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Citation for published version:
Steedman, M 1999, Alternating Quantifier Scope in CCG. in *27th Annual Meeting of the Association for Computational Linguistics, Univeristy of Maryland, College Park, Maryland, USA, 20-26 June 1999..* pp. 301-308. https://doi.org/10.3115/1034678.1034728

Digital Object Identifier (DOI):
10.3115/1034678.1034728

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Publisher's PDF, also known as Version of record

Published In:
27th Annual Meeting of the Association for Computational Linguistics, Univeristy of Maryland, College Park, Maryland, USA, 20-26 June 1999.

Alternating Quantifier Scope in CCG*

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Abstract

The paper shows that movement or equivalent computational structure-changing operations of any kind at the level of logical form can be dispensed with entirely in capturing quantifier scope ambiguity. It offers a new semantics whereby the effects of quantifier scope alternation can be obtained by an entirely monotonic derivation, without type-changing rules. The paper follows Fodor (1982), Fodor and Sag (1982), and Park (1995, 1996) in viewing many apparent scope ambiguities as arising from referential categories rather than true generalized quantifiers.

1 Introduction

It is standard to assume that the ambiguity of sentences like (1) is to be accounted for by assigning two logical forms which differ in the scopes assigned to these quantifiers, as in (2a,b):[1]

(1) Every boy admires some saxophonist.

(2) 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 a grammar/parser 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 non-monotonic 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 the 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 (1). 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 a process of "type-raising" the former. In terms of the notation and assumptions of Combinatory Categorial Grammar (CCG, Steedman 1996) the standard 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" noun-phrases, where the latter are simply the syntactic types corresponding to a generalized quantifier:

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

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

* Early versions of this paper were presented to audiences at Brown U., NYU, and Karlový U. Prague. Thanks to Jason Baldridge, Gann Bierner, Tim Fernando, Kit Fine, Polly Jacobson, Mark Johnson, Aravind Joshi, Richard Kayne, Shalom Lappin, Alex Lascarides, Suresh Manandhar, Jaruslav Peregrin, Jong Park, Anna Szabolcsi, Bonnie Webber, Alistair Willis, and the referees for helpful comments. The work was supported in part by ESRC grant M423284002.

[1] The notation uses juxtaposition *fa* to indicate application of a functor *f* to an argument *a*. Constants are distinguished from variables by a prime, and semantic functors like *admires'* are assumed to be "Curried". A convention of "left associativity" is assumed, so that *admires'yx* is equivalent to $(admires'y)x$.

(T is a variable over categories unique to each individual occurrence of the raised categories (3) and (4), abbreviating a finite number of different raised types. We will distinguish such distinct variables as T, T′, as necessary.)

Because CCG adds rules of function composition to the rules of functional application that are standard in pure Categorial Grammar, the further inclusion of type-raised arguments engenders derivations in which objects command subjects, as well as more traditional ones in which the reverse is true. Given the categories in (3) and (4), these alternative derivations will deliver the two distinct logical forms shown in (2), entirely monotonically and without involving structure-changing operations.

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:

(5) 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 towards 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, the idea that semantic quantifier scope is limited by syntactic derivational scope has some very attractive features. For example, it immediately explains why scope alternation is both unbounded and sensitive to island constraints. There is a further property of sentence (5b) which was first observed by Geach (1972), and which makes it seem as though scope phenomena are strongly restricted by surface grammar. While the sentence has one reading where all of the boys and girls have strong feelings toward the same saxophonist—say, John Coltrane—and another reading where 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, or "Quantifier Movement." For example, if quantifiers are mapped from syntactic levels to canonical subject, object etc. position at predicate-argument structure in both conjuncts in (5b), and then migrate up the logical form to take either wide or narrow scope, then 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.[2]

Related observations led Partee and Rooth (1983), and others to propose considerably more general use of type-changing operations than are required in CCG, engendering considerably more flexibility in derivation that seems to be required by the purely syntactic phenomena that have motivated CCG up till now.[3]

While 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. All 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 sur-

[2]Such observations have been countered by the invocation of a "parallelism condition" on coordinate sentences, a rule of a very expressively powerful "transderivational" kind that one would otherwise wish to avoid.

