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SURFACE-COMPOSITIONAL SCOPE-ALTERNATION WITHOUT EXISTENTIAL QUANTIFIERS*

1 INTRODUCTION

A standard response to the ambiguity of sentences like (1) is to assume they yield two logical forms, expressible in the first-order predicate calculus, differing in the scopes assigned to traditional quantifiers, as in (2a,b):[1]

(1) Everybody loves somebody.

(2) a. $\forall x[person'x \rightarrow \exists y[person'y \wedge loves'yx]]$
b. $\exists y[person'y \wedge \forall x[person'x \rightarrow loves'yx]]$

The Montagovian assumption of "direct surface composition" (Hausser 1984; Jacobson 1996a) requires that all available readings of this kind should arise directly from the combinatorics of syntax operating over the lexical elements and their meanings. However, the grammar of English appears to offer a single syntactic structure for the sentence, in which the subject takes scope over the object, leaving the second reading unaccounted for. The ability of the object to "invert scope" or take wide scope over the subject in the following example is similarly unexplained:

*The present paper began in work at the University of Pennsylvania with Jong Park, whose PhD thesis (1996) reported the first attempt at this problem in CCG. Some of the ideas in the present paper were advanced in embryonic form in Steedman 1999 and Steedman 2000b, p.70-85. The paper completely revises the earlier account, providing a model theory and extensions to a number of new phenomena. Earlier versions were circulated under the title "Syntactic Constraints on Quantifier Scope Alternation" and presented in 1999 to audiences at Brown, NYU, Univerzita Karlova, Prague, the Formal Grammar Conference, Utrecht, and the Twelfth Amsterdam Colloquium, and to the 14th SALT Conference, Northwestern, in June 2004, the Conference on Strategies of Quantification York in July 2004, the conference on Formal Grammar and Mathematics of Language, Edinburgh, August 2005, under the title "Scope Alternation and the Syntax-Semantics Interface", and in talks at the Ohio State University and to the X-TAG seminar at the University of Pennsylvania in 2006-2007. I am grateful to those audiences, and to Jason Baldridge, Gann Bierner, Maria Bittner, Johan Bos, Gosse Bouma, Tim Fernando, Kit Fine, Nissim Francez, Stephen Isard, Polly Jacobson, Mark Johnson, Aravind Joshi, Hans Kamp, Richard Kayne, Frank Keller, Brenda Kennelly, Shalom Lappin, Alex Lascarides, Suresh Manandhar, Jaruslav Peregrin, Jong Park, Ian Pratt-Hartmann, Livio Robaldo, Maribel Romero, Tatiana Scheffler, Matthew Stone, Anna Szabolcsi, Bonnie Webber, Michael White, Alistair Willis, and Yoad Winter, for helpful comments and patient advice over a long period. In particular, Stephen Isard gave extensive help with the model-theory. Any errors remain my responsibility. The work was supported in part by EPSRC grants GR/M96889, GR/R02450, GR/R82838, and GR/S22509, and by EU IP grant FP6-2004-IST-4-27657 PACO+.

[1]The notation in (2) uses concatenation *fa* to indicate application of a functor f to an argument a. Constants are distinguished from variables by a prime, and polyvalent semantic functors like $admires'$ are assumed to be "Curried". A convention of "left associativity" is assumed, so that $admires'yx$ is equivalent to $(admires'y)x$.

(3) Somebody loves everybody.

One way out of this dilemma that has sometimes been proposed is to assume that English determiners are semantically ambiguous between wide and narrow scope readings, so that the same syntactic combinatorics delivers two different interpretations. However, the fact that no-one has ever identified a language in which wide- and narrow- scope quantifier determiners are lexically or morphologically disambiguated, as would be allowed by such a distinction, makes this option unattractive.

A more popular suggestion has been to abandon direct surface composition, and explain the phenomenon in terms of "covert" quantifier movement (Kayne 1998) or essentially equivalent operations of "quantifying in" or "storage" at the level of logical form. However, such accounts are at odds with the general tendency to try to eliminate movement from the theory of syntax in theories of grammar like Generalized Phrase Structure Grammars (GPSG, Gazdar 1981), Lexical-Functional Grammar (LFG, Bresnan 1982), Tree-Adjoining Grammar (TAG, Joshi 1988), Head Driven Phrase Structure Grammar (HPSG, Pollard and Sag 1994), and Combinatory Categorial Grammar (CCG, Steedman 1996, hereafter *SS&I*, Steedman 2000b, hereafter *SP*), the framework used in the present paper.. These theories eliminate "overt" movement or the equivalent in syntax. The assumption of direct surface composition suggests its inverse: if movement can be so easily eliminated from syntax, it should not be necessary in semantics either.

One way to avoid movement might appear to be to leave quantifier scope underspecified at the level of logical form, via a separately maintained set of inequalities, as proposed in Kempson and Cormack 1981, Alshawi and Crouch 1992, Reyle 1993, and much subsequent work, specifying the possible scoped solutions to those inequalities once derivation is complete. However, the possibilities for taking scope explored in section 2.1 of this paper seem to be too closely linked to syntactic derivational combinatorics for such "off-line" specification to be an attractive alternative for the present purpose.

It is tempting, instead, to retain the assumption of surface compositionality, and 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 do this have been proposed, namely: enriching the notion of derivation via type-changing operations; or enriching the lexicon and the semantic ontology. Despite embracing the generalized notion of derivation that CCG affords for syntactic purposes, the present paper takes the latter approach to the semantics of quantifier scope.

The argument will proceed as follows. Part I begins by briefly reviewing the most important generalizations concerning the interaction of derivation and quantifier scope that such a theory must explain. The paper then proposes a semantics according to which all non-universal nounphrases in English translate, not as generalized quantifiers, but as expressions called “generalized Skolem terms.” Like standard Skolem terms, the generalized variety are either constants or functional terms including variables bound by universal quantifiers.

Generalized Skolem terms are semantically of the same type e as individuals in the model, rather than quantificational (that is, of higher types such as $(e \rightarrow t) \rightarrow t$). When they are constants, they “take scope everywhere”, and hence behave like wide scope existentials. When they are in the extent of a bound variable, they behave as entities dependent upon the binder of that variable, and are inaccessible to processes like anaphora from outside that scope.

Generalized Skolem terms are initially (that is, lexically) unspecified as to dependency. Whether they become functional terms or constants depends on a dynamic process of “Skolem term specification” that can occur freely during derivation. While there is a family resemblance between Skolem term specification and the scopal resolution of underspecified quantifiers, this process is here integrated into surface-syntactic derivation. To the extent that this process also resembles derivation-based retrieval of the equivalent of existential quantifiers from “storage” of the kind proposed by Cooper (1983) and in particular the “nested Cooper storage” proposed by Keller (1988), it differs in eliminating the need for a storage memory distinct from the logical form itself, and the stack memory of the extended push-down automaton that is implicit in the CCG derivation. There are empirical consequences in terms of the number of interpretations that are predicted to be available.

The first part of the paper depends very heavily on an analysis in section 3.1 of the apparently anomalous scope possibilities for pronominal anaphora in so-called “donkey sentences”. Such anaphora depends on the assumption that generalized Skolem terms may not only refer, but also introduce new discourse referents to the context, which may in turn act as antecedents to pronouns. We will assume the kind of account of this process that has been proposed in Discourse Representation Theory (DRT, Heim 1990; Kamp and Reyle 1993; van Eijck and Kamp 1997; Asher and Lascarides 2003). In particular, we will assume that some version of DRT will provide an account of exactly how and when such discourse referents are introduced into the context, and under what conditions they are accessible to pronominal anaphora and cataphora.

However, the present account differs from standard DRT in two important respects. First, it assumes that the discourse referents that are established in this way are themselves generalized Skolem terms—that is, *structured representations*, encoding dependency relations among individuals that have to be satisfied in the model—rather than simple DRT variables ranging over individuals. Second, the treatment of quantifier scope proposed here is based on an entirely *static semantics*, rather than the dynamic semantics of scope proposed in DRT and its Dynamic Predicate Logic incarnation (DPL, Groenendijk and Stokhof 1991). A number of benefits follow, including escape from both the notorious “proportion-problem” (and its dual the "uniqueness-problem"), and delivery of the so-called "strong" reading for donkey sentences. Since generalized Skolem terms are full citizens of the logic, rather than being derived from existentially quantified variables, or being existentially closed-over, a model theory for this semantics is provided.

Part I is merely a preliminary to Part II, in which the remaining sections 6 to 11 extend a CCG grammar fragment first sketched in *SP* to a more complete grammar of quantification, in which the pure combinatorics of grammatical derivation and the involvement of generalized Skolem terms at the level of logical form explain not only the phenomenon of scope alternation (including the many occasions on which scope alternation is *not* available, including the case of embedded subject positions), but also the problem of distributivity, the possibility of certain notorious cases of scope inversion out of NP islands, and the interaction of scope alternation with coordinate structure. The conclusion returns to the discussion of the relation of the present proposal to other formalisms, including DRT.

The literature in this area is extensive and ramified, and the critical data are frequently in dispute. A number of distracting peripheral phenomena, whose relevance to the main issue is in the end questionable, consequently have to be disposed of along the way. In an attempt to minimize these distractions, I have relegated many to footnotes and signaled the secondary status of some others that could be skipped on a first reading by giving the relevant subsections titles of the form "An Aside on X".

I: SEMANTICS OF QUANTIFIER-LIKE EXPRESSIONS IN ENGLISH

2 THE PHENOMENON AND SOME EARLY APPROACHES

The proposal to link semantic quantifier scope-taking directly to syntactic combinatorics or derivational scope has some attractive features. First, it suggests an explanation for the following notorious asymmetry in the interactions of universal and existential nominals with conjunction and disjunction.

Partee (1970) noted that the universals distribute over conjunction, and fail to distribute over disjunction:

(4) a. Every man walks and talks = Every man walks and every man talks.
 b. Every man walks or talks≠ Every man walks or every man talks.

However, the reverse conditions hold for singular existentials, which distribute over disjunction, and fail to distribute over conjuction:

(5) a. Some man walks or talks = Some man walks or some man talks.
 b. Some man walks and talks ≠ Some man walks and some man talks

Furthermore, *no man* fails to distribute with either:

(6) a. No man walks or talks $\neq$ No man walks or no man talks.
b. No man walks and talks $\neq$ No man walks and no man talks

These observations are hard to explain on deletion-based accounts of coordinate sentences, which derive the reduced forms on the left from something more like the forms on the right, and provided one of the strongest early motivations for generalized quantifiers and base-generative accounts of coordination (e.g. Montague 1970, 1973; Partee 1970; Geach 1972).

A number of further asymmetries between and among universal and existential nominals of various kinds are set out in the next section.

2.1 The Natural History of Scope-taking

The data are somewhat in dispute, but the facts seem to be as follows:[2]

1. All non-singular so-called quantifiers distribute over existentials that they command. Thus all of the following have a reading in which there is a different pizza for each boy:

(7) a. Every boy ate a pizza.
b. The boys ate a pizza.
c. Three boys ate a pizza.
d. At least three boys ate a pizza.

2. The "Distributive universal" quantifiers *every*, and *each* can also distribute over quantifiers that command them, as in (8a). More controversially, the present paper assumes that such scope-inversion of universals is both unbounded, as in (8b), and sensitive to island constraints, as in (8c,d), where scope alternation over the matrix subject is inhibited, parallel to the extractions in (9).[3]

(8) a. Some referee read every paper. ($\forall\exists/\exists\forall$)
b. Some referee said that she read every paper. ($\forall\exists/\exists\forall$)
c. I met some referee who read every paper. (#$\forall\exists/\exists\forall$)
d. Some referee said that every paper should be accepted. (#$\forall\exists/\exists\forall$)

[2]This account roughly follows Winter 2001:166-7, Beghelli and Stowell 1997:73-4, and other papers in Szabolcsi 1997b, except where noted.

[3]Rodman 1976 seems to have been the first to propose that scope inversion was both unbounded and limited by islands. Both claims were contested by Farkas (1981, cf. 1997b; 2001; Farkas and Giannakidou 1996), although her examples of non-unboundedly inverting universals appear to be confounded with subject islands like that in (8d), and to inversion over *a/an* indefinites. (She herself notes that determiners like *some* support bound readings under inversion more readily—see 1981, note 2—and that on occasion even indefinites do so—see 1997b, p212). The literature has remained conflicted ever since, with Cooper (1983) and Williams (1986) taking Rodman's position, and May (1985) and Ceccheto (2004) taking Farkas'. Recent experimental work with children by Syrett and Lidz (2005, 2006) suggests that they, at least, allow unbounded inversion, even if some adults do not.
The picture is further confused by the fact that, like all island constraints, such limitations on scope alternation are "soft", and can be overcome by context, favorable content, or obsessive contemplation. Cooper (1983) attributes the following case of the second kind to Stanley Peters:
(i) The man who builds each television set also repairs it.
We return to this and other examples of scoping out of NP "islands" in section (8.5) below.

(9) a. The papers that some referee read were rejected.
b. The papers that some referee said that she read were rejected.
c. #The papers that I met a referee who read were rejected.
d. *The papers that some referee said that should be accepted were rejected.

What is more, as May (1985) and Ruys (1993) have noted, such quantifier "movement" appears to be subject to a constraint strikingly reminiscent of Williams' 1978 "Across-the-Board" exception to the Coordinate Structure Constraint upon *Wh*-movement of Ross (1967), in examples like the following, as first noted by Geach (1972) and discussed in *SP*:

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

Like sentence (1), this sentence has two readings, one where all of the boys and girls have strong feelings toward the same wide-scope saxophonist—say, Ben Webster—and another where each individual has some attitude towards some possibly different narrow-scope saxophonist. However, (10) 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 Ben Webster, but the girls each detest a different saxophonist. 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 Ben Webster and the girls all detest Lester Young.

3. "Group-denoting" singular and plural indefinites and definites, like *some, a, the,* and *three*, give the appearance of taking wide scope over unboundedly c-commanding quantifiers in the weak sense that the latter do not distribute over them. Unlike the universals, they are *not* sensitive to island boundaries in this respect:

(11) a. Exactly half the boys in the class kissed some girl. $(\frac{1}{2}\exists/\exists\frac{1}{2})$
b. Every referee read some paper. $(\forall\exists/\exists\forall)$
c. Every referee said that she read some paper. $(\forall\exists/\exists\forall)$
d. Every referee met a student who read some paper. $(\forall\exists/\exists\forall)$
e. Every referee said that some paper should be accepted. $(\forall\exists/\exists\forall)$

It will be convenient to refer to such readings as "global specific indefinite" readings.

4. The "Counting" existentials such as *at least/at most/more than/exactly three* do not at first glance seem to seem to take wide scope in even this weak specific-indefinite sense. For example, (12) seems reluctant to yield the reading that there were at least three papers such that every referee read those three papers:[4]

[4]Examples like the following, which are fairly frequent on the web, seem to depend on some kind of "accidental coreference" (Reinhart 1983) under the narrow-scope reading:
(i) Everyone knows at least one gastropod—the common snail.

(12) Every referee read at least three papers. ($\#{\geq}3\forall/\forall{\geq}3$)

However, as Szabolcsi 1997a:115-116 points out, counting existentials *do* seem to have a specific reading when they are distributed over by a plural, rather than a universal, just so long as the content supports the idea of distributing separate events such as reading over a single global specific indefinite such as a set of books:[5]

(13) More than half the referees read at least three papers. (${\geq}3{>}\frac{1}{2}/{>}\frac{1}{2}{\geq}3$)

Such readings seem to exist, and do not seem to arise from "accidental coreference" under the narrow-scope reading.
5. Nevertheless, no existentials at all invert scope in the strong sense of *distributing over* a structurally-commanding quantifier:[6]

(14) a. Some referee read the papers. ($\#\mathit{def}\,\exists/\exists \mathit{def}$)
b. Exactly half the boys in the class kissed three girls. ($\#3\frac{1}{2}/\frac{1}{2}3$)

The place of the "Plural Quantifiers" *most (of the)*, *all ((of) the)*, *many (of the)*, and *few (of the)* in this taxonomy is unclear. The papers in Szabolcsi 1997b do not commit themselves on this question. Winter 2001:167 classifies them as pure or "rigid" generalized quantifiers, presumably because they seem to invert scope in examples like the following.

(15) Some referee read most papers. $?\mathit{most}\exists/\exists \mathit{most}$

On the other hand, *most* seems to pattern with the plurals and not with the universals in its ability to take a collective reading in combination with verbs like *gather*:

(16) a. The/Three/At least three visitors gathered in the library.
b. Most visitors gathered in the library.
c. #Every visitor gathered in the library.

Because of certain cross-linguistic data discussed in section 10.3, this paper will tentatively adopt the strong hypothesis that the so-called plural quantifiers like *most* pattern with the definites and indefinites, and that their apparent ability to invert scope in examples like (15) stems from other factors that are not of immediate concern, such as implicit modal quantification over events. However, nothing much in the present account hinges on this assumption, about English. In particular, the discussion of the proportion problem in donkey sentences in section 10.5 does not depend on this decision.

