbreviation for $X(x) \wedge BAR\text{-}2(x)$. Similarly, $X_{[\mathrm{PAS}]}(x)$ abbreviates $X(x) \wedge [\mathrm{PAS}](x)$.

[7] I ignore optional *by*-phrases. To allow these, one would make the consequent of (9) a disjunction, one disjunct specifying a *by*-marked PP daughter.

(11) Sammie baked potatoes and potatoes were baked.



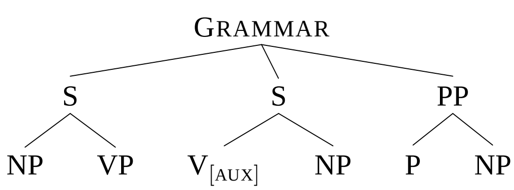
The difficulty is not with passive metarule *per se*, but rather with the structures that it is being interpreted relative to. One must heed the prefix 'meta-', that is, treat the passive metarule as a constraint on admissible rule sets. This can be done within $L^2_{K,P}$, with the interpretation relative to a *grammar tree*.

2.3.2 Grammar trees and TDCs

The passive metarule is fundamentally a constraint on the kinds of grammars linguists are allowed to write, as the above quote from Gazdar et al. 1985 (p. 59) indicates. Only in this indirect sense does it constrain the models of grammars (sentences) themselves. Thus, while one can state the passive metarule in $L^2_{K,P}$, the models must now be taken to represent *entire grammars*. To do this, we exploit the fact that a context-free grammar can be seen as a method for specifying a finite set of local trees. Each rule of the grammar licenses a tree of depth one; see Rogers 1999 for the technical details of this correspondence. We can obtain a single object from this set of trees (and thus state constraints on the entire grammar) by adding a rule that links all the trees via a GRAMMAR root node.

A simple example of how this works is the three rule grammar represented in (12), which I call a *grammar tree*.

(12)



This is just an embedding of the context-free grammar[8] —

(13) GRAMMAR $\twoheadrightarrow$ S | PP
S $\twoheadrightarrow$ NP VP
S $\twoheadrightarrow$ $V_{[AUX]}$ NP
PP $\twoheadrightarrow$ P NP

— into a linguistic tree. We could provide $L^2_{K,P}$ formulae specifying these rules using exactly the scheme employed above for object-language constraints.

This provides an appropriate object for interpreting the passive metarule: we simply use a formula very much like (9), but interpret it relative to a grammar tree. To do this, I introduce the relation $\Rightarrow$, the grammar (meta) counterpart of the tree predicate, and moreover put variables in boldface, to further emphasize the metalevel at which we are operating

[8] In order to avoid arrow confusion, I use $\twoheadrightarrow$ in the statement of formal language grammars.

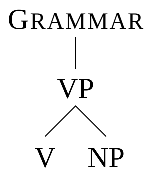
(14) *Passive metarule as a* meta*rule*:

$$\forall \mathbf{X} \forall (\mathbf{x}, \mathbf{y_1}, \mathbf{y_2}) \quad [\mathcal{V}(\mathbf{X}) \wedge [\mathbf{XP}(\mathbf{x}) \Rightarrow \mathbf{X}(\mathbf{y_1})\ \mathrm{NP}(\mathbf{y_2})] \rightarrow \exists \mathbf{z}, \mathbf{w}[[\mathbf{XP}(\mathbf{z}) \Rightarrow \mathbf{X}_{[\mathrm{PAS}]}(\mathbf{w})]]]$$

—every transitive VP rule has a counterpart passive rule based on $\mathrm{V}_{[PAS]}$

As a constraint on grammars, this limits the class of models to those in which there is a injective function from transitive VP rules to passive VP rules. Thus, a *grammar* such as (15)—

(15) *



—is *not* a model if we impose the constraint in (14).

I close this section by noting that if a constraint (meta- or otherwise) regulates the existence of just a single local tree, then it does not matter whether we impose it on natural language objects or on their grammars. For instance, the prohibition (6) on tri-transitive verbs could alternatively be conceived of as a disallowing *rules* of that form. It is only when we need to consider sets of trees that we must move to the grammar tree, where the models are complete grammars.

2.4 Blocking in Danish definites: an empirical challenge met

In this section, I show that an intricate blocking principle can be stated using the same techniques as employed for the passive metarule. Again, it is crucial that this principle regulate grammars, not sentences. The actual statement in $L^2_{K,P}$ presupposes a quite refined version of grammars. This might reflect a limitation on the method employed here, but I suspect that it can be made more natural.

Hankamer and Mikkelsen (2001) argue that the distribution of definiteness marking in Danish nominals is governed by a blocking principle. Their basic generalization is that "in the absence of modifiers, only postnominal definiteness marking is possible" (§3.3). Thus, one has paradigms such as (16) - (17).

(16) a. * den hest
DEF horse

b. hesten
horse.DEF

(17) a. * røde hesten
red horse

b. den røde hest
DEF red horse

However, there are two classes of nouns that cannot take a definite suffix, regardless of whether they are modified: proper names and nouns ending in the suffix -*ende*. Thus, one has, e.g., (18).

(18) a. den (stakkels) studerende
the (poor) student

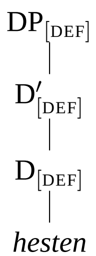
b. * studerende(e)n
student.DEF

Hankamer and Mikkelsen's claim is that, in the domain of definite marking, grammatical suffixation blocks the use of the determiner – the word trumps the periphrastic form.

As in the case of the passive metarule, we cannot make this a direct constraint on the class of models of the grammar. But we can impose it as a condition on the *grammar* of Danish, as follows.

