Steedman 2000
"The Syntactic Process"

4.4 Quantification in CCG

Another phenomenon that is naturally analyzed in terms of relations of command at the level of Logical Form is quantifier scope.

It is standard to assume that the ambiguity of sentences like (48) is to be accounted for by assigning two Logical Forms which differ in the scopes assigned to these quantifiers, as in (49a,b):

(48) Every boy admires some saxophonist.

(49) a. $\forall x.boy'x \rightarrow \exists y.saxophonist'y \wedge admires'yx$
b. $\exists y.saxophonist'y \wedge \forall x.boy'x \rightarrow admires'yx$

The question then arises of how the grammar can assign all and only the correct interpretations to sentences with multiple quantifiers.

This process has on occasion been explained in terms of "quantifier movement" or essentially equivalent computational operations of "quantifying in" or "storage" at the level of Logical Form. However, such accounts present a problem for monostratal and monotonic theories of grammar like CCG that try to do away with movement or the equivalent in syntax. Having eliminated nonmonotonic operations from the syntax, to have to restore them at the level of Logical Form would be dismaying, given the strong assumptions of transparency between syntax and semantics from which this and other monotonic theories begin. Given the assumptions of syntactic/semantic transparency and monotonicity that are usual in the Frege-Montague tradition, it is tempting to try to use nothing but the derivational combinatorics of surface grammar to deliver all the readings for ambiguous sentences like (48). Two ways to restore monotonicity have been proposed, namely: enriching the notion of derivation via type-changing operations; or enriching the lexicon and the semantic ontology.

It is standard in the Frege-Montague tradition to begin by translating expressions like *every boy* and *some saxophonist* into "generalized quantifiers"—in effect exchanging the roles of arguments like NPs and functors like verbs by type-raising the former (Lewis 1970; Montague 1973; Barwise and Cooper 1981; see Partee, ter Meulen and Wall 1990, 359 for a review):

In terms of the notation and assumptions of CCG, one way to incorporate generalized quantifiers into the semantics of CG determiners is to transfer type-raising to the lexicon, assigning the following categories to determiners like *every* and *some*, making them functions from nouns to type-raised NPs, where the latter are simply the syntactic types corresponding to a generalized quantifier:

(50) every := $(\mathrm{T}/(\mathrm{T}\backslash NP))/N : \lambda p.\lambda q.\forall x.px \rightarrow qx$
every := $(\mathrm{T}\backslash(\mathrm{T}/NP))/N : \lambda p.\lambda q.\forall x.px \rightarrow qx$

(51) some := $(\mathrm{T}/(\mathrm{T}\backslash NP))/N : \lambda p.\lambda q.\exists x.px \wedge qx$
some := $(\mathrm{T}\backslash(\mathrm{T}/NP))/N : \lambda p.\lambda q.\exists x.px \wedge qx$

Given the categories in (50) and (51), the alternative derivations that CCG permits will deliver the two distinct Logical Forms shown in (49), entirely monotonically and without involving structure-changing operations, as shown in (52) and (53).

(52) Every boy admires some saxophonist

$$\text{Every} := (T/(T\backslash NP))/N : \lambda p.\lambda q.\forall y.py \rightarrow qy \qquad \text{boy} := N : \lambda x.boy'x$$
$$\text{admires} := (S\backslash NP)/NP : \lambda x.\lambda y.admires'xy$$
$$\text{some} := (T'\backslash(T'/NP))/N : \lambda p.\lambda q.\exists x.px \wedge qx \qquad \text{saxophonist} := N : \lambda x.saxophonist'x$$
$$\text{Every boy} \;(>)\; T/(T\backslash NP) : \lambda q.\forall y.boy'y \rightarrow qy$$
$$\text{some saxophonist} \;(>)\; T'\backslash(T'/NP) : \lambda q.\exists x.saxophonist'x \wedge qx$$
$$\text{admires some saxophonist} \;(<)\; S\backslash NP : \lambda y.\exists x.saxophonist'x \wedge admires'xy$$
$$(>)\; S : \forall y.boy'y \rightarrow \exists x.saxophonist'x \wedge admires'xy$$

(53) Every boy admires some saxophonist

$$\text{Every} := (T/(T\backslash NP))/N : \lambda p.\lambda q.\forall y.py \rightarrow qy \qquad \text{boy} := N : \lambda x.boy'x$$
$$\text{admires} := (S\backslash NP)/NP : \lambda x.\lambda y.admires'xy$$
$$\text{some} := (T'\backslash(T'/NP))/N : \lambda p.\lambda q.\exists x.px \wedge qx \qquad \text{saxophonist} := N : \lambda x.saxophonist'x$$
$$\text{Every boy} \;(>)\; T/(T\backslash NP) : \lambda q.\forall y.boy'y \rightarrow qy$$
$$\text{some saxophonist} \;(>)\; T'\backslash(T'/NP) : \lambda q.\exists x.saxophonist'x \wedge qx$$
$$\text{Every boy admires} \;(>\mathbf{B})\; S/NP : \lambda x.\forall y.boy'y \rightarrow admires'xy$$
$$(<)\; S : \exists x.saxophonist'x \wedge \forall y.boy'y \rightarrow admires'xy$$

The idea that semantic quantifier scope is limited by syntactic derivational scope in this way has some very attractive features. For example, it immediately explains why scope alternation is both unbounded as in (54a) and sensitive to island constraints, as in (54b).