[5]Szabolcsi describes such readings as "very difficult" to attain.
[6]See section 2.2 for discussion of some claimed counterexamples.

2.2 On Some Apparent Cases of Scope-Inverting Non-Universals

It has been suggested that sentences like the following show that *all* quantifiers—even the counting non-universals—can on occasion give rise to scope inversion, at least with indefinite subjects.

(17) A Canadian flag was hanging in front of at least three/many/exactly five windows.

A (preferred) situation that models (17) is indeed one where different flags are involved for each window, as Shieber, Pereira and Dalrymple (1996) point out in the context of a discussion of VP-ellipsis following Hirschbühler (1982), with whom this example originates.

The following examples appear to yield similar readings:

(18) a. A kilt is worn by many Scotsmen.
b. A light was on in exactly five bedrooms.
c. At least two adults accompanied at least ten children.
d. Errors were found in three programs.
e. A good time was had by all.

However, Hirschbühler's original interest in sentences like (17) was that they also appear to support inversion of true universals out of elided VPs, as in (19b), which Williams (1977) and Sag (1976) had shown to be normally forbidden, as in (19a):

(19) a. Some boy admires every saxophonist and some girl does too.
$\#\forall\exists\&\forall\exists/\exists\forall\&\exists\forall$
b. A Canadian flag was hanging in front of every window and an American flag was too. $\forall\exists\&\forall\exists/\exists\forall\&\exists\forall$

The fact that content of the same kind supports the exceptional appearance of a second phenomenon where it is not normally allowed suggests that some further factor inherent in that content is at work in both cases. Chierchia (1995b:187) points out that the predicates in (17) and (18) that support the intended reading and the related VP ellipses studied by Hirschbühler are unaccusatives and passives. In that case it seems likely that the surface subjects correspond to logical objects. The paper will show that the mechanism proposed in sections 3.3 and 10 to allow plurals to distribute over lf-commanded arguments also allows the relevant readings of (17) and (18). Accordingly, this paper continues to maintain that non-universals do not invert in the sense of distributing over commanding non-universals.

2.3 Historical Background

We have noted that some of these generalizations are contested, and we will examine them in more detail at several points below. However, the fact that scope-alternation is so constrained is hard to reconcile with semantic theories that invoke general-purpose mechanisms like abstraction or “quantifying in” and its relatives, or equivalent covert 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 (10), 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 the scope of the right node raised object is separately underpecified with respect to the two universals.

Keenan and Faltz (1978, 1985), Partee and Rooth (1983), Jacobson (1992), Hendriks (1993), Oehrle (1994), and Winter (1995, 2000), among others, have proposed considerably more general use of type-changing operations than are required in CCG, some of which engender considerably more flexibility in derivation than seems to be required by purely syntactic evidence and the assumption of surface composition.[7]

While the tactic of including such order-preserving type-changing operations in the grammar remains a valid alternative for a surface compositional treatment of scope alternation in CCG and related forms of categorial grammar, it considerably complicates the theory. The type-changing operations necessarily engender infinite sets of category types, requiring heuristics based on (partial) orderings on the operations concerned, and raising questions about completeness and practical parsability.

Instead, the present paper follows Woods (1975), VanLehn (1978), Webber (1978), Fodor (1982), Fodor and Sag (1982), Pereira (1990), Park (1995, 1996), Reinhart (1997), Kratzer (1998), Winter (1997, 2001), Farkas (2001), Robaldo (2007), and others, in explaining possibilities for scope-taking in terms of a distinction between true generalized quantifiers and other non-quantificational categories. In particular, in order to capture the narrow-scope object reading for Geach’s right node raised sentence (10), in whose CCG derivation the object must command everything else, the present paper follows *SP* in assuming that both wide and narrow scope readings arise from a single non-quantificational interpretation of *some saxophonist* as a generalized Skolem term.

This approach is in line with much recent literature on the semantics of natural quantifiers that has departed from the earlier tendency to reduce all semantic distinctions of nominal meaning such as *de dicto/de re*, reference/attribution, etc. to distinctions in scope of traditional quantifiers, and instead attributes such distinctions to a rich ontology of different types of referent or referring expression (collective, distributive, intensional, group-denoting, plural, free-variable, arbitrary, etc.). (See for example Carlson 1977, Barwise and Perry 1980, Kamp 1981/1984, Heim 1982, Link 1983, Fine 1983, 1985, Landman 1991, Abusch

[7]For example, in order to obtain the narrow scope object reading for sentence (10), 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.

1994, Schwarzschild 2002, and papers in Szabolcsi 1997b.)

The Skolem terms that are introduced by inference rules like Existential Elimination in proof theories of first-order predicate calculus are of interest for the present purpose, because they directly express dependency on other entities in the model.

Skolem terms are obtained by replacing all occurrences of a given existentially quantified variable by an application of a unique functor to all variables bound by a universal quantifier in whose scope the existentially quantified variable falls. (If there are no such universal quantifiers, then the Skolem term a function of no arguments—that is, a constant.) Thus the two interpretations (2) of *Everybody loves somebody* can be expressed as follows (conventions as in note 1):

(20) a. $\forall x[person'x \rightarrow (person'(sk'_{53}x) \wedge loves'(sk'_{53}x)x)]$
b. $\forall x[person'x \rightarrow (person'sk'_{95} \wedge loves'sk'_{95}x)]$

The first of these means that every person loves the thing that the Skolem function sk'_{53} maps them onto—their own specific dependent beloved. The second means that

The interesting thing about this alternative to the logical forms in (2) is that the two formulæ are identical, apart from the details of the Skolem terms themselves, which capture the distinction in meaning in terms of whether or not the referent of *someone* is dependent upon the individuals quantified over by *everyone*. The Skolem functors sk'_{53} and sk'_{95} in (20) can be thought of as free variables over contextually available functions and individuals, implicitly globally existentially closed over, whose value the hearer does not necessarily know, as in the related account of Kratzer 1998.

The present paper argues: first, that the only determiners in English that are associated with traditional Generalized Quantifiers, and take scope including inverse scope, distributing over structurally commanding indefinites as in (3), are the universals *every*, *each* and their relatives;[8] second, that all indefinite determiners are instead associated with Skolem terms, which are interpreted *in situ* at the level of logical form (lf), forcing parallel interpretations in coordinate sentences like (10); third, that the appearance of indefinites taking wide scope arises from flexibility as to which bound variables (if any) the Skolem term involves; and fourth, that indefinites never distribute over structurally commanding indefinites, because their interpretations are never quantificational.

3 SEMANTICS WITHOUT EXISTENTIAL QUANTIFIERS

This section shows that the introduction of Skolem terms brings a number of benefits to a DRT-like semantic theory, and avoids numerous paradoxes that arise when

[8]The present paper remains agnostic as to whether *most'* is among this number. For the sake of argument, we will assume below that it is not. However, this is not a strong claim, and nothing will hinge on it.

natural language quantifiers are represented by traditional existential quantifiers, ranging from the apparently anomalous scope of indefinites in donkey sentences to certain long-standing paradoxes concerning the interpretation of natural language conditionals in terms of material implication.

The section begins by arguing that Skolem terms are a useful element in an ontology for natural language semantics, independent of the issues of scope alternation and grammatical framework. A grammar-independent model theory for the assumed logical forms is defined in section 4. Section 5 argues for an account of donkey sentences in which (as in more standard versions of DRT) the occasions on which supposed existentials behave as if they were universals are predicted on the basis of a single non-quantificational meaning, the uniqueness problem is avoided, and strong readings are predicted, but in which (as in E-type pronoun-based accounts) the notorious proportion problem is entirely avoided.

3.1 Donkey Sentences

Sentences like the following (adapted from Geach, 1962, who attributes them to much earlier sources) have acted as a forcing function for all modern semantic theories of natural language quantification:

(21) Every farmer who owns a donkey$_i$ feeds it$_i$.

Such "donkey sentences" are quite commonly attested: the following example, to whose subtly different properties we will have reason to return, came to hand at the time of writing from an article on the consequences of the SARS epidemic in Hong Kong:

(22) Everybody who has a face mask wears it.(*The Economist*, Apr.5th, 2003:61)

The interest of such sentences is the following. The existence of preferred readings in which each person feeds or wears the donkey(s) or face-mask (s)he owns makes the pronoun seem as though it might be a variable bound by an existential quantifier associated with *a donkey/face-mask*. However, no purely combinatoric analysis in terms of classical quantifiers allows this, since the existential cannot both remain within the scope of the universal, and come to c-command the pronoun at the level of lf (herafter, lf-command), as is required for true bound pronominal anaphora, of the kind illustrated in the following example:

(23) Every man$_i$ in the bar thinks that he$_i$ is a genius.

Donkey sentences have been extensively analyzed over the last

It might seem unlikely that there could be anything new to say about them, or any need for yet another account. However, the existing theories are pulled in different directions by a pair of problems called the proportion problem and the uniqueness problem, whose definitions we will get to later. Dealing with these problems has engendered very considerable complications to the theories, variously including recategorization of indefinites as universals, dynamic generalizations of the notion of scope itself, exotic varieties of pronouns including choice-functional interpretations, model theories based on exotic notions like "local minimal situations," and various otherwise unmotivated syntactic transformations. Even if some or all of these accounts cover the empirical observations completely, there seems to be room for a simpler theory, if one can be found.

SP argued that donkey sentences provide independent support for an analysis of indefinites as Skolem terms rather than as generalized quantifiers. We will begin by refining the theory of existentials sketched there, again using donkey sentences as the forcing example. The claim will be that, however much we may need DRT-style dynamics to capture the notoriously asymmetric processes of pronominal reference itself, the compositional semantics of sentences like (21) over such referents can be captured with standard statically-scoped models.

Webber (1978), Cooper (1979), Evans (1980), Lappin (1990), Lappin and Francez (1994), and many others have pointed out that donkey pronouns look in many respects more like *non*-bound-variable or discourse-bound pronouns, in examples like the following, than like the bound variable pronoun in (23):

(24) Everyone who meets Monboddo$_i$ likes him$_i$.

For example, the pronouns in (21) and (24) can be replaced by epithets, whereas true bound variable pronouns like that in (23) cannot, because of Condition C:

(25) a. Everyone who meets Monboddo$_i$ likes the fellow$_i$.
b. Every farmer who owns a donkey$_i$ feeds the lucky beast$_i$.
c. *Every professor$_i$ in the department thinks the old dear$_i$ is a genius.

(Since the obvious explanation for Condition C relates it to the notion of scope at the level of logical form, if the pronoun is in the scope of a generalized quantifier interpretation of the donkey in (25), it is unclear why Condition C does not apply there as well.)

This observation suggests that the pronoun here is simply a discourse-bound pronoun, and that it is the donkey to which it refers in (21) that we should concentrate our attention on. In particular, we should consider the possibility that the latter may translate as a referential (or referent-introducing) expression, as Fodor and Sag suggested, rather than as a generalized quantifier.

The present paper follows *SP* in assuming that "a donkey" translates at predicate-argument structure as a Skolem term, to which the pronoun is simply discourse-anaphoric rather than bound-variable anaphoric.[9]

It is important to realise that the way this translation is done is different from standard skolemization of the kind illustrated in the transition from (2) to (20). Skolem terms in the present theory are elements of the logical form in their own right. This fact prevents us from separately predicating properties like *donkey′*

[9]In *SP*, such Skolem terms are tentatively identified with Fine's notion of "arbitrary object".

over Skolem terms, as in (20). We must instead associate nominal properties with the Skolem term itself, as in Steedman 2000b and the Choice Function-based accounts of Kratzer (1998) and Winter 2001.

The noun property in question may of course be arbitrarily complex. For example, to obtain the interpretation of the nounphrase *a fat donkey* in *Every farmer who owns a fat donkey feeds it*, we must associate a property $\lambda y.donkey'y \wedge fat'y$ with the underspecified term, as in (26a). Such properties may recursively include other Skolem terms. For example, *a farmer who owns a donkey* is represented by the term (26b), while plurals like *at least one farmer who owns some donkeys*, *at most three farmers who own a donkey* and *most farmers who own a donkey* are represented as in (26c,d,e).

(26) a. $sk^{\mathcal{E}}_{\lambda y.donkey'y \wedge fat'y}$

b. $sk^{\mathcal{E}}_{\lambda y.farmer'y \wedge own'sk^{\mathcal{E}}_{donkey'}y}$

c. $sk^{\mathcal{E}}_{\lambda y.farmer'y \wedge own'sk^{\mathcal{E}}_{donkey'}y\ ;\ \lambda s.|s|>1}$

d. $sk^{\mathcal{E}}_{\lambda y.farmer'y \wedge own'sk^{\mathcal{E}}_{donkey'}y\ ;\ \lambda s.|s|\leq 3}$

e. $sk^{\mathcal{E}}_{\lambda y.farmer'y \wedge own'sk^{\mathcal{E}}_{donkey'}y\ ;\ \lambda s.|s|>0.5*|all'(\lambda y.farmer'y \wedge own'sk^{\mathcal{E}}_{donkey'}y)}$

$\mathcal{E}$ here denotes the environment of all variables bound by operators such as quantifiers in whose extent the generalized Skolem term falls. The connective ";" in (26c,d) constructs a pair $p;c$ consisting of a nominal property p and a (possibly vacuous) cardinality property c. Where the latter is vacuous, as in (26a,b), it is suppressed in the notation. These properties are separately interpreted in the model theory developed in the next section.

We shall see later that in verifying interpretations involving generalized Skolem terms of the form $sk^{\mathcal{E}}_p$ against a model, we need to unpack them, reinstating the nominal property p as a predication over a traditional Skolem term, as in a traditional Skolemized formula like (20). However, as far as the grammatical semantics and the compositional derivation of logical form goes, expressions like $sk^{(x)}_{donkey'}$ are unanalyzed identifiers, and this part of the responsibility for building logical forms is transfered to interpretation.

The ambiguity of example (1) can now be expressed by the following two logical forms, which differ only in the generalized skolem terms $sk^{(x)}_{person'}$ (denoting a dependent or "narrow-scope" beloved) and $sk_{person'}$, a function of no arguments—thqat is, a Skolem constant. (Since constants behave as if they "have scope everywhere", such terms denote a non-dependent "wide-scope" specific-indefinite beloved):

(27) a. $\forall x[person'x \rightarrow loves' sk^{(x)}_{person'} x)]$

b. $\forall x[person'x \rightarrow loves' sk_{person'} x)]$

We defer until section 6 the question of how exactly surface-compositional derivation of English sentences chooses among possible argument sets for the Skolem terms that translate nominals like "somebody". Clearly the translation process has to "know" what operators the nominal in question falls in the scope of. This mechanism will turn out to be a restricted form of such "environment-passing" devices as "storage" (Cooper 1983; Chierchia 1988). However, unlike the notion of storage in Cooper, Keller (1988), Hobbs and Shieber (1987), Pereira (1990), Shieber, Pereira and Dalrymple (1996), and the related accessibility notion of Farkas (2001), and unlike the related notion of environment which is defined in Section 4, where a model theory is defined for the logical forms which are built by the grammar, the grammatical mechanism defined in Section 6 offers no autonomous degrees of freedom to determine available readings. Environment features are deterministically passed down from the operator to nodes in its c- or lf-command domain, and a specified generalized Skolem term is deterministically bound to *all* scoping universals in the relevant intensional scope at the point in the derivation at which it is specified. The available readings for a given sentence are thereby determined by the combinatorics of syntactic derivation and the logical forms that result, as detailed in Part II.

3.2 Pronouns

For present purposes, we will assume that pronouns like *it* translate as uninterpreted constants, which we might as well write it', distinguishing by subscripts where necessary. Such pronoun interpretations, including those in donkey sentences, are replaced via a DRT-like mechanism that we continue not to define here by "pro-terms" (cf. *SS&I*) of the form $pro'x$, where x is a discourse referent taking the form of a copy of the antecedent expression. Thus the donkey sentence (21) yields the following interpretation:[10]

(28) $\forall x[(farmer'x \wedge own' sk^{(x)}_{donkey'} x) \rightarrow feed'(pro' sk^{(x)}_{donkey'})x]$

(pro' is the identity function, as in Jacobson's (1996b; 1999) account, which offers an alternative mechanism for pronominal anaphora which may or may not be compatible with the present grammar.)

Similarly, the following variant (29a) has the translation (29b) (cf. (26e))

[10]The use of pro-terms is not essential: we could use indices or plain copies of the antecedent, and assume that the binding conditions are consequences of the process of anaphora resolution itself. However, this notation allows us to keep track of the fact that the bindings we need are indeed licenced by these conditions.

(29) a. Most farmers who own a donkey feed it.

b. $\forall z[z \in sk_{\lambda x.farmer'x \wedge own'sk^{(z)}_{donkey'}z\ ;\ \lambda s.|s|>0.5*|all'(\lambda y.farmer'y \wedge own'sk'^{(z)}_{donkey'}y)}$
$\rightarrow feed'(pro'sk^{(z)}_{donkey'})z]$

Crucially for the future solution to the proportion problem, both interpretations quantify over farmers, rather than farmer-donkey pairs.