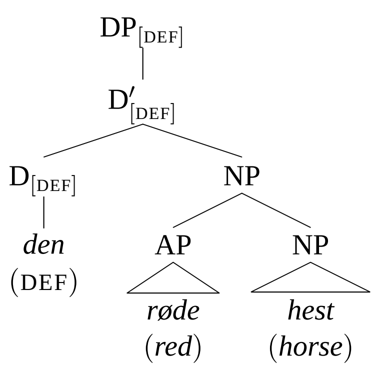
Hankamer and Mikkelsen argue that (19) is the structure of examples such as (16b).

(19)



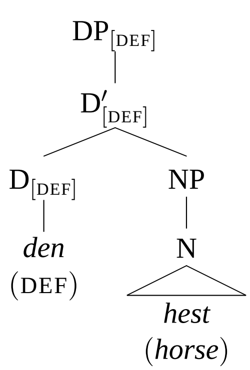
They argue furthermore that (16a) has the structure in (20).

(20)



The structure that is supposed to be blocked by (19), where available, is this one:

(21)



Thus we want to say that a rule licenses a D′ with just one daughter, a D^0 only if there is no rule licensing D′ with daughters D^0 and a non-branching NP. First, we define a class $\mathcal{G}$ of grammatical features, a set of predicates like [PLURAL], [DEF], [PROPER-NAME], etc. Then we state the required blocking principle as the constraint on grammars in (22).

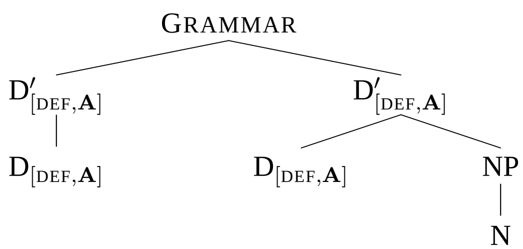
(22) *Blocking with Danish definites*:

$$\forall \mathbf{X}, \mathbf{x}, \mathbf{y}, \mathbf{z}$$
$$[\mathcal{G}(X) \wedge [\mathrm{D}'_{[\text{DEF},\mathbf{X}]}(\mathbf{x}) \;\; \Rightarrow \mathrm{D}_{[\text{DEF},\mathbf{X}]}(y) \;\; \mathrm{NP}(z)] \rightarrow$$
$$\neg\exists \mathbf{v}, \mathbf{w}[\mathrm{D}'_{[\text{DEF},\mathbf{X}]}(\mathbf{v}) \;\Rightarrow\; \mathrm{D}'_{[\text{DEF},\mathbf{X}]}(\mathbf{w})]]$$

—a rule licenses a non-branching definite D' with some feature $\mathbf{X}$ only if there is no rule licensing a D' bearing $\mathbf{X}$ and expanding into a D with $\mathbf{X}$ and a non-branching NP

Thus, the following is not a possible subgrammar of Danish, since the rule (subtree) on the left meets the antecedent condition of (22) but the rule on the right is the negation of the consequent of (22). ($\mathbf{A}$ is an arbitrary member of $\mathcal{G}$.)

(23)



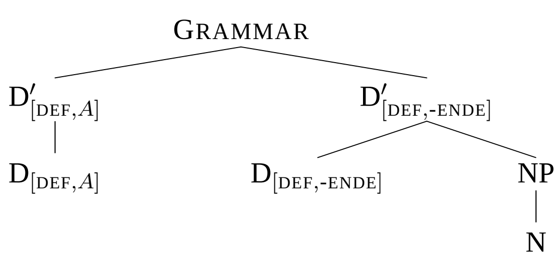
The final piece in this restatement of the Blocking principle is a constraint against expanding proper names and *-ende* nominals as definite marked D's. Since this references just one structure, it could, in isolation, be either a constraint on the grammar or a constraint on sentences themselves. However, we must make it a constraint on grammars, so that it interacts with (22); see (24).

(24) $\forall \mathbf{x}, \mathbf{y}[[D_{[\text{DEF}]}(\mathbf{x}) \wedge \mathbf{x} \triangleleft \mathbf{y}] \rightarrow [\neg[[\text{-ENDE}](\mathbf{y}) \vee [\text{PROPER-NAME}](\mathbf{y})]]]$

—if a node is labelled D and $[\text{DEF}]$, then its daughter is not a member of $[\text{-ENDE}]$ or a proper name

This principle stipulates that proper names and *-ende* nominals never meet the antecedent condition of (22), and hence can take a definite article. According to Hankamer and Mikkelsen (2001), (18) represents an arbitrary morphological gap. So we do no violence to the intuition behind the analysis by stating this principle. The following therefore is a possible fragment of a Danish grammar tree, assuming $A \neq [\text{-ENDE}] \vee [\text{PROPER-NAME}]$.

(25)



A drawback to this statement is that it requires a highly refined view of the rules of the grammar. In particular, we require a different rule of the gross form $[\mathrm{D}'_{[\text{DEF},A]} \;\Rightarrow\; \mathrm{D}_{[\text{DEF},A]}]$ for every feature grammatical feature A. However, it seems clear that the feature inheritance mechanisms of GPSG, which Rogers has shown to be $L^2_{K,P}$ definable, can capture the obvious generalizations over these sets of rules. The account would still, though, have to encode at least as much detail (featural sensitivity) as the above does.

2.5 Historical- and meta- views

The need for constraints like the passive metarule was recognized by Chomsky in his early work. Chomsky (1965: §1.5) draws a distinction between *substantive* and *formal universals*. Substantive universals say things like "All spoken natural languages draw from a fixed set of phonetic features". Formal universal are "of a more abstract sort" (p. 29). They impose conditions on the nature and composition of natural language grammars. This is exactly what the passive metarule does: as noted above, it is a closure property on the set of rules that a natural language grammar tree can contain.