[3]For example, in order to obtain the narrow scope object reading for sentence (5b), Hendriks (1993), subjects the category of the transitive verb to "argument lifting" to make it a function over a type-raised object type, and the coordination rule must be correspondingly semantically generalized.

face structure and scope-taking. The present paper follows 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 (5b), in whose CCG derivation the object must command everything else, the present paper follows Park in assuming that the narrow scope reading arises from a non-quantificational interpretation of *some saxophonist*, one which 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 non-quantificational interpretation is some kind of referring expression.

The claim that many noun-phrases which 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, Fine 1985, and papers in the recent collection edited by Szabolcsi 1997.)

One example of such non-traditional entity types (if an idea that apparently originates with Aristotle can be called non-traditional) 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.

The rest of the paper 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 which are unexplained under any of the alternatives discussed so far.

2 Donkeys as Skolem Terms

One example of an indefinite that is probably better analyzed as an arbitrary object than as a quantified NP occurs in the following famous sentence, first brought to modern attention by Geach (1962):

(6) Every farmer who owns a donkey$_i$ beats it$_i$.

The pronoun looks as though it might be a variable bound by an existential quantifier associated with *a donkey*. However, no purely combinatoric analysis in terms of the generalized quantifier categories offered earlier allows this, since the existential cannot both remain within the scope of the universal, and come to *c*-command the pronoun, as is required for true bound pronominal anaphora, as in:

(7) Every farmer$_i$ in the room thinks that she$_i$ deserves a subsidy

One popular reaction to this observation has been to try to generalize the notion of scope, as in Dynamic Predicate Logic (DPL). Others have pointed out that donkey pronouns in many respects look more like *non*-bound-variable or discourse-bound pronouns, in examples like the following:

(8) Everybody who knows Gilbert$_i$ likes him$_i$.

I shall assume for the sake of argument that "a donkey" translates at predicate-argument structure as something we might write as $arb'donkey'$. I shall assume that the function arb' yields a Skolem term—that is, a term applying a unique functor to all variables bound by universal quantifiers in whose extent $arb'donkey'$ falls. Call it $sk_{donkey}x$ in this case, where sk_{donkey} maps individual instantiations of x—that is, the variable bound by the generalized quantifier *every farmer*—onto objects with the property $donkey'$ in the database.[4]

An ordinary discourse-bound pronoun may be bound to this arbitrary object, but unless the pronoun is in the scope of the quantifiers that bind any variables in the Skolem term, it will include a variable that is outside the scope of its binder, and fail to refer.

This analysis is similar to but distinct from the analyses of Cooper (1979) and Heim (1990),

[4] I assume that arb' "knows" what scopes it is in by the same mechanism whereby a bound variable pronoun "knows" about its binder. Whatever this mechanism is, it does not have the power of movement, abstraction, or storage. An arbitrary object is deterministically bound to *all* scoping universals.

who assume that *a donkey* translates as a quantified expression, and that the entire subject *every farmer who owns a donkey* establishes a contextually salient function mapping farmers to donkeys, with the donkey/E-type pronoun specifically of the type of such functions. However, by making the pronoun refer instead to a Skolem term or arbitrary object, we free our hands to make the inferences we draw on the basis of such sentences sensitive to world knowledge. For example, if we hear the standard donkey sentence and know that farmers may own more than one donkey, we will probably infer on the basis of knowledge about what makes people beat an arbitrary donkey that she beats all of them. On the other hand, we will not make a parallel inference on the basis of the following sentence (attributed to Jeff Pelletier), and the knowledge that some people have more than one dime in their pocket.

(9) Everyone who had a dime in their pocket put it in the parking meter.

The reason is that we know that the reason for putting a dime into a parking meter, unlike the reason for beating a donkey, is voided by the act itself.

The proposal to translate indefinites as Skolem term-like discourse entities is anticipated in much early work in Artificial Intelligence and Computational Linguistics, including Kay (1973), Woods (1975 p.76-77), VanLehn (1978), and Webber (1983, p.353, cf. Webber 1978, p.2.52), and also by Chierchia (1995), Schlenker (1998), and in unpublished work by Kratzer. Skolem functors are closely related to, but distinct from, "Choice Functions" (see Reinhart 1997, Winter 1997, Sauerland 1998, and Schlenker 1998 for discussion. Webber's 1978 analysis is essentially a choice functional analysis, as is Fine's.)