We defer discussion of the following kinds of examples until the discussion of related approaches in section 5 in the light of the model theory to be presented in section 4.[11]

(30) a. A farmer who owns a donkey feeds it.
b. Any farmer who owns a donkey feeds it.
c. If a farmer owns a donkey, she feeds it.
d. If any farmer owns a donkey, she feeds it.

We note that the question of whether such generic statements and conditionals, with or without "free choice" *any*, quantify over farmers, or over farmer-donkey pairs is disputed, but that they do not appear to pattern with universals (Kadmon and Landman (1993), Carlson (1995), Horn (2000), and Giannakidou (2001)).

We have seen that translations like it' of discourse-referential pronouns can come to refer to generalized Skolem terms, provided that they are in the lf-scope of any quantifiers that bind variables in the latter, as in the logical form (28) for (21). However, a full theory of pronominal reference is not attempted here. Such a theory has to show why unbound anaphora is subject to a number of further conditions over and above the standard binding theory. In particular, nounphrases like *no donkey* generally fail to contribute potential antecedents for pronominal referents as other indefinites do, as the impossibility of the following examples shows:[12]

(31) a. #No donkey$_i$ came in, and I fed it$_i$.
b. #Every farmer who owns no donkey$_i$ feeds it$_i$.
c. #Either Elizabeth owns no donkey$_i$, or she feeds it$_i$.

Still other constraints severely limit interclausal cataphora, dependent among other factors upon syntactic subordination:[13]

[11] (30d) is in fact the form in which Geach 1962:128 originally gave the example.

[12] This observation is presumably related to the fact that in the semantics defined below, negation is defined in terms of there being no extension for the relevant generalized Skolem term. Examples like (i)a, due to Barbara Partee, in which *no bathroom* appears to act as the antecedent to *it* seem to depend crucially on the fact that houses usually have bathrooms—cf. (31c), and discussion in Asher and Lascarides (2003). Naturally, such presuppositions can be accomodated, as in (i)b:

(i) a. Either this house has no bathroom$_i$, or it$_i$ is in an unusual place.
b. Either Elizabeth owns no donkey$_i$, or it$_i$ is in the bathroom.

[13] The last example is of a kind that has recently been used to motivate the "copy" theory of movement.

(32) a. #She$_i$ owns it$_j$ and a farmer$_i$ feeds a donkey$_j$.
b. #She$_i$ owns it$_j$ or a farmer$_i$ feeds a donkey$_j$.
c. If she$_i$ owns it$_j$, a farmer$_i$ feeds a donkey$_j$.
d. Every pilot$_i$ who shot at it$_j$ hit the MiG$_j$ that chased him$_i$.
e. #Some professor gave her$_i$ every picture of Lily$_i$

Such conditions appear to reflect the dynamics of processing at a clausal level rather than the level of logical form (see Kamp and Reyle 1993:214-232 and Cann and McPherson 1999 for some discussion). For the present purpose, we assume that some version of DRT context update can do the job. The point of the present paper is that the semantics of donkey sentences can be handled entirely statically in such systems, without recourse to dynamic scope, if discourse referents are represented as generalized Skolem terms—that is, as structured representations encoding dependency relationships among individuals that the model must satisfy, rather than as variables over the individuals themselves.

On the assumption that intensional verbs like *want* also contribute an intensional operator binding an intensional variable to the environment, the possibility of choosing Skolem terms with different argument sets can be used to capture the "de dicto/de re" ambiguity between an intensional and extensional Norwegian:[14]

(33) Harry wants to marry a Norwegian.

Similarly, on the assumption that intensional verbs like *believe* also contribute an intensional operator binding an intensional variable, we correctly predict that the pronoun in the following "intensional donkey" sentence will fail to refer to *de dicto* donkeys that John believes some farmer owns, the reason being that the pronoun cannot be within the "filtering" scope of John's beliefs, despite being within the scope of the universal:[15]

(34) #Every farmer who John believes owns a donkey$_i$ feeds it$_i$.

It is less clear whether other varieties of pronominal anaphora such as the "sloppy" variety found in "paycheck" sentences like (35a) and their VP-elliptical relatives like (35b) in which *it* refers to different paychecks should be handled the same way as donkey anaphora, as Elbourne (2001) has suggested they should be.

(35) a. A man who puts his paycheck in a bank is wiser than a man who puts it in a teapot.
b. Johnson put his paycheck in a teapot, and so did Monboddo.
c. Johnson put his paycheck in a bank. Monboddo put it in a teapot.

Since such anaphora can cross sentence boundaries, as in (35c), it may well be a more general and much less constrained form of discourse anaphora, of the

[14] We shall return later to the observation of Geach (1967) that in general finer distinctions are needed along this dimension.

[15] If a factive "hole" verb like "knows" is substituted for "believes" then the intended reading is available. In present terms, factive verbs include no intensional scope operator.

"telescoping" kind considered later in section 7.6.

3.3 Distributivity

If the nonspecific and counting so-called quantifiers aren't actually quantifiers at all, how do they—even the downward-monotone ones—distribute over arguments that they command in sentences like the following?

(36) a. Some/few/at most two/three boys ate a pizza.
  b. Some/few/at most two/three farmers who own a donkey feed it.

There is every reason to doubt that the distributive reading of (36a), according to which the boys ate different pizzas, arises from a generalized quantifier as the subject, since distributive scope fails to invert in sentences like the following:

(37) A boy ate three pizzas.

We therefore follow Link (1983), Roberts (1991), van der Does (1992), Schein (1993), Schwarzschild (1996), van den Berg (1996) and *SP* (in contrast to, for example, Heim, Lasnik and May 1991, and Winter 1997, 2001) in explaining the distributive behavior of plurals as arising from universal quantification contributed by the logical form of verbs, in rather the same way as the behavior of reflexives and reciprocals under the account of Keenan and Faltz (1985) mentioned earlier. We will defer discussion of exactly how this works, together with a number of other syntax-dependent issues such as the possibility of "intermediate scope" readings, until Part II of the paper.

3.4 Maximal Participancy of Plurals

One further property of plurals with far-reaching implications for the model theory sketched in Section 4 is illustrated by examples like the following:

(38) At most three boys ate a pizza.

This sentence is false in a model in which a set of four boys ate a pizza, despite the fact that four boys eating a pizza might be held to entail several sets of three and two boys also doing so, any of whose cardinality would satisfy the predicate *at most three*. Accordingly, the present paper follows Webber (1978), who in defining the possible antecedent for plural pronouns assumed that the referent of all plurals is a *maximal* set of participants in the predication—in the case of (38), the maximal set of boys who ate a pizza. It follows that in the terms of the present paper, *Three boys ate a pizza* is also false in a model where four boys did so. (Of course, four boys eating a pizza entails that there exists a set of three boys who ate a pizza, via the standard axioms of arithmetic. But that isn't what *Three boys ate a pizza* means.)

This property is reflected in the model theory developed in the next section, 4, where it is assumed that the model includes set individuals and the rule for interpreting predications over set-valued generalized Skolem terms imposes a requirement for the maximum participant set, and the cardinality restriction here conjoined with the connective ";" (the latter applied independently from the property that defines that maximal participant set).[16]

However, *for*-adverbials are anomalous:

4 MODEL THEORY

A model theory for the present calculus can be identified using a variant of the standard statically-scoped model theory for first order logic (cf. Robinson 1974). The presentation is somewhat simplified by the omission of intensional operators and numerical indices for generalized Skolem terms.

4.1 The Problem

It is not usual in standard first-order logic to give a model theory for Skolem terms, because skolemized prenex normal form formulae are sentences of first-order logic (for which a model theory already exists), obtained by well-known equivalences from standard formulae. The main problem in designing a constructive model theory for the present notion of logical form is that generalized Skolem terms, unlike existentially quantified formulæ and the related skolemized prenex normal forms, do not carry explicit information about their scope. This has two important consequences for the model theory. First, it requires that generalized Skolem terms carry their restrictor (which is an unrestricted term of the language) with them, to be unpacked in the scope that they are in at the time of interpretation. Second, we must be careful about the negation implicit in the usual disjunctive interpretation of the material implication connective, or we will end up treating farmers who own donkeys they do not feed (and for which there is therefore no extension satisfying the left disjunct $\neg own' sk^{(x)}_{donkey'} x$) but feed donkeys they do not own (and for which there is therefore an extension satisfying $feed' sk^{(x)}_{donkey'} x$) as satisfying the donkey sentence (21). These requirements are addressed by rule 5 of the syntax and Rules 1b,c and Rule 2d of the semantics, which are discussed further in section 4.5.

It is important to be clear that the model theory does not represent the processes of Skolem term and bound-variable pronoun specification, still less that of unbound or discourse-bound pronominal anaphora. These processes are assumed to to take place externally to semantic interpretation.

[16]Nouwen (2003) has also recently proposed defining plural referents as maximal sets. Zucchi and White (2001) point out that assuming maximal participant sets has the advantage of eliminating a paradoxical consequence of the standard quantifier-based account discussed by Krifka (1989), Moltmann (1991), and White (1994), concerning quantifiers like *at most five fleas* and *some fleas*.

4.2 Syntax

We define the formal language L used above for logical forms generatively as: a set $\{a,b,c,\ldots\}$ of individual **object** symbols; a set $\{x,y,z,\ldots\}$ of **variables**; a set $\{R_1,R_2,\ldots,R_n\}$ of sets of *n*-**ary relation** symbols; a set $\{sk^{\mathcal{A}}_{p;c}, sk^{\mathcal{B}}_{q;d},\ldots\}$ of **generalized Skolem terms**, which can be thought of as triples containing a number unique to the originating NP (which the notation suppresses), a pair $p;c$ consisting of a restrictor p (a unary λ-abstraction over a sentence of L) and a (possibly trivial) condition c on the cardinality, and a set $\mathcal{A}$ of argument variables including any free variables in the λ-term; a set $\{\neg,\wedge,\vee,\rightarrow\}$ of **connectives**, and a set $\{\forall\}$ of **quantifiers**.

We then define **arguments** as either **object** symbols, **variables**, **generalized Skolem terms**, or **pro-terms**, where the latter are recursively defined as terms of the form *pro*′**argument**. Because of the involvement of Skolem terms and their restrictors, we need to identify a notion of **level** for terms including arguments. Object symbols, variables, and the related pro-terms are terms of level 0.

We can then define the atomic formulæ in terms of *n*-**ary relation** symbols followed by *n* **arguments** and then define the well-formed formulæ (wff) of L inductively in terms of the four **connectives** and the single **quantifier**, as follows.

1. If $a_1,\ldots,a_n$ are terms whose maximum level is i, then $R_n(a_1,\ldots,a_n)$ is a wff of level i.

2. If X is a wff of level i then $[\neg X]$ is a wff of level i.

3. If X and Y are wff for which i is the higher of their respective levels, then $[X\wedge Y]$, $[X\vee Y]$, and $[X\rightarrow Y]$ are all wff of level i.

4. If X is a wff of level i then $[\forall x[X]]$ is a wff of level i

5. If X is a wff of level i then $sk^{\mathcal{A}}_{\lambda x.X}$ is a term of level $i+1$ where $\mathcal{A}$ is the set of arguments of the Skolem functor $sk_{\lambda x.X}$ and $\mathcal{A}$ is a superset of the free variables of X other than x.

We then define the notion *complete formula*, or *sentence*, as a wff X all of whose variables are bound by quantifiers or other operators.

We also increase readability of formulæ by omitting square brackets under the following conditions: when they surround an atomic formula; following negation provided that they surround a negation; surrounding the antecedent or consequent of an implication provided that they surround a disjunction, conjunction, or negation; following a quantification provided that they surround a quantified formula; when they are the outermost brackets of the whole formula.

For example, (a) below can be written as (b):

(39) a. $[\forall x[\forall y[\forall z[[[A(x,y)]\wedge[A(y,z)]]\rightarrow[\neg[\neg[A(x,z)]]]]]]]$
b. $\forall x\forall y\forall z[A(x,y)\wedge A(y,z)\rightarrow\neg\neg A(x,z)]$

Most of this is familiar from the standard model theory for first-order logic except for the omission of the existential quantifier and the inclusion of generalized Skolem terms. It is the latter departure that requires each statement in the inductive definition to define the level of a wff in terms of those of its parts, and in the case of skolem term arguments to define them in terms of a superset of the free variables other than x in the restrictor term. The latter apparatus is reminiscent of Farkas' accessibility relation and definition of the interpretation of indefinites (2001, cf. examples 35 and 36).

It is important to notice that the fragment of L that generates the two available interpretations of the Geach sentence (10) will also generate formulae corresponding to the unavailable mixed readings. Of course, it must do so, since these formulae are possible interpretations of *other* (non-right node raised) related English sentences. It is the business of the CCG grammar, not the logic, to say how English sentences correspond to sentences of L.

4.3 Semantics

A model $\mathfrak{M}$ with respect to which the sentences of L can be evaluated can now be defined as a structure consisting of the union of a set $\{\mathfrak{a}, \mathfrak{b}, \mathfrak{c}, \dots\}$ of primitive objects with its powerset, and a set $\{\mathfrak{R}_1, \mathfrak{R}_2, \dots \mathfrak{R}_n\}$ of sets of n-ary relations over the primitive objects and set objects, including unary cardinality properties over them.

There is a correspondence $\mathcal{C}_0$ from the objects and relations in $\mathfrak{M}$ into a set of terms and relation symbols in L. $\mathcal{C}_0$ is a proper superset of a one-to-many correspondence from the objects and relations in $\mathfrak{M}$ into the set of object symbols $\{a,b,c,\dots\}$ and the sets of relations symbols $\{R_1,R_2,\dots,R_n\}$ in L. (Thus we ensure that everything in $\mathfrak{M}$ has at least one name in L.)

We further assume that for every pair $\langle \mathfrak{a}, a\rangle$ in $\mathcal{C}_0$ there is also a pair $\langle \mathfrak{a}, pro'a\rangle$, relating the same object $\mathfrak{a}$ to a coreferring pronoun. (Thus we assume that the antecedents of pronouns are established independently of the semantics, and that those antecedents may be pronouns.) The generalized Skolem terms of L are not included in the range of this base correspondence $\mathcal{C}_0$.

We refer to a generalized Skolem term $sk^{\mathcal{A}}_{p;c}$ with no free variables among its arguments $\mathcal{A}$ (and hence none in its λ-term p) as *saturated*.

If a correspondence $\mathcal{C}$ includes $\mathcal{C}_0$, but does not map any object of $\mathfrak{M}$ to a particular saturated generalized Skolem term t, then we will speak of a correspondence $\mathcal{C}'$ obtained by adding to $\mathcal{C}$ a pair $\langle \mathfrak{a}, t\rangle$ (together with all the related pronoun pairs $\langle \mathfrak{a}, pro't\rangle$, $\langle \mathfrak{a}, pro'(pro't)\rangle$, $\dots$) for some object $\mathfrak{a}\in\mathfrak{M}$ as an "extension of $\mathcal{C}$ to t" and of $\mathfrak{a}$ as the "value" named by t in $\mathcal{C}'$. We will refer to the set of correspondences obtained by extending $\mathcal{C}$ to some set of saturated generalized Skolem terms in L (including the null set) as the "extensions" of $\mathcal{C}$. (That is to say that the extensions of $\mathcal{C}$ include $\mathcal{C}$.)

We define the function $\mathcal{C}^{-1}$ on the range of a correspondence $\mathcal{C}$ as the *inverse* of $\mathcal{C}$.

The following rules then determine, by inductive definition, whether $\mathcal{C}$ satisfies a sentence or well-formed formula in L containing no free variables, where $Y(x)$ denotes a well-formed formula Y of L in which x and no other variable is free, and $Y(a)$ denotes the formula obtained by substituting the term a for x in Y. (Note that an atomic formula that contains no skolem terms is by definition of level 0, and that the restrictor p of a generalized Skolem term is by definition at a level lower than that of its parent atomic formula.)