The tools set out above are not tied to definability in $L^2_{K,P}$. For instance, Chomsky writes "consider the proposal that the syntactic component of a grammar must contain transformational rules…" (p. 29). This presupposes a more powerful formalism than $L^2_{K,P}$, but it yields just as easily to the above techniques. It simply says that every grammar consists of at least one function mapping trees into trees. Similarly, universal constraint rankings on Optimality Theory grammars are restrictions on grammars, not natural language structures. For prominent and diverse examples of such constraints, some of which have obviously transderivational effects, see Prince and Smolensky 1993 (§7, §8), Aissen 1999, Ito and Mester 1998.

In sum, it should be stressed that although grammar constraints have transderivational effects, in that they make statements about the properties of sets of trees, they do not act directly on natural language objects. Indeed, the prefix 'meta-' is exactly correct for this class. The following relations bring this into focus. When one says that a sentence is licensed by a grammar G, one is actually saying that the long conjunction of constraints that compose G has the formula associated with S as a logical consequence, as in (26), in which G is a grammar and C_i are constraints.[9]

(26) *The grammar constrains the possible sentences*:

$$G = C_1 \wedge C_2 \wedge \cdots \wedge C_2 \vDash_1 S$$

So G regulates what can appear on the *right* side of $\vDash_1$. Formal constraints move up a level in a kind of Tarskian hierarchy of languages, imposing constraints on the form of the formula on the *left* side of $\vDash_1$. This is depicted in (27), where $\mathbf{G} = \mathcal{C}_1 \wedge \mathcal{C}_2, \wedge \cdots \wedge \mathcal{C}_n$ is a metagrammar (conjunction of grammar constraints).

(27) *Grammar constraints constrain the possible grammars*:

$$\mathbf{G} = \mathcal{C}_1 \wedge \mathcal{C}_2, \wedge \ldots \mathcal{C}_n \vDash_2$$
$$G = C_1 \wedge C_2 \wedge \cdots \wedge C_2 \vDash_1 S$$

Thus, Rogers's (1996, 1997) accomplishment consists in showing that the relations in both (26) and (27) can often be captured in $L^2_{K,P}$. But not all conditions with the effect of regulating sets of possible sentences are this theoretically friendly. I turn now to the more troublesome class of true TDCs.

3 TDCs of a different sort

Not all TDCs can be stated as restrictions on grammars. Most of the controversial ones must be conceived of either as restrictions on the application of rules or as licensing structures of arbitrary complexity based on the status of comparable structures. This involves quantification over sets of models. $L^2_{K,P}$, a logic allowing quantification over nodes and sets of nodes only, cannot impose such conditions at all. While we could move to yet a higher metalevel, placing constraints on the constraints on the rule set (and so on in an upward Tarskian

[9] Kornai and Pullum (1990: §3.2) state the phrase structure condition Optionality as a constraint on grammars, in a manner that could be translated directly into grammar tree notation of this paper. For relevant discussion, see Pullum and Scholz 2001 (§2.3).

whirl), we simply cannot constrain the constraints themselves. This limitation is fundamental to the logics that underlie linguists' grammars and is central to their reasoning about natural language objects; see section 4 for brief comment.

As noted above, true TDCs divides into two subclasses, optional TDCs and intrinsic TDCs. Those in the first class are TDCs only in some formalisms. Those in the second are TDCs no matter what machinery is adopted. I begin with a discussion of optional TDCs. Although Scope Economy is the only linguistic proposal known to me that falls into this class, I show first that it is a well-defined class of constraints, using abstract rewriting systems to illustrate. I then turn to the intrinsically transderivational, focussing on Rule H of Fox (2000).

3.1 Optional TDCs

3.1.1 Illustration in the abstract

It is straightforward to show that TDCs can expand the weak generative capacity of a grammar formalism. Consider the context-free grammar in (28). (This example is due to Geoff Pullum.)

(28) A context-free grammar generating $L = \{a^i b^j c^k \mid i = j \vee j = k \ \wedge i, j, k \geqslant 0\}$

S	$\twoheadrightarrow$	aXbC	S	$\twoheadrightarrow$	AbZc
S	$\twoheadrightarrow$	C	S	$\twoheadrightarrow$	A
X	$\twoheadrightarrow$	aXb	Z	$\twoheadrightarrow$	bZc
X	$\twoheadrightarrow$	ab	Z	$\twoheadrightarrow$	bc
X	$\twoheadrightarrow$	e	Z	$\twoheadrightarrow$	e
C	$\twoheadrightarrow$	cC	A	$\twoheadrightarrow$	aA
C	$\twoheadrightarrow$	e	A	$\twoheadrightarrow$	e

Some sample derivations are given in (29).

(29)

a.	b.	c.
S	S	S
aXbC	AbZc	AbbZcc
aaXbbC	aabZc	Abbbccc
aaXbbC	aabbcc	bbbccc
aaabbbC		
aaabbbc		

It is well-known that the language $a^n b^n c^n$ is not context-free. We cannot impose the condition that the a's and c's match in number using only rules of the form in (28); derivations like (29a) are unavoidable. This requires the power of a tree-adjoining grammar, a (small) step up in the complexity hierarchy.

But now consider the transderivational constraint in (30) imposed on the language L of (28).

(30) The string $a^n b^n c^m$ is in L only if $b^n c^m$ is in L.

The only way $b^n c^m$ can be in L is if $m = n$. Thus, if this condition is added to the grammar (28) we generate the $a^n b^n c^n$. But, as noted, one need not adopt a TDC like (30) in order to obtain this language. Moving to a tree-adjoining grammar suffices.