3 Scope Alternation and Skolem Entities

If indefinites can be assumed to have a referential translation as an arbitrary object, rather than a meaning related to a traditional existential generalized quantifier, then other supposed quantifiers, such as *some/a few/two saxophonists* may also be better analyzed as referential categories.

We will begin by assuming that *some* is not a quantifier, but rather a determiner of a (singular) arbitrary object. It therefore has the following pair of subject and complement categories:

(10) a. some := $(\mathrm{T}/(\mathrm{T}\backslash NP))/N : \lambda p.\lambda q.q(arb'p)$
b. some := $(\mathrm{T}\backslash(\mathrm{T}/NP))/N : \lambda p.\lambda q.q(arb'p)$

In this pair of categories, the constant arb' is the function identified earlier from properties p to entities of type e with that property, such that those entities are functionally related to any universally quantified NPs that have scope over them at the level of logical form. If $arb'p$ is not in the extent of any universal quantifier, then it yields a unique arbitrary constant individual.

We will assume that *every* has at least the generalized quantifier determiner given at (3), repeated here:

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

These assumptions, as in Park's related account, provide everything we need to account for all and only the readings that are actually available for the Geach sentence (5b), repeated here:

(12) Every boy admires, and every girl detests, some saxophonist.

The "narrow-scope saxophonist" reading of this sentence results from the (backward) referential category (10b) applying to the translation of *Every boy admires and every girl detests* of type S/NP (whose derivation is taken as read), as in (13). Crucially, if we evaluate the latter logical form with respect to a database after this reduction, as indicated by the dotted underline, for each boy and girl that we examine and test for the property of admiring/detesting an arbitrary saxophonist, we will find (or in the sense of Lewis (1979) "accommodate" or add to our database) a potentially different individual, dependent via the Skolem functors sk'_{sax_1} and sk'_{sax_2} upon that boy or girl. Each conjunct thereby gives the appearance of including a variable bound by an existential within the scope of the universal.

The "wide-scope saxophonist" reading arises from the same categories as follows. If Skolemization can act *after* reduction of the object, when the arbitrary object is within the scope of the universal, then it can also act *before*, when it is not in scope, to yield a Skolem constant, as in (14). Since the resultant logical form is in all important respects model-theoretically equivalent to the one that would arise from a wide scope existential quantification, we can entirely eliminate the quantifier reading (4) for *some*, and regard it as bearing only the arbitrary object reading (10).[5]

[5]Similar considerations give rise to apparent wide and nar-

(13) Every boy admires and every girl detests — some saxophonist

$$\dfrac{\dfrac{\text{Every boy admires and every girl detests}}{S/NP : \lambda x.and'(\forall y.boy'y \rightarrow admires'xy)(\forall z.girl'z \rightarrow detests'xz)} \quad \dfrac{\text{some saxophonist}}{S\backslash(S/NP) : \lambda q.q(arb'sax')}}{S : and'(\forall y.boy'y \rightarrow admires'(arb'sax')y)(\forall z.girl'z \rightarrow detests'(arb'sax')z)}{<}$$

$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$

$$S : and'(\forall y.boy'y \rightarrow admires'(sk'_{sax_1}y)y)(\forall z.girl'z \rightarrow detests'(sk'_{sax_2}z)z)$$

(14) Every boy admires and every girl detests — some saxophonist

$$\dfrac{\dfrac{\text{Every boy admires and every girl detests}}{S/NP : \lambda x.and'(\forall y.boy'y \rightarrow admires'xy)(\forall z.girl'z \rightarrow detests'xz)} \quad \dfrac{\text{some saxophonist}}{\begin{array}{c} S\backslash(S/NP) : \lambda q.q(arb'sax') \\ \cdots\cdots\cdots\cdots \\ : \lambda q.q(sk'_{sax}) \end{array}}}{S : and'(\forall y.boy'y \rightarrow admires'sk'_{sax}y)(\forall z.girl'z \rightarrow detests'sk'_{sax}z)}{<}$$

Consistent with Geach's observation, these categories do not yield a reading in which the boys admire the same wide scope saxophonist but the girls detest possibly different ones. Nor do they yield one in which the girls also all detest the same saxophonist, but not necessarily the one the boys admire. Both facts are necessary consequences of the monotonic nature of CCG as a theory of grammar, without any further assumptions of parallelism conditions.

In the case of the following scope-inverting relative of the Geach example, the outcome is subtly different.

(15) Some woman likes and some man detests every saxophonist.