1. $\mathcal{C}$ satisfies an atomic formula $R(a_1,\ldots,a_n)$ in L if and only if there is an extension $\mathcal{C}'$ of $\mathcal{C}$ for which the terms $a_1,\ldots,a_n$ are all in the range of $\mathcal{C}'$ and:
   (a) The n-tuple $\langle \mathcal{C}'^{-1}(a_1),\ldots,\mathcal{C}'^{-1}(a_n)\rangle$ is in the relation $\mathcal{C}'^{-1}(R)$ in $\mathfrak{M}$;
   (b) For all a_i that are Skolem terms of the form $sk^{\mathcal{A}}_{p;c}$, if a_i is individual-valued then $\mathcal{C}'$ also satisfies $p(a_i)$, and if a_i is set-valued, then for all members a_{i_j} of a_i, $\mathcal{C}'$ also satisfies $p(a_{i_j})$ and $c(a_i)$;
   (c) For all such Skolem terms of the form $sk^{\mathcal{A}}_{p;c}$ whose value under $\mathcal{C}'$ is a set object $\mathfrak{a}'$, there is no correspondence $\mathcal{C}''$ differing from $\mathcal{C}'$ only in the value $\mathfrak{a}''$ named by $sk^{\mathcal{A}}_{p;c}$ that satisfies the atomic formula and the above property and cardinality conditions in which $\mathfrak{a}''$ is a proper superset of $\mathfrak{a}'$;
2. Given two sentences Y and Z in L:
   (a) $\mathcal{C}$ satisfies a sentence $\neg Y$ if and only if $\mathcal{C}$ does not satisfy Y;
   (b) $\mathcal{C}$ satisfies a sentence $Y \vee Z$ if and only if $\mathcal{C}$ satisfies at least one of Y or Z;
   (c) $\mathcal{C}$ satisfies a sentence $Y \wedge Z$ if and only if there is an extension $\mathcal{C}'$ of $\mathcal{C}$ to all and only the saturated generalized Skolem terms common to Y and Z that are not in the range of $\mathcal{C}$ such that $\mathcal{C}'$ satisfies both Y and Z;
   (d) $\mathcal{C}$ satisfies a sentence $Y \rightarrow Z$ if and only if every extension $\mathcal{C}'$ of $\mathcal{C}$ to all and only the saturated generalized Skolem terms common to Y and Z that are not in the range of $\mathcal{C}$ that satisfies Y also satisfies Z;
3. Given a well-formed formula $Y(x_1,\ldots,x_n)$ in L not beginning with a universal quantifier $\forall$, in which all and only the variables x_i are free:
   (a) $\mathcal{C}$ satisfies a sentence $\forall x_1 \ldots \forall x_n[Y(x_1,\ldots,x_n)]$ if and only if there is an extension $\mathcal{C}'$ to all positive-polarity saturated generalized Skolem

terms in $Y(x_1,\ldots,x_n)$ such that, for all tuples $a_1,\ldots,a_n$ of object symbols a_i in L, $\mathcal{C}'$ satisfies $Y(a_1,\ldots,a_n)$.

We then define truth of a sentence Y in a model $\mathfrak{M}$ as follows: Y is true in $\mathfrak{M}$ relative to a correspondence $\mathcal{C}$ if and only if $\mathcal{C}$ satisfies Y.

4.4 Example

Consider a model containing six individuals: $\mathfrak{Anne}$, $\mathfrak{Bess}$, $\mathfrak{Elizabeth}$, $\mathfrak{Pedro}$, $\mathfrak{Modestine}$, and $\mathfrak{Maxwelton}$. The unary relation $\mathfrak{farmer}$ holds for $\mathfrak{Anne}$, $\mathfrak{Bess}$, and $\mathfrak{Elizabeth}$. The unary relation $\mathfrak{donkey}$ holds for $\mathfrak{Pedro}$, $\mathfrak{Modestine}$, and $\mathfrak{Maxwelton}$. The binary relation $\mathfrak{own}$ holds for the pairs $\{\mathfrak{Anne}, \mathfrak{Pedro}\}$, $\{\mathfrak{Anne}, \mathfrak{Modestine}\}$, and $\{\mathfrak{Elizabeth}, \mathfrak{Maxwelton}\}$. The binary relation $\mathfrak{feed}$ holds for the same pairs $\{\mathfrak{Anne}, \mathfrak{Pedro}\}$, $\{\mathfrak{Anne}, \mathfrak{Modestine}\}$, and $\{\mathfrak{Elizabeth}, \mathfrak{Maxwelton}\}$.

Consider the correspondence $\mathcal{C}_0$ which consists of the following pairs:

(40)
$\{\mathfrak{Anne}, \mathit{anne}'\}$ $\{\mathfrak{Maxwelton}, \mathit{maxwelton}'\}$
$\{\mathfrak{Bess}, \mathit{bess}'\}$ $\{\mathfrak{farmer}, \mathit{farmer}'\}$
$\{\mathfrak{Elizabeth}, \mathit{elizabeth}'\}$ $\{\mathfrak{donkey}, \mathit{donkey}'\}$
$\{\mathfrak{Pedro}, \mathit{pedro}'\}$ $\{\mathfrak{own}, \mathit{own}'\}$
$\{\mathfrak{Modestine}, \mathit{modestine}'\}$ $\{\mathfrak{feed}, \mathit{feed}'\}$

Consider the truth in this model of the two readings (b) and (c) of (41a), in which the number and (vacuous) cardinality restrictions have been suppressed:

(41) a. Every farmer owns some donkey.
b. $\forall x[\mathit{farmer}'x \to \mathit{own}'(\mathit{sk}_{\mathit{donkey}'})x]$
c. $\forall x[\mathit{farmer}'x \to \mathit{own}'(\mathit{sk}^{(x)}_{\mathit{donkey}'})x]$

In the case of (41b), the formula stripped of the quantifier contains a saturated generalized Skolem term $\mathit{sk}_{\mathit{donkey}'}$, so Rule 3a says there has to be a non-trivial extension to $\mathcal{C}_0$ to $\mathit{sk}_{\mathit{donkey}'}$ such that for all object symbols a in L the extension satisfies $\mathit{farmer}'a \to \mathit{own}'(\mathit{sk}_{\mathit{donkey}'})a$, according to rule 2d. The interesting extensions are those where $\mathit{sk}_{\mathit{donkey}'}$ names either $\mathfrak{Pedro}$, $\mathfrak{Modestine}$, or $\mathfrak{Maxwelton}$, and the interesting object symbols a are then anne', bess', and $\mathit{elizabeth}'$. None of the extensions satisfies the sentence, so it is false in the model.

In the case of (41c), the formula stripped of the quantifier contains only an *un*saturated generalized Skolem term $\mathit{sk}^{(x)}_{\mathit{donkey}'}$ in which x is unbound, so under rule 3a, $\mathcal{C} = \mathcal{C}_0$. Rule 3a requires us to ask directly whether for all object symbols a in L, $\mathcal{C}_0$ satisfies $\mathit{farmer}'a \to \mathit{own}'(\mathit{sk}^{(a)}_{\mathit{donkey}'})a$. Again, the interesting cases of a are anne', bess', and $\mathit{elizabeth}'$, for each of which we are required by rule 1a to find an extension to the now-saturated generalized Skolem term that $\mathit{sk}^{(a)}_{\mathit{donkey}'}$ satisfies the ownership relation and the donkey restriction.

In the case of $\mathfrak{Elizabeth}$, extending to $\mathfrak{Maxwelton}$ does so. In the case of $\mathfrak{Anne}$, extending either to $\mathfrak{Pedro}$ or to $\mathfrak{Modestine}$ does the trick. (Since $sk^{(a)}_{donkey'}$ is not set-valued, the maximal participants condition in 1c does not apply here.) However, When we come to evaluate $own'(sk^{(bess')}_{donkey'})bess'$, there is no such extension, so this sentence also is false in the model.

Now consider the donkey sentence (21) and its interpretation (28), repeated here, in which the number and cardinality restriction of the two identical skolem terms have again been suppressed:

(42) $\forall x[farmer'x \wedge own'sk^{(x)}_{donkey'}x \rightarrow feed'(pro'sk^{(x)}_{donkey'})x]$

As in the case of (41c), the Skolem term $sk^{(x)}_{donkey'}$ is unsaturated, so that under rule 3a, $\mathcal{C} = \mathcal{C}_0$. By rule 3a, $\mathcal{C}_0$ satisfies the sentence if and only if for all object symbols a in L $\mathcal{C}_0$ satisfies $farmer'a \wedge own'(sk^{(a)}_{donkey'})a \rightarrow feed'(pro'sk^{(a)}_{donkey'})a$.

The interesting cases are $a = anne'$ and $a = elizabeth'$. By rule 2d, every extension $\mathcal{C}_0$ to the now-saturated Skolem terms common to antecedent and consequent such as $sk^{(anne)}_{donkey'}$ that satisfies the former must satisfy the latter. The interesting extensions, once the Skolem terms are unpacked by rules 1a and 1b, are by the pairs $\{\mathfrak{Pedro},\ sk^{(anne')}_{donkey'}\}$, $\{\mathfrak{Modestine},\ sk^{(anne')}_{donkey'}\}$, and $\{\mathfrak{Maxwelton},\ sk^{(elizabeth')}_{donkey'}\}$. They satisfy the condition of rule 2d, so this sentence is true in this model.

By stipulating that *all* extensions that satisfy the antecedent must satisfy the consequent, rule 2d yields the "strong" reading: the sentence would be false in a model identical in every respect except for the relation $\mathfrak{feed}$ lacking the pair $\{\mathfrak{Anne},\ \mathfrak{Pedro}\}$–that is, including a farmer who feeds some but not all of their donkeys. The reader will easily be able to convince themselves that the same holds for (48), *If a farmer owns a donkey, she feeds it*.

Such variants of the standard donkey sentence as (22), *Everybody who has a facemask wears it*, give rise to the "weak" reading—that is, they appear to be true in models in which people who own facemasks wear one but not all of them (that is, where the pair $\{\mathfrak{Anne}, \mathfrak{Pedro}\}$ is deleted from the relation $\mathfrak{feed}$, and the following pairs and extensions are substituted in the correspondance $\mathcal{C}_0$ and the earlier example):

(43) $\{\mathfrak{farmer},\ person'\}$
$\{\mathfrak{donkey},\ facemask'\}$
$\{\mathfrak{feed},\ wear'\}$
$\{\mathfrak{Pedro},\ sk^{(anne')}_{facemask'}\}$
$\{\mathfrak{Modestine},\ sk^{(anne')}_{facemask'}\}$
$\{\mathfrak{Maxwelton},\ sk^{(elizabeth')}_{facemask'}\}$,

The present model theory does not account for the weak reading.[17]

The reader can easily satisfy themselves that adding a relation $\mathfrak{beat}$ consisting of the single pair $\{\mathfrak{Anne}, \mathfrak{Pedro}\}$ to the original model, and adding the pair $\{\mathfrak{beat}, beat'\}$ to the original correspondence $\mathcal{C}_0$, to obtain a model in which every farmer does not beat some donkey he or she owns, correctly fails to satisfy the stronger requirements of (50b), the translation of (50a), *No farmer who owns a donkey beats it*.

4.5 Remarks

The above examples show this model theory to be less strange than it may have seemed. The way that rule 1b "unpacks" generalized Skolem terms into a Skolem term object name and a predication of the relevant restrictor λ-term p and cardinality condition c over it simply transfers part of the burden of logical-form building from derivation to interpretation (cf. example (20)). The last condition c in rule 1 ensures that verifying set individuals are maximal participant sets, in the sense used in section 10. The condition c on cardinality of certain plural set individuals must be checked independently from the maximal participants property, via condition 1b. (This move similarly transfers something like the approach to maximal participants of Zucchi and White (cf. 2001, p.254-255) from logical form to interpretation.)

Otherwise, the truth conditions for a formula of L are the same as for a standard formula of FOPL with existentially quantified variables in place of the Skolem terms, apart from cases where one or more saturated generalized Skolem terms that are not yet in the range of $\mathcal{C}$ occur inside universal quantification (rule 3), or on both sides of the conjunctive connectives (rules 2c,d), as in the crucial case of donkey sentences. In these cases, $\mathcal{C}$ must be extended immediately to all and only those generalized Skolem terms to satisfy the conditions in the rule. In the case of universal quantification, this reflects the standard treatment of skolem terms that are independent of the quantified variable as existentially quantified outside its scope. In the case of conjunction and implication (which we shall see below is also conjunctive), this amounts to treating conjunction as a form of implicit universal quantification.

In all other cases, and in particular in the grounding case of atomic formulæ without generalized Skolem terms and cases where all generalized Skolem terms are already in $\mathcal{C}$, the extension $\mathcal{C}'$ referred to in the rule is simply $\mathcal{C}$ itself. The business of extension to any *other* generalized Skolem terms must be deferred to a lower level of the recursion. The fact that we have defined the extensions of $\mathcal{C}$ as including $\mathcal{C}$ itself allows us to treat these conceptually distinct cases in a single rule.

[17]Note 18 points out that the present model theory could be set up to yield weak readings rather than strong. However, it is argued below that the weak reading should be accounted for by embedding the present logic in a dynamic logic in the sense of Harel 1984.

A little more needs to be said about rule 2d, the form of which is dictated by donkey examples like (21), as discussed in the last section, 4.4. Here too, we need to handle the case where there is a hitherto unassigned saturated generalized Skolem term in both antecedent and consequent. If there is, either *all* values for the Skolem term must satisfy *both* antecedent *and* consequent, or there must be no value that satisfies the antecedent. This amounts to applying the truth conditions for $\forall x.[Y(x) \to (Y(x) \wedge Z(x))]$, or equivalently $\forall x.[\neg Y(x) \vee (Y(x) \wedge Z(x))]$.[18]

Treating implication in this way means that we lose the classical equivalence of $Y \to Z$ to $(\neg Y) \vee Z$. In particular, the following formula means that there is either no donkey that Elizabeth owns, or that she feeds some donkey, rather than that if she owns one, she feeds it (cf. (31c)):

(44) $(\neg own' sk_{donkey'}\, elizabeth') \vee feed' sk_{donkey'}\, elizabeth'$

However, in this respect, the model theory seems simply to be true to the linguistic facts: whatever the following sentences mean, they do not seem to be equivalent in any sense to *If Elizabeth owns (does not own) a donkey, she feeds (does not feed) that donkey*:[19]

(45) a. #Either Elizabeth doesn't own a donkey, or she feeds it/the donkey.
b. #Either Elizabeth owns a donkey, or she doesn't feed it/the donkey.

Similarly, the following example from Abbott (2004) doesn't seem equivalent to *If Alice comes, Bob will too*:

(46) #Either Alice won't come, or Bob will too.

These observations are merely representative of very widespread dissatisfaction with the Philonian definition of the natural language conditional in terms of material implication. For nearly two and a half millenia, generations of students have balked at the idea that the mere falsity of the antecedent renders a conditional true, the anomaly that provided one of the major impulses behind the development of modal logic and intuitionism. Jackson (1979) points out that "the circumstances under which it is natural to assert the ordinary indicative conditional 'If P then Q' are those in which it is natural to assert 'Either not P, or P and Q"'. Having noted that, given "the standard and widely accepted truth functional definitions of 'not', 'or', and 'and'," $\neg P \vee (P \wedge Q)$ is truth-conditionally equivalent to material implication, Jackson proposes to repair the deficiencies of the latter in terms of con-

[18]It is this particular detail of rule 2d that makes the donkey sentence false if owners of multiple donkeys fail to feed all of them. Another version of the model theory is possible in which 2d is defined in terms of the existence of *some* extension $\mathcal{C}'$ to common saturated generalized Skolem terms that satisfies both Y and Z. The latter version would mean that the facemask sentence (22) is true even though multiple facemask owners wear only one of their facemasks, leaving the stronger reading of the donkey sentences to pragmatics.

[19]Oddly, examples like the following do seem equivalent to the corresponding conditional—cf. note 12:
(i) Either this house doesn't have a bathroom$_i$, or it/the bathroom$_i$ is in an unusual place.
Both this reading and the unusual possibility of pronominal anaphora and definite reference inside negation seem to depend on the idea of "the bathroom that houses *usually* have."

ventional implicature and a notion of "robustness" with respect to the antecedent defined in terms of probability which need not concern us here. By contrast, in the logic defined here, certain cases that involve generalized Skolem terms on both sides of the implication engender a truth-functional difference which requires this more natural definition. More generally, this seems to be a treatment of implication that would be necessary in any logic that treats negation intuitionistically, as failure, as is standard in logic programming.

While the present theory remains entirely neutral as between classical and intuitionistic interpretations, the latter is a very natural one to adopt under present assumptions. In particular, once we equate negation and failure, the fact that conjunction, conditionals, and disjunction are all "filters on presuppositions," obeying the conditions stated by Karttunen 1973, 1974—cf. Heim 1983 and Beaver 1997—follows immediately, including asymmetric projection by the conditional and the symmetric versions of conjunction and disjunction. A further desirable consequence of this treatment of connectives is that the conservativity property of all the quantifier determiners considered here (see Keenan and Stavi 1986) follows immediately from the fact that their logical forms include the connectives $\wedge$ and $\Rightarrow$.

5 RELATED APPROACHES TO DONKEY SENTENCES

If we abstract away from the specific involvement of generalized Skolem terms, the present analysis of donkey anaphora has some obvious affinities to earlier attempts, and in particular to a form of DRT in which discourse referents are generalized Skolem terms, expressing relations of dependency among individuals in the model, rather than variables over such individuals as in standard DRT.

In particular, the present theory shares with DRT the property of treating donkey pronouns as standard unbound discourse pronouns, rather than as some more exotic object like a definite or a functional entity, and of associating existential force with *a donkey* via the interpretation procedure. (Heim 1990:137 notes that these properties are logically independent of the dynamic aspects of DRT).