This example is general. For instance, the language $a^n b^n c^n d^n f^n$ is not a tree-adjoining language (Vijayshanker 1988: §4.2), but a TDC like (30) plus a tree-adjoining grammar generating $\{a^i b^i c^i d^j d^k f^k \mid i = j \vee j = k \wedge i, j, k \geqslant 0\}$ would clearly suffice.

I turn now to a recent linguistic proposal that falls into class of optional TDCs.

3.1.2 Scope Economy and Shortest Move

The Scope Economy condition of Fox 2000 (§2) is an interesting case of a constraint that can be conceived of either as a TDC or as a condition on sentences-as-sets-of-trees. The condition is given in (31).

(31) SCOPE ECONOMY (Fox 2000: p. 26)
An SSO [Scope Shifting Operation—CP] can move XP_1 from a position in which it is interpretable only if the movement crosses XP_2 and $\langle \text{XP}_1, \text{XP}_2 \rangle$ is not scopally commutative.

$\langle \text{XP}_1, \text{XP}_2 \rangle$ is scopally commutative (when both denote generalized quantifiers) if for every model, and for every $\phi \in D_{\langle e,et \rangle}$,
$[\![\text{XP}_1]\!](\lambda x[\![\text{XP}_2]\!](\lambda y \phi(y)(x)) = [\![\text{XP}_2]\!](\lambda x[\![\text{XP}_1]\!](\lambda y \phi(y)(x))$

I assume that the definition of "scopally commutative" is actually a biconditional. For simplicity's sake, I grant that semantic (model-theoretic) identity is something that can be easily and effectively computed, and so treat it as in effect a feature of nodes.[10] I also assume that (31) has an added exception clause allowing a quantifier to raise out of the VP even where this has no semantic consequences. Fox's proposals seem to require such movement, which is perhaps syntactically motivated.

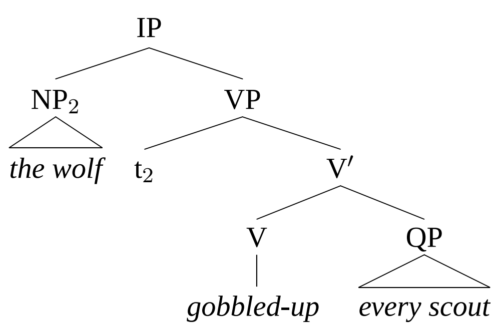
The effects of Scope Economy are dependent on another principle, Fox's version of Shortest Move, which I provide in (32)

(32) SHORTEST MOVE (Fox 2000: p. 23)
QR must move a QP to the closest position in which it is interpretable. In other words, QP must always move to the closest clause-denoting element that dominates it.

Fox situates (31) in a derivational theory, in which sentences are represented using ordered sets of trees. We can most easily capture this by assuming that an *ad hoc* DERIVATIONAL NODE links the trees in a derivation, ordered left-to-right.

With this background in mind, consider the sentence in (33) and its initial representation (34).

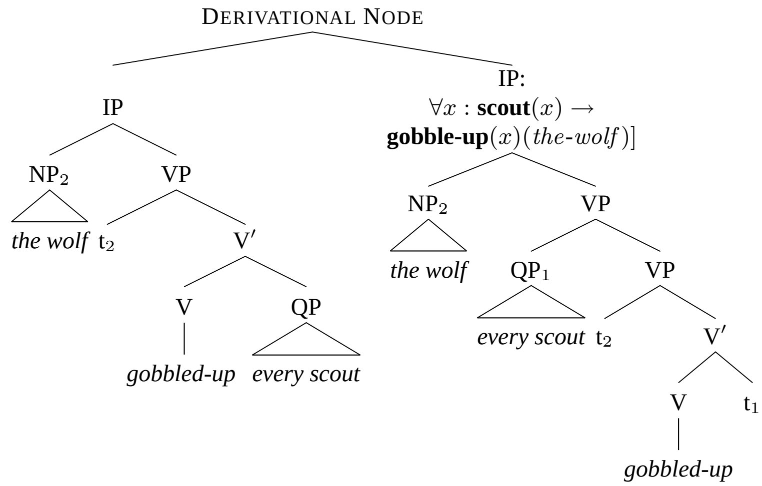
(33) The wolf gobbled-up every scout.

(34)


This is not an interpretable structure given Fox's assumptions. The verb *gobble-up* denotes a relation between individuals, hence requires that its sister denote in $\langle e \rangle$. But *every scout* lacks such a denotation, so there is a type-mismatch. This triggers QR of the object. By Scope Economy and Fox's assumption that the VP is clause-denoting, this yields (35).