The scope-inverting reading arises from the evaluation of the arbitrary woman and man *after* combination with *every saxophonist*, within the scope of the universal:

(16) $\forall x.saxophonist'x \rightarrow$
$and'(likes'x(sk'_{woman}x))(detests'x(sk'_{man}x))$

The reading where *some woman* and *some man* appear to have wider scope than *every saxophonist* arises from evaluation of (the interpretation of) the residue of right node raising, *some woman likes and some man detests*, before combination with the generalized quantifier *every saxophonist*. This results in two Skolem constants, say sk'_{woman} and sk'_{man} liking every saxophonist, again without the involvement of a true existential quantifier:

(17) $\forall x.saxophonist'x \rightarrow$
$and'(likes'x\ sk'_{woman})(detests'x\ sk'_{man})$

These readings are obviously correct. However, since Skolemization of the arbitrary man and woman has so far been assumed to be free to occur any time, it seems to be predicted that one arbitrary object might become a Skolem constant in advance of reduction with the object, while the other might do so after. This would give rise to further readings in which only one of *some man* or *some woman* takes wide scope—for example:[6]

(18) $\forall x.saxophonist'x \rightarrow$
$and'(likes'x\ sk'_{woman})(detests'x(sk'_{man}x))$

Steedman (1991) shows on the basis of possible accompanying intonation contours that the coordinate fragments like *Some woman likes and some man detests* that result from right node raising are identical with information structural units of utterances—usually, the "theme." In the present framework, readings like (18) can therefore be eliminated without parallelism constraints, by the further assumption that *Skolemization/binding of arbitrary objects can only be done over complete information structural units*—that is, entire themes, rhemes, or utterances. When any such unit is resolved in this way, *all* arbitrary objects concerned are obligatorily bound.[7]

While this account of indefinites might appear to mix derivation and evaluation in a dangerous way, this is in fact what we would expect from a mono-

row scope versions of the existential donkey in (6).

[6]The non-availability of such readings has also been used to argue for parallelism constraints. Quite apart from the theoretically problematic nature of such constraints, they must be rather carefully formulated if they are not to exclude perfectly legal conjunction of narrow scope existentials with explicitly referential NPs, as in the following:
(i) Some woman likes, and Fred detests, every saxophonist.

[7]I am grateful to Gann Bierner for pointing me towards this solution.

tonic semantics that supports the use of incremental semantic interpretation to guide parsing, as humans appear to (see below).

Further support for a non-quantificational analysis of indefinites can be obtained from the observation that certain nominals that have been talked of as quantifiers entirely fail to exhibit scope alternations of the kind just discussed. One important class is the "non-specific" or "non-group-denoting counting" quantifiers, including the upward-monotone, downward-monotone, and non-monotone quantifiers (Barwise and Cooper 1981) such as *at least three, few, exactly five* and *at most two* in examples like the following, which are of a kind discussed by Liu (1990), Stabler (1997), and Beghelli and Stowell (1997):

(19) a. Some linguist can program in at most two programming languages.
b. Most linguists speak at least three /few/exactly five languages.

In contrast to true quantifiers like *most* and *every*, these quantified NP objects appear not to be able to invert or take wide scope over their subjects. That is, unlike *some linguist can program in every programming language* which has a scope-inverting reading meaning that every programming language is known by some linguist, (19a) has no reading meaning that there are at most two programming languages that are known to any linguist, and (19b) cannot mean that there are at least three/few/exactly five languages. languages that most linguists speak.

Beghelli and Stowell (1997) account for this behavior in terms of different "landing sites" (or in GB terms "functional projections") at the level of LF for the different types of quantifier. However, another alternative is to believe that in syntactic terms these noun-phrases have the same category as any other but in semantic terms they are (plural) arbitrary objects rather than quantifiers, like *some, a few, six* and the like. This in turn means that they cannot engender dependency in the arbitrary object arising from *some linguist* in (19a). As a result the sentence has a single meaning, to the effect that there is an arbitrary linguist who can program in at most two programming languages.