Kamp 1981/1984 overcame the difficulty concerning the relative scopes of the universal and existential by in essence translating the universal donkey sentence (21) into the same representation as the conditional version (48), and then building a universal into the implication condition (cf. Kamp and Reyle 1993:177). This tactic amounts to universally quantifying over farmer-donkey pairs, and encounters the "proportion problem" posed by models in which there is one farmer who owns many donkeys and feeds all of them, and two farmers who own one donkey which they do not feed, and variants of (21) like (29a), repeated here:

(47) Most farmers who own a donkey feed it.

Kamp and Reyle 1993 tried to escape the proportion problem by making the

DRT implication condition for quantifiers a duplex, quantifying only over farmers. However this move had the effect of imposing the weak reading on the standard donkey sentence (21) (Kamp and Reyle 1993:421-425). This led van Eijck and Kamp (1997:222-225) to reintroduce generalized quantifier interpretations in DRT for *all* quantifiers except indefinites.

There are some close affinities between van Eijck and Kamp's interpretation for generalized quantifiers and the present model theoretic treatment of implication (including the implicit universal and the equivalence of implication to $\neg P \vee (P \wedge Q)$—see especially their strong-reading-inducing definition (80)). In other respects the theories diverge. In particular, the present theory allows us to assume that (47), like (21), quantifies over farmers who own donkeys, as in (29), rather than farmer-donkey pairs, as detailed later in section 10. Thus to the extent that the present theory can be seen as a form of DRT in the rather general sense of Heim 1990, it is a variant distinguished by escaping the proportion problem, without resorting to such problematic complications to the model theory as "minimal situations" involving farmer-donkey pairs, while still yielding strong readings.[20]

Under these assumptions, and the account of implication in the model theory of section 4, the analysis of donkey anaphora via generalized Skolem terms also explains the variants of the donkey sentence (21), mentioned at (30) and repeated here, whose translation is as in (48c):

(48) a. A/any farmer who owns a donkey feeds it.
b. If a/any farmer owns a donkey, she feeds it.
c. $\mathit{own}' sk_{\mathit{donkey}'}\, sk_{\mathit{farmer}'} \rightarrow \mathit{feed}'(\mathit{pro}' sk_{\mathit{donkey}'})(\mathit{pro}' sk_{\mathit{farmer}'})$

Because of the semantics of the conditional defined in rule 2d of the model theory in section 4, neither farmer nor donkey are referential or individual-denoting like the Skolem constants in sentences like the following:

(49) a. (Today,) a/*any farmer bought a donkey.
b. $\mathit{buy}' sk_{\mathit{donkey}'}\, sk_{\mathit{farmer}'}$

Instead, like the DRT of Kamp and Reyle 1993, the model theory developed in section 4, rule 2d, requires that *all* instantiations of generalized Skolem terms (a.k.a. discourse referents) that satisfy the antecedent of a conditional also satisfy the consequent. The fact that the dominant and possibly the only reading of (48a,b) is as statements about all farmers and all donkeys each farmer owns, rather than about a specific farmer like (49), is thereby explained, as in DRT.

Similarly, the salient interpretation of sentence (50a) can be captured using generalized Skolem constants, as in (50b):

[20] Another approach related to DRT, Dynamic Predicate Logic (DPL, Groenendijk and Stokhof 1991) achieves similar effects by retaining the notion of generalized quantifiers, but at the expense of dynamically generalizing the notion of scope itself. For present purposes we can consider this approach as equivalent to van Eijck and Kamp 1997.

(50) a. No farmer who owns a donkey beats it.

b. $\neg(beat'(pro' sk_{donkey'})sk_{\lambda y.farmer' y \wedge own' sk_{donkey} y})$

The formula (50b) is true according to the model theory of section 4, rules 2a and 1, in models where you cannot choose a farmer who owns a donkey such that the farmer beats that donkey—cf. the later discussion of (109).

We will defer further discussion of negation to section 7.1, where syntactic polarity is introduced.

It is sometimes argued that "quantificational adverbial" modifiers such as *usually* or *mostly* behave the same way as (47) with respect to proportion problem-inducing models in examples like the following (which originate with Lewis 1975):

(51) a. Any/a farmer who owns a donkey usually/mostly feeds it.

b. If any/a farmer owns a donkey, she usually/mostly feeds it.

However, opinions differ as to whether such sentences do in fact have the reading corresponding to quantification over farmers like (47), rather than over farmer-donkey pairs like (48), with Lewis himself and Kamp and Reyle 1993:645 inclining to the latter view.

It seems likely that these adjuncts in fact translate as something paraphrasable as "probably" or "in most cases." If so, the prediction of the present theory is that the variants in (51) should behave as Kamp and Reyle 1993 claim with respect to such models, since according to the model theory of section 4, the conditional with indefinites has the effect of quantifying over farmer-donkey pairs. This result is therefore a consequence of the semantics, rather than a stipulation that could be specified otherwise.

In regarding the indefinite *a donkey* as referential/functional rather than quantificational, the present theory also resembles the discourse-referent based proposals of Karttunnen (1976), Fodor and Sag (1982); Fodor (1982), Chierchia (1992), in part, and Park (1995, 1996). In regarding the ability of the discourse pronoun to refer to the dependent donkey indefinite as depending on its being within the scope of the universal that binds the latter, it also resembles the account in Reinhart 1987:156-159.

The specific proposal to translate indefinites as generalized Skolem terms is anticipated in the early work cited above. The present version is closely related to Chierchia 1995a , and Schubert 1999, 2007, and to the Choice Function-based approaches of Reinhart (1997), Winter (1997, 2001, 2004), and Kratzer (1998). The present proposal differs from all of these theories in making all quantifiers unambiguously *either* generalized quantifiers *or* Skolem terms, and in treating both group-denoting definites/indefinites and counting nominals uniformly as the latter—cf. Kratzer 1998:192, Winter 2001:166. We shall return to the comparison with Kratzer and Winter later, in the light of the discussion of intermediate scope in section 7.3.

The present proposal is more distantly related to the “E-type pronoun,” approach originating with Evans (1977) and Cooper (1979) and elaborated by Heim (1990), Kadmon (1990), Chierchia (1992, 1995a), and more recently by Elbourne (2001, 2002), Abbott (2002), and Büring (2004). Under such approaches, the pronoun is assumed to take on a distinctive non-quantificational reading just in case it c-commands an indefinite, embodying a definite meaning equivalent to *the donkey that x owns*, *the donkey*, or *that donkey*, constructed by a syntactic transformation (Heim), or by reference to the head (or $\overline{\mathrm{N}}$) of the antecedent (Chierchia), or by copying and NP deletion (Elbourne). Such accounts tend to encounter a “uniqueness problem” with respect to models in which the mapping from farmers to donkeys is one-to-many, because of the uniqueness presupposition of the definite. For example, sentence (50), *No farmer who owns a donkey beats it* either fails to yield a meaning or is false for such models. For examples like the following, there are no models in which they are true, a consequence so grave as to have made Heim (1982) temporarily abandon the E-type analysis entirely:

(52) Every woman who bought a sageplant had to buy eight others along with it.

The standard technique since Heim (1990) for E-type theories to escape the uniqueness problem has been to interpret subjects like *Every farmer who owns a donkey* as quantifying not only over individual farmers but also over the “minimal situations” involving a single farmer-donkey pair, and to interpret the pronoun as referring to *the donkey in that situation*. However, as Heim (1990) herself pointed out, this solution to the uniqueness problem immediately leads to a number of further problems, because the definition of minimal situations is itself problematic, as illustrated by the following example (adapted from Heim 1990), in which the minimal situation needs to contain indistinguishable individuals:

(53) Every bishop who meets a(nother) bishop blesses him.

Other problems that have to be circumvented under the E-type proposal, such as the difficulty in constructing appropriate versions of the assumed definite descriptions with split antecedents (as in (54a), from Elbourne 2001), with disjunctive or conjunctive antecedents (as in (54b), also adapted from Elbourne 2001), and the susceptibility of donkey pronouns to weak crossover effects (as in (54c), from Büring 2004):

(54) a. Every farmer who has a wife who owns a donkey loves them.
b. Every farmer who meets Johnson or Monboddo likes him.
c. *Its lawyer will sue every farmer who beats a donkey.

Solutions have been proposed for all of these problems in the cited papers. However, they considerably complicate both syntax and semantics. In the present theory, in which both the pronoun and its antecedent simply have the interpretations that they bear in other contexts, without uniqueness assumptions, such problems do not arise. These are simply the things that normal pronouns and indefinites do anyway.

Elbourne and Büring also address the question of strict and sloppy anaphora over donkey sentences in VP ellipsis. In (55a), adapted from Elbourne, in which this anaphora appears to be strict and cannot be sloppy (that is, the priest feeds the donkey that the farmer owns, not one that he owns himself). By contrast, in (55b), also from Elbourne, the sloppy reading appears to be available and preferred.

(55) a. Every farmer$_i$ who owns a donkey$_j$ feeds it$_j$, and the local priest may [*feed it$_j$*] too
b. Almost every student who was awarded a prize$_j$ accepted it$_j$, but the valedictorian didn't [*accept it$_j$*]

In the terms of the present theory, one would not expect any kind of true bound intersentential anaphora to dependent Skolem donkeys, since the pronoun is by definition outside the scope of the universal. It is therefore noteworthy that such anaphora is also possible across sentential boundaries, as in the following example from Elbourne (2001):

(56) Every farmer who owns a donkey$_i$ feeds it$_i$. The local priest feeds it$_?$, too

The latter pronoun really does seem to have a translation like that of a E-type definite, whose antecedent is something like "the donkey in question". However, such anaphora is very different from the earlier semantically-bound cases.

It is a measure of this difference that in order to explain the difference between (55a) and (55b) in terms of an E-type pronoun account, Elbourne and Büring have to assume that the situation implicit in the former does not support a presupposition that the priest in that situation has a donkey but does allow him to feed other people's donkeys, while in the latter, the implicit situation supports the presupposition that the students that were awarded prizes in it *including one particular student among them, the valedictorian*, can accept or decline *only the prize that they have been awarded*. This is all perfectly reasonable, but the situated presupposition-based mechanism used by Elbourne to explain how readings analogous to strict and sloppy anaphora are available in the E-type theory also offers an explanation for why they are available in *non-* E-type accounts of these sentences such as the one offered here. By the same token, it is probably an error to equate these readings with semantically bound anaphora.[21]

The present theory shares with many of these theories (including Elbourne 2001) the assumption that the "strong" reading in the donkey example (21) is primary, and that the "weak" reading characteristic of the facemask example (22) arises from the pragmatics of events and situations, and the inferences we draw on the basis of world knowledge. For example, it is world knowledge that tells us that the act of feeding one donkey one owns leaves unaffected the reasons and

[21] The present paper continues to be agnostic as to which side of this divide paycheck sentences belong.

preconditions for feeding other donkeys one owns. On the other hand, the act of putting on a facemask obviates the reasons and preconditions for putting on a facemask, so the found example (22), *Everybody who has a face mask wears it*, behaves differently.[22]

The present propoposal is more distantly related to approaches based on scopal underspecification (Kempson and Cormack 1981). Although generalized Skolem terms are lexically unspecified as to scope, their specification is determined by surface derivation, rather than post-derivationally.

Finally, the relation to environment-passing accounts using storage and the accessibility relation of Farkas (2001) is apparent from the model theory in the preceding section. The main difference is that the interface to CCG syntax developed in the next section, 6, obliges generalized Skolem terms to be terms in *all* variables bound by operators in whose scope they fall at the time of specification (cf. Farkas 2001, 57, ex. (35)). It is this property of the grammar (which is not represented at all in the model theory for the formulæ that *result* from this process of specification) which captures grammatical constraints on possible readings via syntactic combinatorics. This property has important consequences for the analysis of the available readings for the Geach sentence (10) and the related examples discussed in section 11.2, and for the possibilities for "intermediate scope" discussed in section 7.3, and it is to the grammar that we now turn.

II: Syntactic Constraints on Quantifier Scope

6 Combinatory Categorial Grammar (CCG)

CCG is a form of lexicalized grammar in which grammatical *categories* are made up of: a) a syntactic type defining valency (the number of arguments if any) and the type of the result, the linear order (if any) of those arguments, and the order (if any) of their combination; and b) a logical form. For example, the English intransitive verb *walks* has the following category, which identifies it as a function from (subject) NPs, which the backward slash identifies as on the left, into sentences:[23]

[22]Example (22) is of course related to the "dime and parking-meter" example of Schubert and Pelletier (1989), *Everyone who had a dime put it in the parking meter*. It has been proposed that the difference stems from the involvement of an event or stage-level predicate, as opposed to the stative or individual-level predicate in the standard donkey sentence. However, although the property of voiding their own preconditions is frequently associated with stage-level predicates, it is not invariably so. For example, the preconditions for selling shares in a financially unsound company are not voided by the sale of a single share, so the following stage-level sentence has an implication parallel to the standard donkey sentence:

(i) Every manager who owned a share in Enron sold it.

A calculus for representing such dynamic aspects of events in terms of the dynamic logic of Harel (1984) is discussed in Steedman 2002.

[23]This is the "result leftmost" convention for function categories. There is an alternative "result on top" convention, due to Lambek.

(57) walks := $S\backslash NP_{3SG} : \lambda x.walk'x$

The feature-value indicated by subscript *3SG* on the subject identifies as bearing third person singular agreement. Where agreement is ambiguous, as with *walked*, or is irrelevant, it is suppressed in examples.

The interpretation of categories such as (57) is written as a λ-term associated with the syntactic category by the operator ":". We associate with the propositional body of verb interpretations an environment $\mathcal{E}$ whose value as in the model theory of section 4 is a set of operator-bound variable identifiers. When the environment is the empty set, as here, we may suppress it in the notation. Thus, the above category is an abbreviation for $S\backslash NP_{3SG} : \lambda x.[walk'x]^{\{\}}$

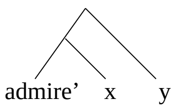
We make the following assumption about environment passing. When a function with environment $\mathcal{F}$ applies to an argument with environment $\mathcal{A}$, the environment of the argument in the resulting lf is the union $\mathcal{F} \cup \mathcal{A}$ of the two. When the resulting environment of the argument is the same as that of the function (that is, when the environment of the argument before reduction was empty), we suppress the environment of the argument in the notation.

The transitive verb *admires* has the category of a function from (object) noun-phrases (which the forward slash identifies as on the right) into predicates or intransitive verbs:

(58) admires := $(S\backslash NP_{3SG})/NP : \lambda x \lambda y.admire'xy$

Juxtaposition of function and argument symbols in logical forms as in $admire'x$ indicates function application as before. The convention of left associativity holds, according to which $admire'xy$ is equivalent to $(admire'x)y$. Such predicate-argument structures can therefore be thought of as tree-structures like the following, over which a standard notion of structural command can be defined:

(59)



Again, empty environments are suppressed, so that $admire'xy$ in (58) abbreviates $[admire'xy]^{\{\}}$. However, not all verbs begin life with empty environments. Intensional verbs like *seeks* contribute an intensional variable linked to their subject which we will write i_y here and leave explicit:

(60) seeks := $(S\backslash NP_{3SG})/NP : \lambda x \lambda y.[seek'xy]^{\{i_y\}}$

Under the above assumption concerning environment-passing, the application of this function to arguments will make their environment the union of those of each argument with the set $\{i_y\}$

In the case of (58), the syntactic type is simply the SVO directional form of the semantic type. In other cases categories may "wrap" arguments into the logical form, in a lexicalized version of the analysis of Bach (1979, 1980), Dowty (1982), and Jacobson (1992). For example, the following is the category of the English ditransitive verb *showed*:[24]

(61) showed := $((S\backslash NP)/NP)/_{\diamond}NP : \lambda x\lambda y\lambda z.show'yxz$

The reason for doing this is to capture at the level of logical form the binding theory and its dependence on the c- or lf-command hierarchy in which subject outscopes direct object, which outscopes indirect (dative) object, which outscopes more oblique arguments. The interpretation x of the first argument of (61), the indirect object is commanded by y, the direct object, in the logical form $show'yxz$. Having the accessibility hierarchy directly represented in this way allows us to capture binding asymmetries like the following in terms of condition C, which prohibits an anaphor like *each other* from c- or lf-commanding an antecedent like *people*:

(62) a. I showed people themselves/each other.
b. *I showed themselves/each other people.

In *SS&I*, this is done by defining the interpretation of anaphoric arguments at the level of logical form as terms of the form $ana'x$, with x a variable bound to the antecedent. Such terms are a form of pro-terms, and resemble PRO in transformational theory. The equivalent of c-command (here called lf-command) can then be defined as follows:

(63) *Lf-command*
A node α in a predicate-argument structure lf-commands another node β if the node immediately dominating α dominates β and α does not dominate β, or if α is the argument in a pro-term and the pro-term lf-commands β.

The relation "dominates" is defined as the transitive closure of "immediately dominates".