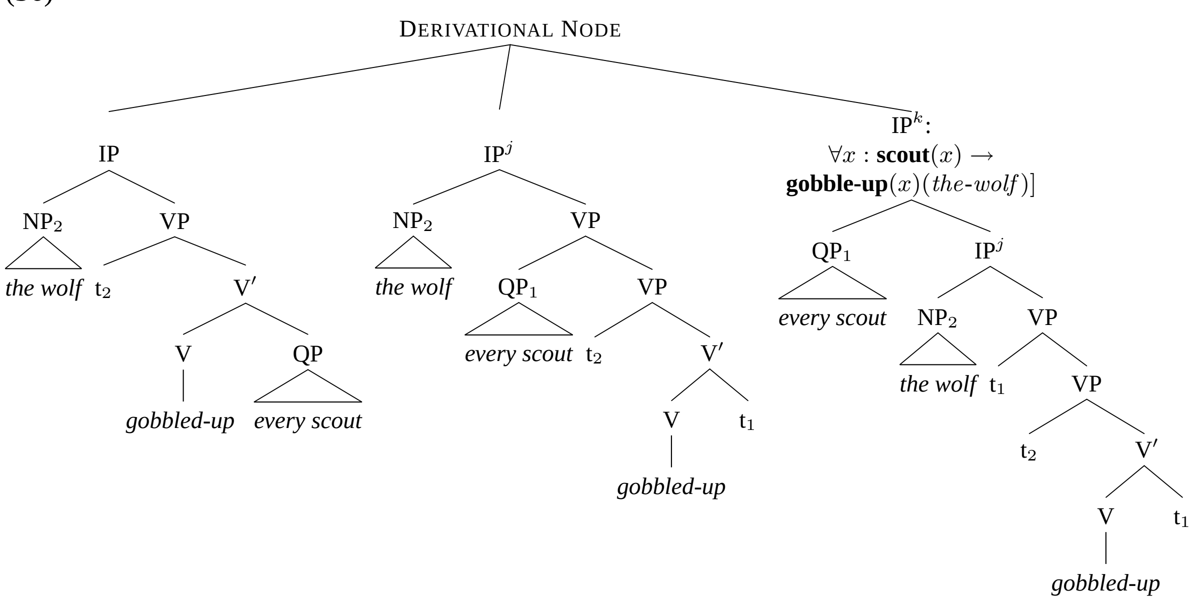
[10] This is granting a lot. Although there are classes of first-order formulae for which computing mutual entailments is a decidable problem, this is not true in general. See Hunter 1971 (p. 253).

(35)



The question now is whether *every scout* can undergo QR to the next highest clause-denoting node. Suppose that we allow this derivation, producing (36).

(36)



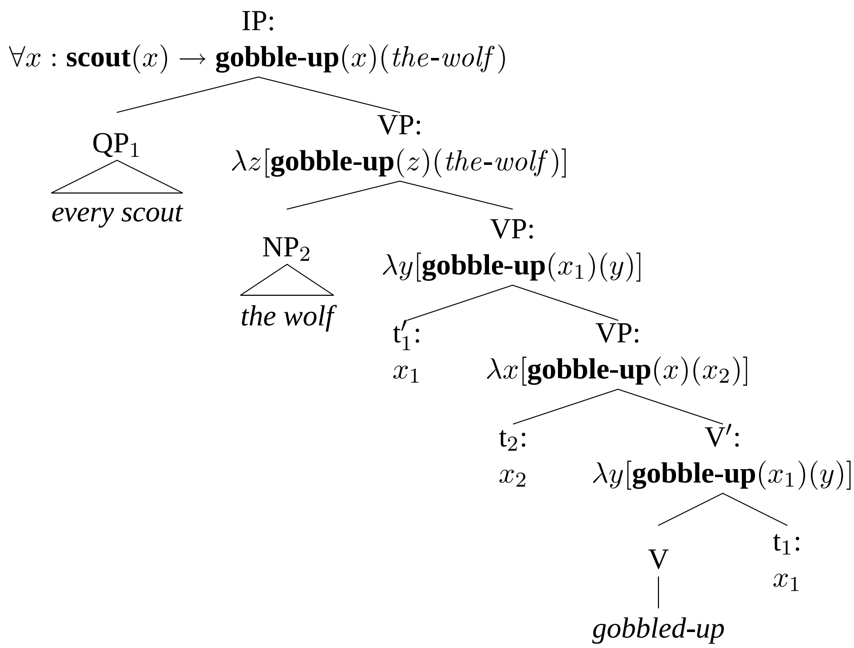
This derivation should be blocked. But how can we establish that the second application of QR failed to produce a meaning difference? This cannot be read off the final tree, the LF, because no proper subpart of that tree has as its meaning anything comparable to the meaning of the root node. If the Logical Form is the only interpreted structure, then the only way to block (36) is by appeal to the derivation represented in (35).

But this means that we can prevent Scope Economy from being a TDC by denying that only LFs are interpreted. An adequate grammar, Minimalist or otherwise, probably needs to have access to semantic information prior to LF anyway. (Johnson and Lappin (1999: §3.4) argue this point persuasively; see also Epstein et al. 1998 and Nissenbaum 2001.) If the tree rooted at IP^j in (36) is also interpreted, then it will have the same meaning as the third tree. Thus, Scope Economy can be seen as referencing just this derivation. Call this an *intraderivational* interpretation, since it places a condition on the function mapping one tree to another in a single derivation. Since such a function is necessary in a derivational theory anyway, Scope Economy does not, in all likelihood, require an increase in expressivity.

Before moving on to a discussion of a constraint that is irredeemably transderivational, it is worth pausing to flesh out two important implications of the above discussion.

Intraderivational Scope Economy is necessarily derivational Suppose that we adopt a declarative theory, so that the question is whether the LF (37) satisfies Scope Economy.