(54) a. At least one witness said that the accused knew every victim.
b. Some witness who saw every plaintiff denounced him.

However, linking derivation and scope as simply and directly as this makes the obviously false prediction that in sentences where there is no ambiguity of CCG derivation there should be no scope ambiguity. In particular, object topicalization and object right node raising are derivationally unambiguous in the relevant respects, and force the displaced object to command the rest of the sentence in derivational terms. So they should only have the wide scope reading of the object quantifier. This is not the case:

(55) a. Some saxophonist, every boy admires.
b. Every boy admires, and every girl detests, some saxophonist.

Both sentences have a narrow scope reading in which every individual has some attitude toward some saxophonist, but not necessarily the same saxophonist. This observation appears to imply that even the relatively free notion of derivation provided by CCG is still too restricted to explain all ambiguities arising from multiple quantifiers.

Nevertheless, (55b) has a further property, first observed by Geach (1972), that makes it seem as though scope phenomena are strongly restricted by surface grammar. Although the sentence has one reading where all of the boys and girls have strong feelings toward the same saxophonist—say, John Coltrane—and the reading already noted, according to which their feelings are all directed at possibly different saxophonists, it does not have a reading where the saxophonist has wide scope with respect to *every boy*, but narrow scope with respect to *every girl*—that is, where the boys all admire John Coltrane, but the girls all detest possibly different saxophonists. There does not even seem to be a reading involving separate wide scope saxophonists respectively taking scope over boys and girls—for example, where the boys all admire Coltrane and the girls all detest Lester Young.

These observations are very hard to reconcile with semantic theories that invoke powerful mechanisms like abstraction or Quantifying In and its relatives, (Montague 1973; Cooper 1983; Hobbs and Shieber 1987; Pereira 1990; Keller 1988), or quantifier movement. (Carden 1973; May 1985). For example, if quantifiers are mapped from syntactic levels to canonical subject, object (etc.) position at predicate-argument structure in both conjuncts in (55b) and then migrate up the Logical Form to take either wide or narrow scope, it is not clear why *some saxophonist* should have to take the *same* scope in both conjuncts. The same applies if quantifiers are generated in situ, then lowered to their surface position. Such observations might be countered by the invocation of a "parallelism condition" on coordinate sentences, of the general kind discussed by Fox (1995). But such rules are of very expressively powerful "transderivational" kind that one would otherwise wish to avoid. (See Jacobson (1998) for discussion and arguments against transderivational parallelism.)

Related observations led Keenan and Faltz (1978, 1985), Partee and Rooth (1983), Jacobson (1992a), Hendriks (1993), Oehrle (1994), and Winter (1995, to appear), among others, to propose considerably more general use of type-changing operations than are required in CCG, engendering considerably more flexibility in derivation than seems to be required by the purely syntactic phenomena that have motivated CCG up till now.[23]

Although the tactic of including such order-preserving type-changing operations in the grammar remains a valid alternative for a monotonic treatment of scope alternation in CCG and related forms of categorial grammar, there is no doubt that it complicates the theory considerably. The type-changing operations necessarily engender infinite sets of categories for each word, requiring heuristics based on (partial) orderings on the operations concerned, and raising questions about completeness and practical parsability. Some of these questions have been addressed by Hendriks and others, but the result has been to dramatically raise the ratio of mathematical proofs to sentences analyzed.

It seems worth exploring an alternative response to these observations concerning interactions of Surface Structure and scope-taking. The present section follows Woods (1975), VanLehn (1978), Webber (1978), Fodor (1982), Fodor and Sag (1982), and Park (1995, 1996) in explaining scope ambiguities in terms of a distinction between true generalized quantifiers and other purely referential categories. For example, in order to capture the narrow scope object reading for Geach's right-node-raised sentence (55b), in whose CCG derivation the object must command everything else, the present proposal follows Park in assuming that the narrow scope reading arises from a nonquantificational interpretation of *some saxophonist*, one that gives rise to a reading indistinguishable from a narrow scope reading when it ends up in the object position at the level of Logical Form. The obvious candidate for such a nonquantificational interpretation is some kind of referring expression.

The claim that many NPs that have been assumed to have a single generalized quantifier interpretation are in fact purely referential is not new. Recent literature on the semantics of natural quantifiers has departed considerably from the earlier tendency for semanticists to reduce all semantic distinctions of nominal meaning such as *de dicto/de re*, reference/attribution, etc. to distinctions in scope of traditional quantifiers. There is widespread recognition that many such distinctions arise instead from a rich ontology of different types of (collective, distributive, intensional, group-denoting, arbitrary, etc.) individual to which nominal expressions refer. (See for example Webber 1978, Barwise and Perry 1980, Fodor and Sag 1982, Fodor 1982, Hobbs 1983, 1985, Fine 1985, and papers in the recent collection edited by Szabolcsi 1997.)

One example of such nontraditional entity types (if an idea that apparently originates with Aristotle can be called nontraditional) is the notion of "arbitrary objects" (Fine 1985). An arbitrary object is an object with which properties can be associated but whose extensional identity in terms of actual objects is unspecified. In this respect, arbitrary objects resemble the Skolem terms that are generated by inference rules like Existential Elimination in proof theories of first-order predicate calculus.

I will argue that arbitrary objects so interpreted are a necessary element of the ontology for natural language semantics, and that their involvement in CCG explains not only scope alternation (including occasions on which scope alternation is *not* available), but also certain cases of anomalous scopal binding

that are unexplained under any of the alternatives discussed so far.