A system of lexical rules is assumed, whereby base forms such as infinitival verbs are mapped by default onto a family of inflected forms. For example, the default rule for (agentive) passives, applying in the absence of positive evidence of irregularity, might be written as follows, where "$/\$$" schematizes over zero or more rightward arguments, over and above subject and first internal argument, and "…" schematizes over the corresponding semantic arguments:

[24] $\diamond$ modality on the accusative argument of *give* prevents overgeneration of heavy shifted datives **We gave a flower a very heavy policeman*. The empty environment in $[show'yxz]^{\{\}}$ is suppressed. The present analysis differs from that of Bach and colleagues in making WRAP a *lexical* combinatory operation, rather than a syntactic combinatory rule. One advantage of this analysis, which is discussed further in *SS&I*, is that phenomena depending on WRAP, such as anaphor binding and control, are immediately predicted to be *bounded* phenomena.

(64) $\mathsf{verb} := ((S\backslash NP)/\$)/NP : \lambda x\lambda\ldots\lambda y.\mathsf{verb}'\ldots xy$
$\Rightarrow_{LEX}$ $\mathsf{verb{+}\text{-}en} := ((S_{PPT}\backslash NP)/PP_{BY})/\$$
$: \lambda\ldots\lambda y\lambda x.\mathsf{verb}'\ldots x\ one' \wedge one' = y$

A similar rule, instantiated here with the verb "hang" that is central to (17), gives middle or unaccusative verbs from transitives:

(65) hang $:= (S\backslash NP)/NP : \lambda x\lambda y.hang'xy$
$\Rightarrow_{LEX}$ hang $:= S_{MID}\backslash NP : \lambda x.hang'x\ one'$

Such rules may or may not be associated with explicit morphology. In English it is one category of the morpheme "-ed" that embodies rule (64), but (65) is an example of a lexical rule with no morphological reflex in English.

By a similarly lexicalized analysis derived from proposals by Keenan and Faltz (1985) and Reinhart and Reuland (1993) (whose details we will pass over here, referring the reader to *SS&I*, chapter 2), the logical forms corresponding to (62) come out as the following:

(66) a. $show'(ana'people')people'i'$
b. $*show'people'(ana'people')i'$

The second of these is in violation of condition C, because a pro-term $ana'people'$ lf-commands its antecedent $people'$ under the left associativity convention of note 1.

Categories like (57) and (58) can combine by a number of "combinatory" syntactic operations to assemble such interpretations. The combinatory rules of CCG are distinguished from transformations by being strictly type-dependent, rather than structure-dependent.

The simplest such operations correspond to *functional application*, and can be written as follows:

(67) *The functional application rules*
a. $X/_{\star}Y : f \quad Y : a \quad \Rightarrow \quad X : fa$ $(>)$
b. $Y : a \quad X\backslash_{\star}Y : f \quad \Rightarrow \quad X : fa$ $(<)$

Under the earlier assumption concerning environment-passing, the semantic component of every combinatory rule makes the environment of the argument a the union $\mathcal{F}\cup\mathcal{A}$ of the environments of the input terms f and a, so this detail is omitted from the notation. As usual if any of these environments is empty it can be suppressed by convention in derivations.

The present paper follows Jacobson (1990, 1992), Hepple (1990), Baldridge (2002), and Baldridge and Kruijff (2003) in assuming that rules and function categories are "modalized," as indicated by a subscript on slashes. Baldridge further assumes that slash modalities are features in a type hierarchy, drawn from some finite set $\mathcal{M}$. The modalities used here are $\mathcal{M} = \{\star, \diamond, \times, \cdot\}$. The effect of each of these modalities will be described as each of the combinatory rules and its interaction with the modalities is described. The basic intuition is as follows: the $\star$ modality is the most restricted and allows only the most basic application rules; $\diamond$ permits order-preserving associativity in derivations; $\times$ allows limited permutation; and $\cdot$ is the most permissive, allowing all rules to apply. The relation of these modalities to each other can be compactly represented via the hierarchy given in figure 6:[25]

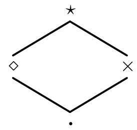


Figure 1: CCG type hierarchy for slash modalities (from Baldridge and Kruijff 2003).

We will by convention write the maximally permissive slashes $/_{\cdot}$ and $\backslash_{\cdot}$ as plain slashes $/$ and $\backslash$ omitting the dot. This allows us to continue writing the categories that bear this modality, such as that of the transitive verb (58), as before.

The application rules (67) allow derivations equivalent to those of traditional context-free phrase structure grammar (CFPSG), like the following, in which all environments are empty and suppressed in the notation:

(68)
$$\begin{array}{ccc}
\text{Harry} & \text{admires} & \text{Louise} \\
\hline
NP : harry' & (S\backslash NP_{3SG})/NP : \lambda x\lambda y.admire'xy & NP : louise' \\
 & \multicolumn{2}{c}{\underline{\hspace{12em}}{>}} \\
 & \multicolumn{2}{c}{S\backslash NP_{3SG} : \lambda y.admire'louise'y} \\
\multicolumn{3}{c}{\underline{\hspace{20em}}{<}} \\
\multicolumn{3}{c}{S : admire'louise'harry'}
\end{array}$$

CCG includes a number of further more restricted combinatory operations for combining categories. They are strictly limited to various combinations of operations of *type-raising* (corresponding semantically to the combinator **T**), *composition* (corresponding to the combinator **B**), and *substitution* (corresponding to the combinator **S**), with the first two doing most of the work.

Type-raising turns argument categories such as *NP* into functions over the those functions (such as the verbs (57), (58) and (61)) that take an NP as first argument, into the results of such functions. In particular, we are concerned with the two "order-preserving" instances of type-raising that can be written as the following lexical rules, where X is a (function into) an argument category (such as *NP*) of type ε (such as e), \$ is a (possibly null) set of syntactic argument types (such as N), while T is any lexical syntactic category of semantic type τ and $\mathrm{T}/(\mathrm{T}|X)$ is a function of type $((\varepsilon,\tau),\tau$:

[25]The use of a hierarchy such as this as a formal device is optional, and instead could be replaced by multiple declarations of the combinatory rules.

(69) a. $X\$ \quad \Rightarrow_{LEX} \quad \mathrm{T}/_i(\mathrm{T}\backslash_i X)\$$
b. $X\$ \quad \Rightarrow_{LEX} \quad \mathrm{T}\backslash_i(\mathrm{T}/_i X)\$$

(The *i* on the slashes is a variable over the modality of the slash on the actual argument of the raised category–that is $\cdot$, $\times$, $\diamond$ or $\star$, and is suppressed in derivations.)

For example, NPs like *Harry* can take on such categories as the following:

(70) a. $S/(S\backslash NP_{3SG}) : \lambda p.p\ harry'$
b. $S\backslash(S/NP) : \lambda p.p\ harry'$
c. $(S\backslash NP)\backslash((S\backslash NP)/NP) : \lambda p.p\ harry'$
d. *&c.*

These categories are order-preserving in the sense that in the absence of any other changes to the grammar they admit exactly the strings that are admitted by the ground category *NP*, such as *Harry walks*, and *Harry admires Louise*.

Type raising must be restricted to ensure decidability, and in practice X in (69) can be strictly limited to the class of *phrasal argument categories* NP, AP, PP, VP, S and $\bar{S}$ and their various inflected subtypes, while T is restricted to the set of function types that exist in the lexicon. In (69) we have assumed that type-raising is a lexical rule that compiles type-raising into the categories for proper names, determiners, and the like, in which case their original ground types like NP, NP/N, etc. can be eliminated. Type-raised categories tend to take up a lot of space, so we will often abbreviate the entire type-raised NP schema (69) as $NP^{\uparrow}$, the corresponding PP schema as $PP^{\uparrow}$, and so on, usually spelling out the relevant instance of the schema in full in derivations.[26]

The inclusion of composition rules like the following as well as simple functional application and lexicalized type-raising engenders a potentially very freely "reordering and rebracketing" calculus, engendering a generalized notion of surface or derivational constituency.[27]

(71) *Forward composition* ($>\mathbf{B}$)
$X/_{\diamond}Y : f \quad Y/_{\diamond}Z : g \quad \Rightarrow_{\mathbf{B}} \quad X/_{\diamond}Z : \lambda x.f(gx)$

For example, the simple transitive sentence of English has *two* equally valid surface constituent derivations, each yielding the same logical form (as usual, trivial environment-passing is suppressed):

(72)
$$\begin{array}{ccc}
\text{Harry} & \text{admires} & \text{Louise} \\
\hline
S/(S\backslash NP_{3SG}) & (S\backslash NP_{3SG})/NP: & S\backslash(S/NP) \\
: \lambda f.f\ harry' & \lambda x\lambda y.admire'xy & : \lambda p.p\ louise' \\
\hline
\multicolumn{2}{c}{S/NP : \lambda x.admire'x\ harry' \quad >\mathbf{B}} & \\
\hline
\multicolumn{3}{c}{S : admire'louise'harry' \quad <}
\end{array}$$

[26]This is actually the way wide-coverage CCG parsers handle type raising, instantiating type-raised categories via unary rules at the point in the derivation where they combine (see Hockenmaier and Steedman 2002, Hockenmaier 2003, Clark and Curran 2004).

[27]Again, the environment of the resulting function is the union $\mathcal{F} \cup \mathcal{G}$ of the environments $\mathcal{F}$ and $\mathcal{G}$ of the two inputs.

(73)
$$\begin{array}{ccc}
\text{Harry} & \text{admires} & \text{Louise} \\
\hline
S/(S\backslash NP_{3SG}) & (S\backslash NP_{3SG})/NP: & (S\backslash NP)\backslash((S\backslash NP)/NP) \\
:\lambda f.f\ harry' & \lambda x\lambda y.admire'xy & :\lambda p.p\ louise' \\
\cline{2-3}
 & \multicolumn{2}{c}{S\backslash NP_{3SG} : \lambda y.admire'louise'y \quad <} \\
\hline
\multicolumn{3}{c}{S : admire'louise'harry' \quad >}
\end{array}$$

In the first of these, *Harry* and *admires* compose as indicated by the annotation $>\mathbf{B}$ to form a non-standard constituent of type S/NP. In the second, there is a more traditional derivation involving a verbphrase of type $S\backslash NP$. Both yield identical logical forms, and both are legal surface or derivational constituent structures. More complex sentences may have many semantically equivalent derivations, a fact whose implications for processing are discussed in *SP*.

Rule (71) is restricted by the $\diamond$ modality, which means that it cannot apply to categories bearing the $\times$ or $\star$ modalities of Figure 6. Crucially, "crossing" composition rules, in which the directionality of the composed functions differ, are also allowed in CCG, unlike the Lambek Calculus. An example is the following rule, required for the "Heavy NP shift" construction in English:[28]

(74) *Backward Crossed Composition* ($<\mathbf{B}_\times$)
$$Y/_{\times}Z : g \quad X\backslash_{\times}Y : f \quad \Rightarrow_{\mathbf{B}} \quad X/_{\times}Z : \lambda x.f(gx)$$

Such rules increase the expressive power of the formalism to the "mildly context-sensitive" class identified by Joshi, Vijay-Shanker and Weir (1991). For a language like English, they must be narrowly restricted by the $\times$ modality, because they have a re-ordering effect.

There is a third and final class of combinatory operations, which also occur in harmonic and crossed forms. We defer discussion of their linguistic motivation until a later section but we will need the following instances:

(75) *Forward Substitution* ($>\mathbf{S}$)
$$(X/_{\diamond}Y)/_{\diamond}Z : f \quad Y/_{\diamond}Z : g \quad \Rightarrow_{\mathbf{S}} \quad X/_{\diamond}Z : \lambda x.fx(gx)$$

(76) *Backward Crossed Substitution* ($<\mathbf{S}_\times$)
$$Y/_{\times}Z : g \quad (X\backslash_{\times}Y)/_{\times}Z : f \quad \Rightarrow_{\mathbf{S}} \quad X/_{\times}Z : \lambda x.fx(gx)$$

The principles under which these particular instances of the combinatory rules are allowed, together with the two other instances of each that are made available by Universal Grammar, is discussed at length in *SP* and Baldridge 2002.

This theory has been applied to the linguistic analysis of unbounded dependencies in English and many other languages (*SS&I*, Steedman 1990, 2000a; Hoffman 1995; Bozsahin 1998; Komagata 1999; Baldridge 1998, 2002, Trechsel 2000). For example, since substrings like *Harry admires* are now fully interpreted derivational *constituents*, then if we assume that object relative pronouns have the

[28] See *SS&I*. Again, the environment of the resulting function is the union $\mathcal{F} \cup \mathcal{G}$ of the environments $\mathcal{F}$ and $\mathcal{G}$ of the two inputs.

following category, then we not only predict that such fragments can form relative clauses, but also that they can do so unboundedly:[29]

(77) who(m), which, that := $(N\backslash_{\diamond}N)/_{\diamond}(S/NP) : \lambda q\lambda n\lambda y.ny \wedge qy$

(78)
$$\begin{array}{ccccccc}
\text{The} & \text{saxophonist} & \text{that} & \text{Louise} & \text{said} & \text{she} & \text{detests}\\
(S/(S\backslash NP))/_{\diamond}N & N & (N\backslash_{\diamond}N)/_{\diamond}(S/NP) & S/(S\backslash NP) & (S\backslash NP)/_{\diamond}S & S/(S\backslash NP) & (S\backslash NP)/NP\\
 & & & \multicolumn{2}{c}{S/_{\diamond}S \quad {>}\mathbf{B}} & \multicolumn{2}{c}{S/NP \quad {>}\mathbf{B}}\\
 & & & \multicolumn{4}{c}{S/NP \quad {>}\mathbf{B}}\\
 & & \multicolumn{5}{c}{N\backslash_{\diamond}N \quad {>}}\\
 & \multicolumn{6}{c}{N \quad {<}}\\
\multicolumn{7}{c}{NP \quad {>}}
\end{array}$$

We can further assume that conjunctions like *and* bear the following category, in which T is any syntactic category, p and q are of type t or any function into t:[30]

(79) and := $(\mathrm{T}\backslash_{\star}\mathrm{T})/_{\star}\mathrm{T} : \lambda p\lambda q.[p \wedge q]$

For the moment, we can assume that the conjunction '$\wedge$' schematises over the usual pointwise recursion over logical conjunction (Gazdar 1980; Partee and Rooth 1983), although later we will assume a more complete semantics due to Winter (1996). Our standard assumption about environment passing means that the environment of p and q in the result is the union of their environments with that of the conjunction.

Non-traditional constituents of type S/NP can also undergo coordination via this schematized conjunction category (79), allowing a movement- and deletion-free account of right node raising, as in (80):

(80)
$$\begin{array}{cccc}
[\text{Harry admires}] & \text{and} & [\text{Louise says she detests}] & \text{a saxophonist}\\
S/NP \quad {>}\mathbf{B} & (\mathrm{T}\backslash_{\star}\mathrm{T})/_{\star}\mathrm{T} & S/NP \quad {>}\mathbf{B} & S\backslash(S/NP)\\
 & \multicolumn{2}{c}{(S/NP)\backslash_{\star}(S/NP) \quad {>}} & \\
\multicolumn{3}{c}{(S/NP) \quad {<}} & \\
\multicolumn{4}{c}{S \quad {<}}
\end{array}$$

The $\star$ modality on the conjunction category (79) means that it can *only* combine like types by the application rules (67). Hence (as in GPSG, Gazdar 1981), this type-dependent account of extraction and coordination, as opposed to the standard account using structure-dependent rules, makes the across-the-board condition (ATB) on extractions from coordinate structures a prediction, rather than a

[29] The diamond modalities on this category and on the categories of determiners adjectives and other noun-modifiers prevent overgenerations such as **a good that I met man*—see *SS&I* and Baldridge 2002 for discussion. Note that the modality permits such composition across NP and other island boundaries. Such islands are discussed in section 8.5. We defer discussion of the semantics until the section on quantification, except to note that it is as purely surface-compositional as the earlier examples.

[30] We do not treat multiple coordination here, as in *Freeman, Hardy, and Willis*. However, the approach of Maxwell and Manning (1996), which treats comma as a conjunction, transfers directly.

stipulation, as consideration of the types involved in the following examples will reveal:

(81) a. A saxophonist [that$_{(N\backslash_{\diamond}N)/_{\diamond}(S/NP)}$ [[Harry admires]$_{S/NP}$ and [Louise says she detests]$_{S/NP}$]$_{S/NP}$]$_{N\backslash_{\diamond}N}$

b. A saxophonist that$_{(N\backslash_{\diamond}N)/_{\diamond}(S/NP)}$ *[[Harry admires]$_{S/NP}$ and [Louise says she detests him]$_{S}$]]

c. A saxophonist that$_{(N\backslash_{\diamond}N)/_{\diamond}(S/NP)}$ *[[Harry admires him]$_{S}$ and [Louise says she detests]$_{S/NP}$]

These observations immediately suggest that CCG already embodies a solution to the problem posed by (10), in which we have noted that the possibilities for the right-node-raised object to take wide or narrow scope also have an across-the-board character.[31]

7 Quantifier Scope Alternation in CCG

Type-raising is also the operation that Montague used in semantics to treat quantification in natural language, and capture phenomena of scope exemplified in (1). It is standard in this tradition to translate expressions like "every farmer" and "some donkey" into "generalized quantifiers"—in effect exchanging the roles of arguments like NPs and functors like verbs by a process of type-raising the former from type e to type $(e \rightarrow t) \rightarrow t$. Semantic type-raising is in fact closely related to the notion of "(covert) movement to specifier position", since it gives the nounphrase interpretation derivational scope over the property of which it is the argument.