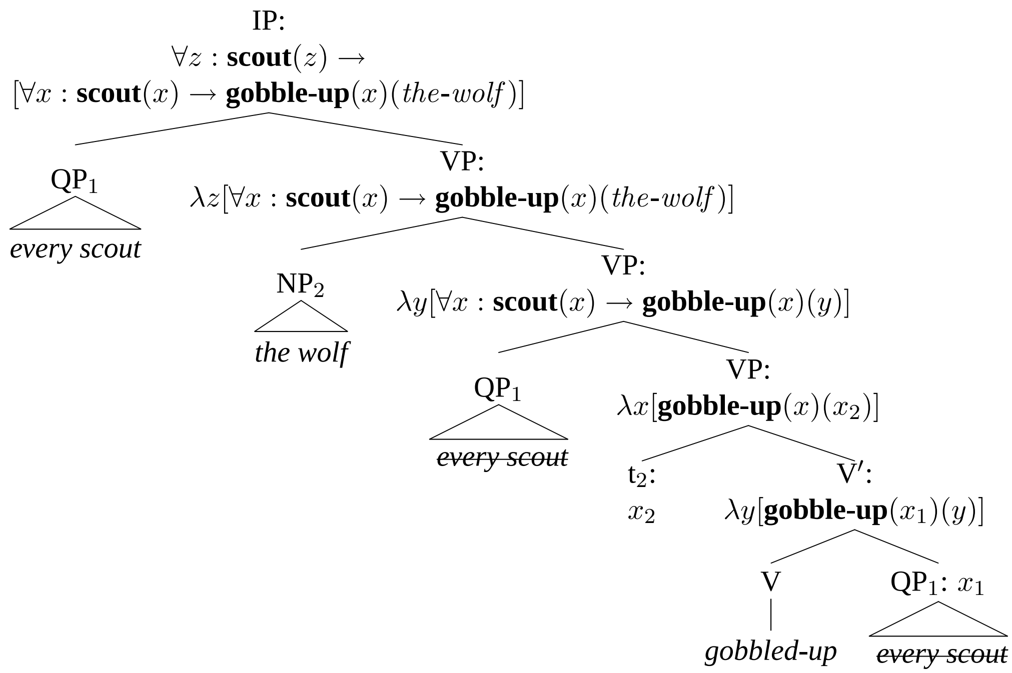
(37)



There is no subtree of this structure that has the same meaning as the root node. Hence, Scope Economy would necessarily reference another tree, in this case a tree in which *every scout* was adjoined in the position of t'_1, at the VP-level.

This holds even in a copy theory of movement, but it is somewhat difficult to see this. A very strict version of the copy theory would derive the LF (38).

(38)



Suppose, for simplicity's sake, that we can optionally interpret any subset (proper or not) of the copies of *every scout* as quantifiers, letting the rest denote individuals, as I have done above for the lowest copy.[11] Then it is arguably true that the highest VP node is equivalent to the IP node; for this, one must assume that the structural rules of Contraction and Weakening, given in (39), are valid for natural languages:[12]

(39) a. CONTRACTION $\stackrel{def}{=}$ $(p \rightarrow (p \rightarrow q)) \;\rightarrow\; (p \rightarrow q)$

b. WEAKENING $\stackrel{def}{=}$ $(p \rightarrow q) \;\rightarrow\; (p \rightarrow (p \rightarrow q))$

But this does not suffice to obtain the desired result. Consider a derivation involving non-scopally-commutative quantifiers:

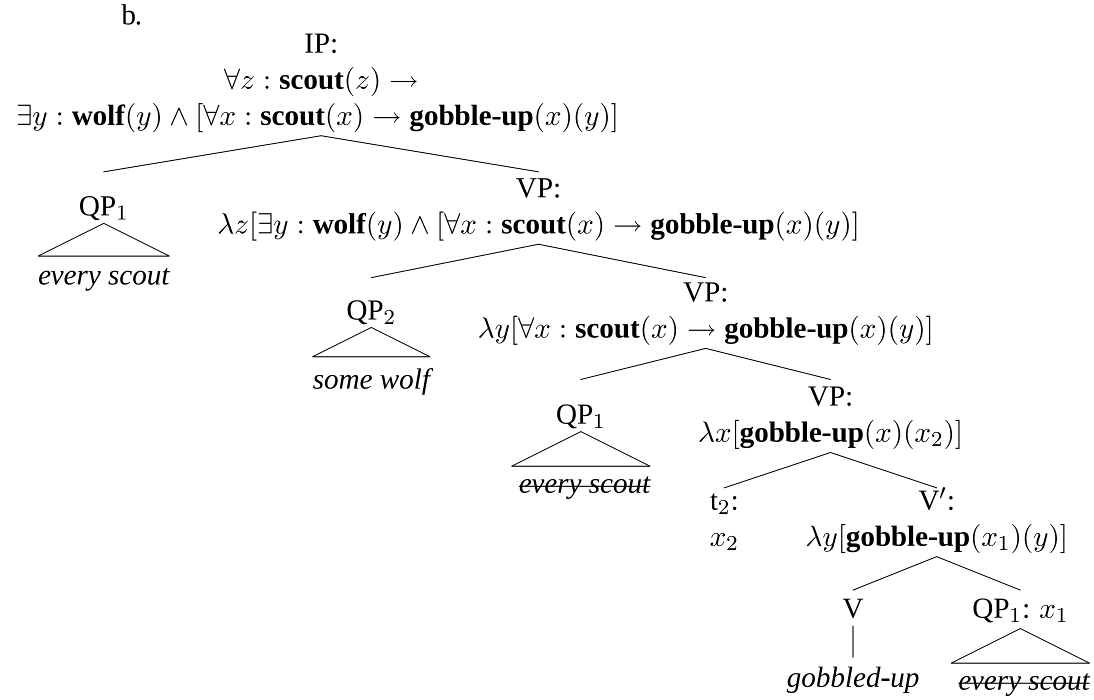
---

[11]This avoids the important question of how the lowest copy could ever be interpreted without some kind of type shift, of the verb or the quantifier; see the discussion of (33).

[12]This is very far from being an innocent assumption. The rules of Contraction and Weakening are denied in Linear Logic (Girard 1987), which is widely employed by linguists, particularly those working in Lexical Functional Grammar; see the papers in Dalrymple 2001. The rules are also absent from Categorial Grammars with directional application, which have of course found numerous applications in linguistics.

(40) a. Some wolf gobbled up every scout.

b.