4 Computing Available Readings

We may assume (at least for English) that even the non-standard constituents created by function composition in CCG cannot increase the number of quantifiable arguments for an operator beyond the limit of three or so imposed by the lexicon. It follows that the observation of Park (1995, 1996) that only quantified arguments of a single (possibly composed) function can freely alternate scope places an upper bound on the number of readings. The logical form of an n-quantifier sentence is a term with an operator of valency 1, 2 or 3, whose argument(s) must either be quantified expressions or terms with an operator of valency 1, 2 or 3, and so on. The number of readings for an n quantifier sentence is therefore bounded by the number of nodes in a single spanning tree with a branching factor b of up to three and n leaves. This number is given by a polynomial whose dominating term is $b^{\log_b n}$—that is, it is linear in n, albeit with a rather large constant (since nodes correspond up to $3! = 6$ readings). For the relatively small n that we in practice need to cope with, this is still a lot of readings in the worst case.

However, the actual number of readings for real sentences will be very much lower, since it depends on how many true quantifiers are involved, and in exactly what configuration they occur. For example, the following three-quantifier sentence is predicted to have not $3! = 6$ but only 4 distinct readings, since the non-quantifiers *exactly three girls* and *some book* cannot alternate scope with each other independently of the truly quantificational dependency-inducing *Every boy*.

(20) Every boy gave exactly three girls some book.

This is an important saving for the parser, as redundant analyses can be eliminated on the basis of identity of logical forms, a standard method of eliminating such "spurious ambiguities."

Similarly, as well as the restrictions that we have seen introduced by coordination, the SVO grammar of English means (for reasons discussed in Steedman 1996) that embedded subjects in English are correctly predicted neither to extract nor take scope over their matrix subject in examples like the following:

(21) a. *a boy who(m) I know that admires John Coltrane
b. Somebody knows that every boy admires some saxophonist.

As Cooper 1983 points out, the latter has no readings where *every boy* takes scope over *somebody*. This three-quantifier sentence therefore has not $3! = 6$, not $2! * 2! = 4$, but only $2! * 1 = 2$ readings. Bayer (1996) and Kayne (1998) have noted related restrictions on scope alternation that would otherwise be allowed for arguments that are marooned in mid verb-group in German. Since such embeddings are crucial to obtaining proliferating readings, it is likely that in practice the number of available readings is usually quite small.

It is interesting to speculate finally on the relation of the above account of the available scope readings with proposals to minimize search during processing by building "underspecified" logical forms by Reyle (1992), and others cited in Willis and Manandhar (1999). There is a sense in which arbitrary individuals are themselves under-specified quantifiers, which are disambiguated by Skolemization. However, under the present proposal, they are disambiguated during the derivation itself.

The alternative of building a single underspecified logical form can under some circumstances dramatically reduce the search space and increase efficiency of parsing—for example with distributive expressions in sentences like *Six girls ate five pizzas*, which are probably intrinsically unspecified. However, few studies of this kind have looked at the problems posed by the restrictions on available readings exhibited by sentences like (5b). The extent to which inference can be done with the under-specified representations themselves for the quantifier alternations in question (as opposed to distributives) is likely to be very limited. If they are to be disambiguated efficiently, then the disambiguated representations must embody or include those restrictions. However, the restriction that Geach noted seems intrinsically disjunctive, and hence appears to threaten efficiency in both parsing with, and disambiguation of, under-specified representations.

The fact that relatively few readings are available and that they are so tightly related to surface structure and derivation means that the technique of incremental semantic or probabilistic disambiguation of fully specified partial logical forms mentioned earlier may be a more efficient technique for computing the contextually relevant readings. For example, in processing (22) (adapted from Hobbs and Shieber 1987), which Park 1995 claims to have only four readings, rather than the five predicted by their account, such a system can build both readings for the *S/NP every representative of three companies saw* and decide which is more likely, before building both compatible readings of the whole sentence and similarly resolving with respect to statistical or contextual support:

(22) Every representative of three companies saw some sample.

5 Conclusion

The above observations imply that only those so-called quantifiers in English which can engender dependency-inducing scope inversion have interpretations corresponding to genuine quantifiers. The others are not quantificational at all, but are various types of arbitrary individuals translated as Skolem terms. These give the appearance of taking narrow scope when they are bound to truly quantified variables, and of taking wide scope when they are unbound, and therefore "take scope everywhere." Available readings can be computed monotonically from syntactic derivation alone. The notion of syntactic derivation embodied in CCG is the most powerful limitation on the number of available readings, and allows all logical-form level constraints on scope orderings to be dispensed with, a result related to, but more powerful than, that of Pereira (1990).

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