7.1 Generalized Quantifiers and Skolem Terms

In terms of the notation and assumptions of CCG, the natural way to incorporate generalized quantifiers into the semantics of CG determiners, given the assumption that type-raising is an operation of the lexicon, is to assign the following category schema to determiners like *every*, making them functions from nouns to type-raised nounphrases, schematizing over them using the $NP^{\uparrow}$ abbreviation, where the schematized types are simply the syntactic types corresponding to a generalized quantifier:[32]

[31] It has occasionally been suggested on the basis of some examples first noticed by Ross 1967 and Goldsmith 1985 like *What did you go to the store and buy*, *How much beer can you drink and not get sick?*, *This is the stuff that those guys in the Caucasus drink every day and live to be a hundred*, that the coordinate structure constraint and the ATB exception are an illusion. This argument has recently been revived by Kehler (2002) and Asudeh and Crouch (2002). It is discussed in Steedman (2007) and Cormack and Smith (2005), but is omitted here as a distraction, although we will later note some related claims concerning parallel restrictions of quantifier scope by Ruys (1993) and Sauerland (2001).

[32] The $\diamond$ modality is required on all English determiners to prevent crossed composition into them analogous to that permitted for verbs (see Baldridge 2002).

(82) every, each := $NP^{\uparrow}_{3SG}/_{\diamond}N_{3SG} : \lambda p \lambda q \lambda \ldots \forall x[px \rightarrow qx \ldots]^{\{x\}}$

Note that the environment of the resulting logical form is non-trivial. Under our standard assumption about environment-passing, the two applications of this category to a noun property p and a predicate q will add the newly quantified variable, x to their environments.

These rules schematize over a finite number of different raised types, via the $NP^{\uparrow}$, which ranges over the (in English, finite) set of all lexical and derived function categories over *NP*. The dots ... in the schematized logical forms represent the fact that q may bind more variables than x, and that these variables get passed in to q (under a wrapping ordering convention discussed in *SS&I*) (cf. Partee and Rooth (1983)). The schemata also add the quantifier-bound variable x to the union of the restrictor and predicate environments as the environment of the whole generalized quantifier result. (We will see this environment passing in action in example (89) below.)

Thus, (82) schematizes over the following categories, among others:[33]

(83) a. every, each := $(S/(S\backslash NP_{3SG}))/_{\diamond}N_{3SG} : \lambda p \lambda q.\forall x[px \rightarrow qx]^{\{x\}}$

b. every, each := $(S\backslash(S/NP_{3SG}))/_{\diamond}N_{3SG} : \lambda p \lambda q.\forall x[px \rightarrow qx]^{\{x\}}$

c. every, each := $((S\backslash NP)\backslash((S\backslash NP)/NP_{3SG}))/_{\diamond}N_{3SG}$
$: \lambda p \lambda q.\lambda y.\forall x[px \rightarrow qxy]^{\{x\}}$

d. every, each := $(((S\backslash NP)/NP)\backslash(((S\backslash NP)/NP)/NP_{3SG}))/_{\diamond}N_{3SG}$
$: \lambda p \lambda q.\lambda y \lambda z.\forall x[px \rightarrow qyxz]^{\{x\}}$

e. etc.

In derivations like (89) and (90) below, the interpretations will usually be spelled out as the relevant specific instance. On occasion, where the instance is obvious, we will abbreviate the syntactic type of a raised NP as $NP^{\uparrow}$ to save space.

7.2 Skolem Terms

In contrast to the universal determiners, the interpretations assigned to the indefinite determiners are not generalized quantifiers at all. Rather, they are Skolem terms, initially *unspecified* as to their bound variables, if any.[34]

We will write the underspecified translation of *a donkey* in (21) as $skolem'_n donkey'$. (The subscript n is a number unique to the nounphrase from which the term originates, and distinct from any other occurrence of *a donkey*. Since there is usually only one occurrence of a given nounphrase per example, n is usually suppressed.) The unspecified forms of the generalized Skolem terms in (26) therefore appear as follows:

[33]We shall see in section 8.1 that these categories are more narrowly specified to exclude combination with predicates with negative polarity.

[34]This is a different sense of underspecification to the scope underspecification proposed by Kempson and Cormack (1981) and much subsequent work in DRT, see *SP* for discussion.

(84) a. $skolem'(\lambda y.donkey'y \wedge fat'y)$
b. $skolem'(\lambda y.farmer'y \wedge own'(skolem'donkey')y)$
c. $skolem'(\lambda y.farmer'y \wedge own'(skolem'donkey')y\ ;\ \lambda s.|s| \geq 1)$
d. $skolem'(\lambda y.farmer'y \wedge own'(skolem'donkey')y\ ;\ \lambda s.|s| \leq 3)y)$
e. $skolem'(\lambda y.farmer'y \wedge own'(skolem'donkey')y$
$;\ \lambda s.|s| > 0.5 * |all'(\lambda y.farmer'y \wedge own'(skolem'donkey')y)|)$

Specification of an underspecified Skolem term of the form $skolem'_n p; c$ involving a property p and a (possibly vacuous) cardinality condition c is defined as an "anytime" operation that can occur at any point in a grammatical derivation, to yield a *generalized Skolem term* of the kind introduced in Part I, obtained as follows.

First, let the *environment* of an unspecified skolem term be defined thus:

(85) *The environment* $\mathcal{E}$ of an unspecified skolem term $\mathcal{T}$ is a tuple comprising all variables bound by a universal quantifier or other operator in whose structural scope $\mathcal{T}$ has been brought *at the time of specification, by the derivation so far*.

Skolem specification can then be defined as follows:[35]

(86) *Skolem specification* of a term t of the form $skolem'_n p; c$ in an environment $\mathcal{E}$ yields a generalized Skolem term $sk^{\mathcal{E}}_{n,p;c}$, which applies a generalized Skolem functor $Sk_{n,p}$ to the tuple $\mathcal{E}$, defined as the environment of t at the time of specification, which constitutes the *arguments* of the generalized Skolem term.

—where n is a number unique to the nounphrase that gave rise to t, p is a nominal property corresponding to the restrictor of that nounphrase, and c is a possibly vacuous cardinality condition. The Skolem number is normally suppressed. For non-plural terms to which the maximal participants condition does not apply, there is no cardinality conditions. Thus singular Skolem terms are identified solely in terms of the restrictor property and environment as $sk^{\mathcal{E}}_p$. Where there are distinct Skolem terms arising from identical nounphrases with the same restrictor p and environment $\mathcal{E}$ they will be distinguished by Skolem number as (say) $sk^{\mathcal{E}}_{53,p}$, $sk^{\mathcal{E}}_{95,p}$, etc.

If there is more than one occurrence of a underspecified Skolem term t derived from the *same* nounphrase in the *same* environment $\mathcal{E}$, as in the following interpretation for *Giles owns and operates some donkey* (87), the above definitions mean that they will necessarily be specified as the *same* generalized Skolem term $sk^{\mathcal{E}}_p$:

(87) $own' sk_{donkey'} giles' \wedge operate' sk_{donkey'} giles'$

[35]The decision to make the arguments of the Skolem term the entire environment $\mathcal{E}$ is forced by the analysis of the Geach sentence (10) and related examples in section 11.2.

Rule (86) implies that *skolem*′ is a function from properties like *donkey*′ to functions from environments like (x) to generalized Skolem terms like $sk^{(x)}_{n,donkey'}$. Skolem specification thus resembles a derivationally restricted form of the "existential closure" over choice functions used by Winter (1997, 2001). The present theory differs from Winter in eschewing existential quantification over the Skolem functions, and in assuming that *all* non-universals are unambiguously translated as generalized Skolem functions.

Determiners like *a* and *some* therefore have the following category schema:

(88) a, an, some := $NP^{\uparrow}_{3SG}/_{\diamond}N_{3SG} : \lambda p\lambda q.q(skolem'p)$

Syntactically and semantically, they have the same type as the generalized quantifier determiners (82). However, the unspecified Skolem term appears as the argument of the predicate q, in order to bring it within the lf scope of any quantifiers that may eventually determine its specification. Unlike some other theories that treat indefinites as ambiguous between referential and existential readings, the present theory assumes that non-universals are *always* Skolem terms, and never quantificational.

In this schema, the underspecified Skolem term $skolem'p$ names the function identified earlier from properties p to entities of type e with that property, such that those entities are functionally related to any intensional operators or universal quantifiers that have scope over them at the level of logical form, as represented in the environment. If the term $skolem'p$ when specified is not in the extent of any universal quantifier—that is, if the environment is empty—then it yields a unique individual-denoting constant. Such constants "have scope everywhere," and therefore give the appearance of wide scope quantification, without benefit of covert movement or existential quantification at the level of logical form.

This ensures that for both the left-branching derivation exemplified in (72) and the right-branching ones like (73), we get both "wide" and "narrow scope" readings for existentials. For example, the following are the two readings for the former, left-branching, derivation (those for the latter, more standard, right-branching derivation are suggested as an exercise).

(89)

$$
\begin{array}{ccc}
\text{Every farmer} & \text{owns} & \text{some donkey} \\
\hline
S/(S\backslash NP_{3SG}) & (S\backslash NP_{3SG})/NP & S\backslash(S\backslash NP) \\
: \lambda p.\forall y[farmer'y \rightarrow py]^{\{y\}} & \lambda x.\lambda y.own'xy & : \lambda q.q(skolem'donkey') \\
\hline
\multicolumn{2}{c}{S/NP : \lambda x.\forall y[farmer'y \rightarrow own'xy]^{\{y\}} \quad >\mathbf{B}} & \\
\hline
\multicolumn{3}{c}{S : \forall y[farmer'y \rightarrow own'(skolem'donkey')y]^{\{y\}} \quad <} \\
\multicolumn{3}{c}{\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots} \\
\multicolumn{3}{c}{S : \forall y[farmer'y \rightarrow own'sk^{(y)}_{donkey'}y]^{\{y\}}}
\end{array}
$$

(90)
$$\begin{array}{ccc}
\text{Every farmer} & \text{owns} & \text{some donkey}\\
\hline
S/(S\backslash NP_{3SG}) & (S\backslash NP_{3SG})/NP & S\backslash(S\backslash NP)\\
:\lambda p.\forall y[farmer'y \to py]^{\{y\}} & \lambda x.\lambda y.own'xy & :\lambda q.q(skolem'donkey')\\
\cline{1-2}
\multicolumn{2}{c}{S/NP:\lambda x.\forall y[farmer'y \to own'xy]^{\{y\}}} \;{>}\mathbf{B} & \cdots\cdots\cdots\cdots\\
 & & :\lambda q.q(sk_{donkey'})\\
\hline
\multicolumn{3}{c}{S:\forall y[farmer'y \to own'(sk_{donkey'})y]^{\{y\}}} \;{<}
\end{array}$$

In (89), it is important that the logical form for *some* in (88) packs the restrictor inside the generalized Skolem term, rather than predicating it separately as in a standard existential Generalized Quantifier. In (90), the skolem term indefinite is a constant, rather than a function term in the bound variable *y* in its environment.

The fact that Skolem term specification is an anytime operation also means that we get both de dicto and de re readings for both derivations of (33), *Harry wants to marry a Norwegian*.

The fact that the present theory lacks any independent notion of quantifier movement imposes strong restrictions on scope ambiguities of universals with respect to intensional verbs. For example, the following sentence is correctly predicted to lack any meaning paraphrasable by "It seems that every/each woman is approaching":[36]

(91) Every/Each woman seems to be approaching.

7.3 "Intermediate Scope"

Among all the other uncertainties surrounding the data concerning quantifier scope, perhaps the most contentious concerns the possibility of "intermediate" scope readings for sentences with more than two quantifiers, like the following:

(92) Every professor knows that every student read some/a certain book.

Among a number of other readings for (92), it has been claimed to be possible to obtain not only the obvious narrowest-scope reading (where books are dependent on both professors and students), and the obvious widest-scope reading where there is just one book in question, but also an "intermediate" reading of a kind endorsed by Farkas 1981:64 (but rejected by Fodor and Sag 1982), in which the books are wide scope with respect to the students but narrow with respect to the professors.

It would in fact technically be possible to obtain the intermediate reading for this sentence in the present framework, if the process of Skolem specification were allowed to intervene between application of the derivational constituent *ev-*

[36]There is a distracting but irrelevant interpretation under which "every woman" is interpreted as a set entity equivalent to "all of the women," of the kind found in dubious sentences like the following, said of a specific group of women:
(i) #That is every woman.
However, such readings are not available for "each", and do not seem to be quantificational. I am grateful to Gosse Bouma for drawing my attention to examples like (91).

ery student read and the object *some book*, and beta-normalization of the resulting formula, as in the following derivation.[37]

(93)
$$\begin{array}{ccc}
\text{Every professor knows that} & \text{every student read} & \text{some book} \\
\hline
S/_{\diamond}S & S/NP & S\backslash(S/NP) \\
:\lambda s.\forall x[professor'x \rightarrow knows'sx]^{\{x\}} & :\lambda z.\forall y[student'y \rightarrow own'zy]^{\{y\}} & :\lambda p.p(skolem'book') \\
\cline{2-3}
 & \multicolumn{2}{c}{S : (\lambda p.p(skolem'book'))(\lambda z.\forall y[student'y \rightarrow own'zy]^{\{y\}})\ )} \quad < \\
\hline
S : \forall x[professor'x \rightarrow knows'(& (\lambda p.p(skolem'book')) & (\lambda z.\forall y[student'y \rightarrow own'zy]^{\{y\}})\ )x]^{\{x\}} \quad > \\
\cdots & \cdots\cdots\cdots\cdots\cdots\cdots & \cdots \\
S : \forall x[professor'x \rightarrow knows'(& (\lambda p.p\ sk_{book'}^{(x)} & (\lambda z.\forall y[student'y \rightarrow own'zy]^{\{y\}}))\ )x]^{\{x\}} \\
\hline
\multicolumn{3}{c}{S : \forall x[professor'x \rightarrow knows'(\forall y[student'y \rightarrow own'sk_{book'}^{(x)}y]^{\{y\}})x]^{\{x\}}} \quad \beta
\end{array}$$

Such a strategem would also allow an intermediate reading for the universally quantified double-object construction, in sentences like the following.

(94) Some teacher showed every pupil every movie.

Besides the obvious ∃∀∀ and ∀∀∃ readings, and a further possibility for specifying *some teacher* when *every pupil* has combined but not *every movie*, yielding a reading in which teachers are dependent upon (are outscoped by) pupils, but are independent of (outscope) movies, a fourth reading parallel to (93) in which a possibly different teacher shows each movie to the whole class, would arise from the possibility of delaying β-normalization of the formula,

Rather surprisingly, this rather alarming strategem appears not to compromise other constraints on scope-taking, such as those involved in the Geach sentence (10), and in fact I succumbed to its temptations in some circulated drafts of the present paper. Such an explanation of intermediate scopes in terms of anytime Skolem specification would be very similar to the explanation in terms of free existential closure of choice functions in Winter 1997—see Chierchia (2001) for discussion.

However, the close linkage of possibilities for Skolem specification to the CCG derivation means that there are many other cases for which very similar intermediate readings have been claimed where CCG fails to predict them—for example, (95a), discussed by Abusch (1994), or the simpler version (95b) discussed by Chierchia (2001):

(95) a. Every linguist studied every solution to some problem she considered.
b. Every student studied every paper by some author.

There is no derivation in which an unspecified $skolem'(\lambda z.problem'z \wedge consider'z\ she')$ can come within the scope of "every linguist" without first coming into the scope of "every problem". Thus, according to the present theory, the claimed intermediate reading (96) must arise from "irrelevant construal" of the narrowest scope reading, plus some worldly inference of the kind proposed for these examples by Schwarzschild (2002) and Kratzer (2003) to the effect that only

[37]The ⋄ modalities are necessary to limit freedom of word order, and replace category-based restrictions on composition rules in *SP*.

one problem/author per linguist/student need be considered, despite Chierchia's claim to the contrary:

(96) $\forall x[linguist'x \rightarrow \forall y[solution'y \wedge to'sk^{(x,y)}_{\lambda z.problem'z \wedge consider'z\ (pro'x)}y]]$

Such processes also offer an alternative explanation for the apparent availability to some judges of intermediate readings in (93) and (94), without interleaving β-normalization and Skolem specification.

The same possibility of worldly inference may also explain the possibility of an "intermediate" reading for the following in which every woman in question wants to marry a possibly different *de re* Norwegian:[38]

(97) Every woman wants to marry a Norwegian.