The IP does not denote a proposition that corresponds to any reading of (40a). (40b) asserts that *if* x is a scout, then there's a wolf that gobbled-up every scout. But the only readings of (40a) correspond to (i) every scout is such that a wolf gobbled-up him up; and (ii) there is a wolf that gobbled-up every scout. In essence, (40b) is a wide-scope reading of *some wolf* that does not entail the existence of a wolf.

Although the fact that this impossible reading is derivable poses a range of problems for this version of the copy theory, the only ramification it has for present purposes is that it must be possible to interpret only the highest copy of a quantifier, translating the others as individual variables. But this means that (37) is among the available derivations. We have seen already that (37) cannot combine with Scope Economy to block the second application of QR. We would have to refer to a set of derivations that included (38). That is, we would need to interpret Scope Economy as a TDC.

Given the discussion in Section 3.1.1, this situation invites a conjecture. We have found a rule the cannot be stated non-transderivationally in a representational theory, but can be stated in a derivational one. It would be surprising to find a rule, whether applicable to natural languages or not, that could be given *only* a representational view, since all the information in such a theory's trees is generally encoded in the final tree in a derivational theory. So it is extremely likely, though as yet not established, that the derivational theories properly contain the representational ones.

Overall complexity The above shows only that Scope Economy can be given a non-TDC interpretation. It does not establish that it can be defined in $L^2_{K,P}$. In fact, this seems impossible, since we require a tree isomorphism in order to compare the structures. Rogers (1998) shows that tree isomorphisms are not definable in $L^2_{K,P}$. But the ability to state these isomorphisms is a reasonable expansion of the logical language; Lindell (1992) has shown that graph isomorphism for trees is computationally highly tractable. In contrast, intrinsic TDCs require drastic, ill-understood changes is the underlying logic of linguistic theory.

3.2 RULE H: an Inherent TDC

Fox (2000: §4) proposes another economy condition, which he called Rule H:

(41) RULE H (Fox 2000, p. 115)
A pronoun, α, can be bound by an antecedent, β, only if there is no closer antecedent, γ, such that it is possible to bind α by γ and *get the same semantic interpretation*.

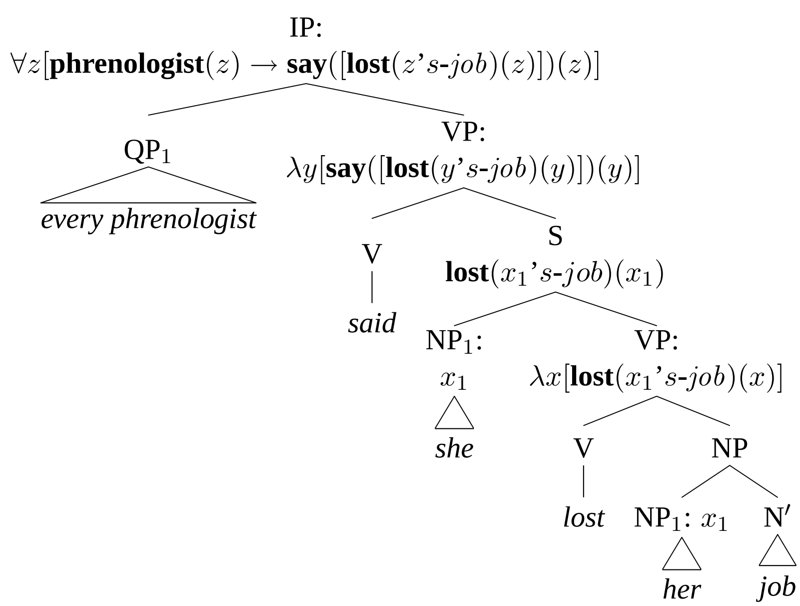
Although this condition sounds very much like Scope Economy, in that it makes the well-formedness of certain operator-variable relationships dependent upon meaning, it turns out to be intrinsically transderivational.

A simple application of this principle is as follows (based on Fox 2000 (p. 115ff)):

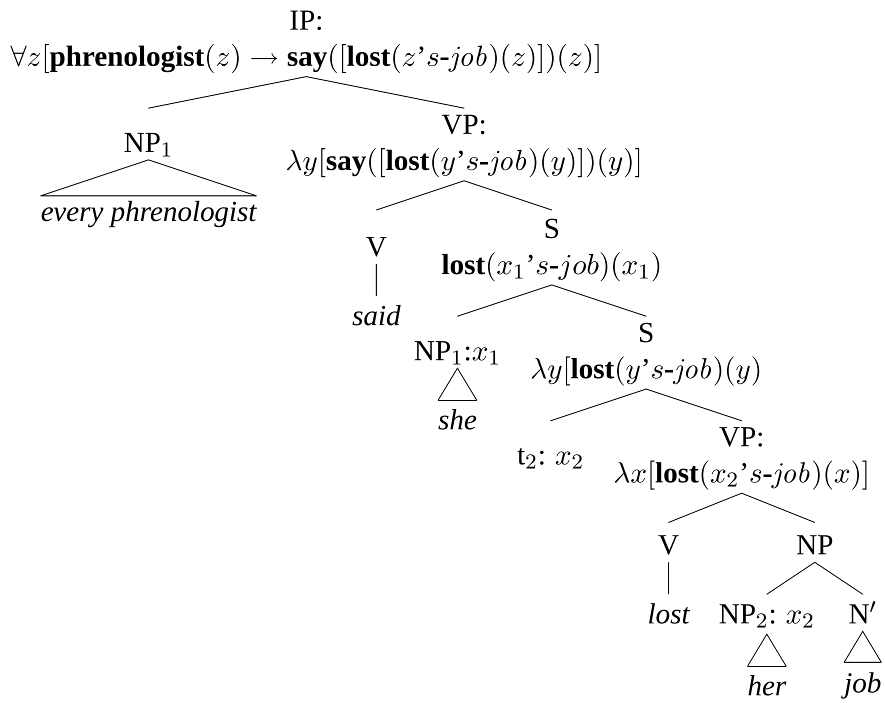
(42) Every phrenologist said that she lost her job.

The question is whether *Every phrenologist* can bind both the pronoun *she* and the pronoun *her*. That is, is (43a) well-formed?

(43) a.



b.



The intended answer is "No, (43a) is not well-formed". The binding relation between *every phrenologist* and *her* is blocked by Rule H, because the interpretation of this structure is identical to that of (43b), but *her* has a closer antecedent in (43b) than in (43a), namely *she*.

It is evident from the structures in question that Rule H cannot be an intraderivational constraint. There is no sense in which either of the trees in (43) is properly contained in the other (derived from the other), so the information required by Rule H is not available. To evaluate either of the trees in (43), one must consider a set that includes at least (43b), which makes evaluation of (43a) intrinsically transderivational.

4 Conclusions

The above discussion suggests that the class of TDCs is at least this structured:

(44)

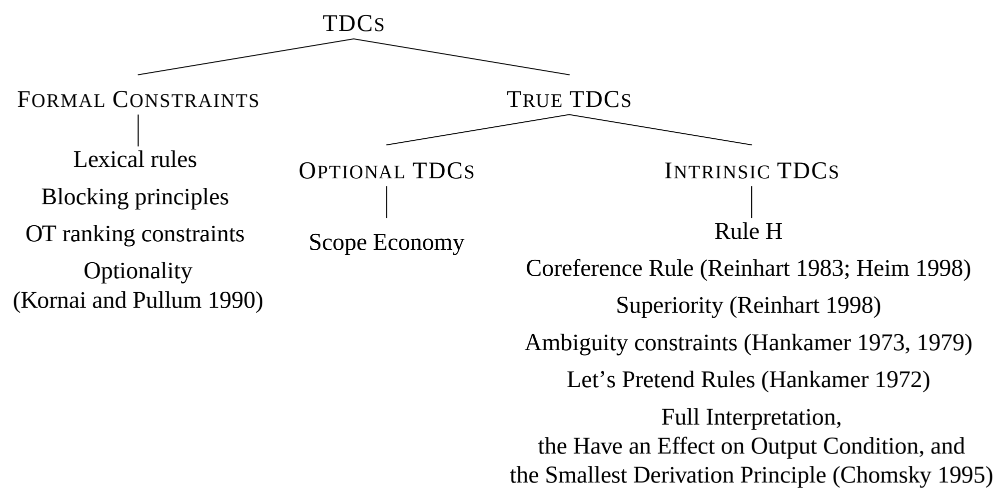
1. *Grammar constraints* are constraints on the set of constraints. The either establish closure properties on sets of rules (e.g., the passive metarule), or make one rule contingent on the (non-) existence of another (e.g., blocking with Danish definites).
2. *Optional TDCs* are transderivational only in certain frameworks. For example, Scope Economy is an intrinsic TDC in a nonderivational theory, but has an intraderivational interpretation in a derivational theory. This is possible because *the trees that are compared on the TDC interpretation are contained in the derivation*.
3. *Intrinsic TDCs*, such a Rule H, fundamentally involve quantification over sentences, whether modelled as single trees or ordered tuples of trees, because the relevant structures are not part of the derivational history of any one of them.

Interestingly, it turns out that the fact that a principle constrains a rule's domain of application does not make it an intrinsic TDC; both Scope Economy and Rule H have this property, but only Rule H is intrinsically a TDC. Rather, the crucial factor is whether or not the set of trees referenced by the constraint can be found in the derivation of the sentence in question.

We have, then, three kinds of TDC: grammar constraints, optional TDCs, and intrinsic TDCs. These are ordered by proper inclusion with respect to definability. Any grammar constraint can be stated intraderivationally (e.g., a passive transformation vs. a passive metarule), but not the reverse (Scope Economy has no metarule-type statement). And intraderivational constraints can (and in some frameworks must) be given a transderivational interpretation (as discussed above for Scope Economy).

I provide, in (45), a classification of TDCs that have been proposed in the past in the linguistic literature.

(45)



The list of intrinsic TDCs is long. It is worth asking, then, what kind of logic would allow their statement and form an adequate basis for linguistic theory. The challenge lies mainly in the fact that most linguistic proposals concern constraints between nodes in individuals trees (e.g., "a reflexive must have a clausemate antecedent"; "a negative polarity item must be in the scope of a downward entailing operator"). Thus, the theory cannot view trees atomic individuals. They must be rich relational structures – i.e., models. But TDCs require quantification over sets of trees, which seems to demand quantification over sets of *models*. It is easy to imagine how this might be done within the bounds of a reasonable logic: we divide the theory in half, as it were: in one part, the models are trees, the individuals nodes; in the other, the models are tree sets, the individuals trees. A relation between models and individuals in models would link the two universes.[13]

It is easy, then, to *describe* the required formal foundation. But the result is evidently of extreme complexity and also yields an oddly fragmented theory. In light of these considerations, we should be skeptical of TDC proposals, subjecting their empirical motivation to great scrutiny and searching hard for alternative accounts.

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[13]In forthcoming work, I argue that layered languages (Blackburn et al. 1993; Blackburn and Meyer-Viol 1997) provide a maximally constrained basis for a theory incorporating TDCs, and discuss the conceptual and theoretical drawbacks to adopting such a logic.

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