7.4 Bound-Variable Pronouns

We will here further assume that a pronoun translation it' that has been brought by the derivation into an environment $\mathcal{E}$ is obligatorily bound to a variable in it via the following rule similar to (86):[39]

(98) *Bound-variable Pronoun Specification* of a term such as him', her' or it' in an environment $\mathcal{E}$ yields a pro-term of the form $pro'x$, where $x \in \mathcal{E}$.

Bound-variable pronoun specification, like Skolem specification, is an anytime operation. Logical forms are subject to the standard binding conditions, characterized in CCG terms in *SS&I*. (Hence, a bound variable pronoun reading is ruled out for (24) under Condition B.)

However, if a pronoun occurs inside the restrictor property of a Generalized Skolem term, as in (100) and (101), then it seems as though it has to be bound at the same time as Skolem specification, under the following condition:

(99) *Forced pronoun binding*: Skolem specification of a term $skolem'p$ forces pronoun reference resolution for any pronoun in the restrictor property p.

Thus, if Skolem specification is left until after the derivation is complete, we get the bound reading (100b) for (100a):

(100) a. Every man$_i$ loves a woman who loves him$_i$

b. $\forall x[man'x \rightarrow love'(sk^{(x)}_{\lambda y.woman'y \wedge love'(pro'x)y})x]$

Similarly, (101a) yields (101b):

[38] Such inference may also explain Geach's observation that finer distinctions are needed on the de dicto/de re dimension.

[39] We ignore details of number, gender, and case for present purposes. This rule will be important for the correct analysis of the interaction of coordination and bound-variable pronoun anaphora discussed in connection with example (191) in section 11.

(101) a. Every farmer who owns a donkey that she likes feeds it.

b. $\forall x[(farmer'x \wedge own'sk^{(x)}_{\lambda y.(donkey'y \wedge like'y(pro'x))}x)$
$\rightarrow feed'(pro'sk^{(x)}_{\lambda y.(donkey'y \wedge like'y(pro'x))})x]$

A pronoun can of course (by a process that we continue not to attempt to specify) also receive a reading discourse-anaphoric to a globally available referent, before it is brought into the scope of a quantifier, as it must in that example and in the following "wide-scope woman" reading for (100), triggered by early Skolem specification under the condition above, and meaning that every man loves the same woman, who also loves the contextually available referent Monboddo:

(102) c. $\forall x[man'x \rightarrow love'(sk_{\lambda y.woman'y \wedge love'(pro'monboddo')y})x]$

However, condition (99) excludes readings like the following for (100), where the Skolem term is specified early as a Skolem constant, but the pronoun is bound after it has come into the scope of the quantifier, meaning that every man loves the same woman, who loves all of them.

(103) c. *$\forall x[man'x \rightarrow love'(sk_{\lambda y.woman'y \wedge love'(pro'x)y})x]$

Such readings arise under Winter's 1997 and Kratzer's 1998 related Choice-functional/ Skolem-functional accounts, and are tolerated by Winter (2001:115-8). Geurts (2000) argues that such readings must be excluded (although his stronger conclusion that movement is the only way to do this does not follow under the present account).

The fact that reading (103) is excluded by condition (99) means that the earlier example (95a) from Abusch via Chierchia, repeated here, cannot acquire an "intermediate-scope" reading in which it is required that for every professor there is a possibly different book such that that professor rewarded every student who read that book:

(104) Every linguist studied every solution to some/a certain problem that she considered.

Even if we could obtain the intermediate reading for the simpler (95b), the bound variable reading would require skolem specification of the translation of "some problem she considered" before combination with "every solution". Any such specification would force pronoun anaphora resolution and prevent "she" from being a bound variable pronoun bound by "every linguist", just as it prevents (103). Such readings are therefore excluded under the present theory,

7.5 Donkeys Revisited

The derivation of (21) is similar to (89):[40]

[40]Unsurprisingly, there is a second derivation where *a donkey* is syntactically raised over *who owns*, $(N\backslash N)/NP$, another instance of schema (88).

(105)

Every	farmer	who	owns	a donkey	feeds it
$(S/(S\backslash NP_{3SG})/_{\diamond}N_{3SG}$	N_{3SG}	$(N_{agr}\backslash_{\diamond}N_{agr})/_{\diamond}(S\backslash NP_{agr})$	$(S\backslash NP_{3SG})/NP$	$(S\backslash NP)\backslash((S\backslash NP)/NP)$	$S\backslash NP_{3SG}$
$: \lambda n\lambda p.\forall x[nx \rightarrow px]^{\{x\}}$	$: farmer'$	$: \lambda q\lambda n\lambda y.ny \wedge qy$	$: \lambda x\lambda y.own'xy$	$: \lambda p.p(skolem'donkey')$	$: \lambda y.feed'it'y$

$$\text{owns a donkey} \;{<}\;: \quad S\backslash NP_{3SG} : \lambda y.own'(skolem'donkey')y$$

$$\text{who owns a donkey} \;{>}\;: \quad N_{3SG}\backslash N_{3SG} : \lambda n\lambda y.ny \wedge own'(skolem'donkey')y$$

$$\text{farmer who owns a donkey} \;{<}\;: \quad N_{3SG} : \lambda y.farmer'y \wedge own'(skolem'donkey')y$$

$$\text{Every farmer who owns a donkey} \;{>}\;: \quad S/(S\backslash NP_{3SG}) : \lambda p.\forall x[farmer'x \wedge own'(skolem'donkey')x \rightarrow px]^{\{x\}}$$

$${>}\;: \quad S : \forall x[farmer'x \wedge own'(skolem'donkey')x \rightarrow feed'it'x]^{\{x\}}$$

$$\cdots\cdots\quad S : \forall x[farmer'x \wedge own'sk^{(x)}_{donkey'}x \rightarrow feed'it'x]^{\{x\}}$$

$$\cdots\cdots\quad S : \forall x[farmer'x \wedge own'sk^{(x)}_{donkey'}x \rightarrow feed'(pro'sk^{(x)}_{donkey'})x]^{\{x\}}$$

(In the last step, the pronoun is bound by rule (98), forced under condition (99).)

In every case, the generalized quantifier determiner categories give the universal quantifier scope over the main predicate q. They therefore have the effect of a restricted form of "covert movement" of the quantifier itself to the "Spec of CP" position. However, in present terms, such "movement" is not syntactic, but lexically defined at the level of logical form. Syntactic derivation merely projects the scope relation defined in the lexicon, and the restrictions on scope to be discussed below follow as predictions from the syntactic combinatorics.

The quantifier determiner *no* is often categorized as a universal, suggesting the category $NP^{\uparrow}/N : \lambda p\lambda q\lambda \ldots \forall x[px \rightarrow \neg qx \ldots]^{\{x\}}$. However, in most linguistic respects, including number agreement, *no* behaves like the non-universals. (In particular, we shall see in section 9.1 that it shares the property of not inverting scope over c-commanding indefinites.) Accordingly, it receives the following determiner category here:[41]

(106) no $:= (S_{-}/(S\backslash NP_{agr}))/_{\diamond}N_{agr} : \lambda p\lambda q.\neg q(skolem'p)$

This category also assumes that both ordinary negation and NPs like *no farmer* mark sentences that result from their combination syntactically as bearing negative polarity S_{-}.

This category yields the following reading for the sentence *No farmer owns a donkey*:

(107)

No farmer	owns	a donkey
$S_{-}/(S\backslash NP_{3SG})$	$(S\backslash NP_{3SG})/NP$	$S\backslash(S\backslash NP)$
$: \lambda p.\neg p(skolem'farmer')$	$\lambda x.\lambda y.own'xy$	$: \lambda q.q(skolem'donkey')$

$$\text{No farmer owns} \;{>}\mathbf{B}\;: \quad S_{-}/NP : \lambda x.\neg own'x(skolem'farmer')$$

$${<}\;: \quad S_{-} : \neg own'(skolem'donkey')(skolem'farmer')$$

$$\cdots\cdots\quad S_{-} : \neg own'sk_{donkey'}sk_{farmer'}$$

[41] In earlier circulated drafts of this paper, *no* was treated as a universal $\forall\neg$. Such a treatment remains entirely compatible with the model theory in section 4, and would in fact immediately exclude examples like (31a). However, it fails to explain why *no* fails to invert scope like other universals, as discussed in section 9.1.

According to the model theory in section 4, this sentence is true in models where there are no farmer-donkey pairs in the ownership relation—that is, it is the reading which is paraphrasable as “No farmer owns any donkey”.

The theory further predicts that this sentence lacks any “wide-scope donkey” reading, according to which there is some donkey that no farmer owns

To allow the paraphrase with negative-polarity *any*, we need a category for *any* specified for negative polarity, as follows, where $NP^{\uparrow}_{-,3SG}$ schematizes over raised categories such as $S_{-}\backslash(S_{-}/NP_{3SG})$:

(108) any:= $NP^{\uparrow}_{-,3SG}/_{\diamond}N_{3SG} : \lambda p\lambda q.q(skolem'p)$

We have assumed via the category (106) that NPs like *no farmer* mark sentences that result from their combination syntactically as bearing negative polarity S_{-} The exact details of polarity agreement are somewhat technical, and we pass over them in the present paper, referring the interested reader to the categorial accounts of Dowty (1994), Bernardi (2002) and Szabolcsi (2004).

The derivation of the negative donkey sentence (50) then goes as follows:[42]

(109)
$$
\begin{array}{ccc}
\text{No} & \text{farmer who owns a donkey} & \text{beats it} \\
\hline
(S_{-}/(S\backslash NP_{agr}))/N_{agr} & N_{3SG} & S\backslash NP_{3SG} \\
: \lambda n\lambda p.\neg p(skolem'n) & : \lambda y.farmer'y \wedge own'(skolem'donkey')y & : \lambda y.beat'it'y \\
\hline
\multicolumn{2}{c}{S_{-}/(S\backslash NP_{3SG}) : \lambda p.\neg p(skolem'(\lambda y.farmer'y \wedge own'(skolem'donkey')y))} \; > & \\
\hline
\multicolumn{3}{c}{S_{-} : \neg beat'it'(skolem'(\lambda y.farmer'y \wedge own'(skolem'donkey')y))} \; < \\
\multicolumn{3}{c}{\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots} \\
\multicolumn{3}{c}{S_{-} : \neg beat'it'(skolem'(\lambda y.farmer'y \wedge own'sk_{donkey'}y))} \\
\multicolumn{3}{c}{\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots} \\
\multicolumn{3}{c}{S_{-} : \neg beat'(pro'sk_{donkey'})(skolem'(\lambda y.farmer'y \wedge own'sk_{donkey'}y))} \\
\multicolumn{3}{c}{\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots} \\
\multicolumn{3}{c}{S_{-} : \neg beat'(pro'sk_{donkey'})sk_{(\lambda y.farmer'y \wedge own'sk_{donkey'}y)}}
\end{array}
$$

The formula that it yields is true according to the semantics of negation given in section 4 just in case there is no farmer-donkey ownership pair such that the farmer beats the donkey.

Heim and Kratzer (1998) have claimed a second, “specific indefinite,” reading for sentences like (109), parallel to that discussed for (107), and arising from the category (108), according to which there is a certain donkey such that no farmer who owns it beats it, but where there may be other donkeys some of whose farmer-owners beat them. Their actual example is the following:

(110) No student from a/some foreign country was admitted.

Many judges seem in doubt whether specific indefinite readings are in fact available for (109) and (110), and the present theory does not currently account for

[42]Example (31b), from Lappin (1990), repeated as (i)a below, which would otherwise have a derivation similar to (109), is anomalous because of dynamic constraints on pronominal anaphora that we continue not to account for in the semantics.

(i) a. #Every farmer who owns no donkey feeds it.

b. $\forall x[(farmer'x \wedge \neg own'sk^{(x)}_{donkey'}x) \rightarrow feed'(pro'sk^{(x)}_{donkey'})x]$

them.

7.6 An Aside on Leaking Scope

We have assumed above that Skolem term specification precedes DRT-based unbound pronominal anaphora resolution, a process whose precise nature the present paper does not address. However, if that assumption is relaxed, all of the above derivations potentially have alternatives in which the relevant antecedents are *un*specified Skolem terms. For example, the donkey sentence (21) initially could yield the following representation:

(111) $\forall x[(\mathit{farmer}'x \wedge \mathit{own}'(\mathit{skolem}'\mathit{donkey}')x \rightarrow \mathit{feed}'\mathit{it}'x]$

As an alternative to first specifying the skolem donkey then binding the pronoun to the result as in (28), the pronoun in (111) can be bound first, to the unspecified skolem term $\mathit{skolem}'\mathit{donkey}'$, to yield the following:

(112) $\forall x[(\mathit{farmer}'x \wedge \mathit{own}'(\mathit{skolem}'\mathit{donkey}')x \rightarrow \mathit{feed}'(\mathit{pro}'(\mathit{skolem}'\mathit{donkey}'))x]$

Whenever the two unspecified Skolem donkeys are specified, they must by rule (86) become the same generalized Skolem term $\mathit{sk}^{(x)}_{\mathit{donkey}'}$, since both are in the environment $\{x\}$ of the universal quantifier, so this path again yields the formula in (28).

However, if the pronoun and the antecedent are in *different* environments, then the logical form that results from specifying the Skolem term after pronominal anaphora has been resolved will not be the same as that obtained by the other route. While a pronoun outside the scope of the universal quantifier binding x cannot refer to $\mathit{sk}^{(x)}_{\mathit{donkey}'}x$, it can refer to the unspecified term $\mathit{skolem}'\mathit{donkey}'$. While such a term cannot literally be bound by the quantifier, it still bears the donkey property. I assume that is what allows the scope of univerals to "leak" in sentences like (56), discussed in section 7.6, repeated here:

(113) Every farmer who owns a donkey$_i$ feeds it$_i$. The local priest feeds it$_?$, too

To the extent that such pronouns can be understood as referring to the donkeys in the first clause, it seems to be by specification of $\mathit{pro}'(\mathit{skolem}'\mathit{donkey}')$ to yield a proterm in a Skolem constant which we might paraphrase as "the donkey in question," whose interpretation is only inferentially dependent on the universal, in much the same sense that "the local priest" is. Of course, this will allow rather general appearance of anomalous scope. The fact that scopes leak in this way (which Roberts 1987 calls "telescoping") is well-known, and should not be confused with true bound anaphora.[43]

[43]It seems possible that the same mechanism may underlie the "sloppy" anaphora illustrated in (55). However, we leave this possibility for future research, like all questions of pronominal anaphora.

8 UNIVERSAL QUANTIFIERS

8.1 How True Universal Quantifiers Invert Scope

Because certain universals, by contrast with the existentials, are genuine quantifiers, they and they alone can truly invert scope in both right- and left-branching derivations. For example, *every* can invert as follows (once again the left-branching inverting reading and the non-inverting readings for both derivations are suggested as an exercise):[44]

(114)

$$\begin{array}{ccc}
\text{Some farmer} & \text{owns} & \text{every donkey} \\
\hline
S/(S\backslash NP_{3SG}) & (S\backslash NP_{3SG})/NP & (S\backslash NP)\backslash((S\backslash NP)/NP) \\
:\lambda p.p(skolem'farmer') & :\lambda x\lambda y.own'xy & :\lambda q.\forall x[donkey'x \rightarrow qx]^{\{x\}} \\
\cline{2-3}
 & \multicolumn{2}{c}{S\backslash NP_{3SG} : \lambda y.\forall x[donkey'x \rightarrow own'xy]^{\{x\}} \quad <} \\
\hline
\multicolumn{3}{c}{S : \forall x[donkey'x \rightarrow own'x(skolem'farmer')]^{\{x\}} \quad >} \\
\multicolumn{3}{c}{\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots} \\
\multicolumn{3}{c}{S : \forall x[donkey'x \rightarrow own'x\, sk^{(x)}_{farmer'}]^{\{x\}}}
\end{array}$$

Similar derivations allow the universals *every* and *each* to invert over most non-universals, such as *(at least/exactly/at most) two* and *several, many, most*. The exceptions to this pattern include *few* and *no*, which seem not to permit inversion:

(115) a. Few farmers own every donkey. ($few\forall/\#\forall few$)
b. No farmer owns every donkey. ($no\forall/\#\forall no$)

These exceptions seem to be related to the negation implicit in these determiners, and the general reluctance of the universals to scope over negation noted by Beghelli and Stowell (1997), who point out (1997: 95-97) that the following are all anomalous with $\forall\neg$ scope readings:[45]

(116) a. ?Every boy didn't leave.
b. ?Each boy didn't leave

(117) a. ?John didn't read every book
b. ?John didn't read each book

We might also note the anomaly of inverted readings:

(118) a. ?Some linguist hasn't heard of every language.
b. ?Some linguist hasn't heard of each language

---

[44]The present notation differs slightly from that in *SP*, where terms like $sk^{(x)}_{donkey'}$ are written as explicit skolem terms such as $sk_{donkey'}x$. Such terms must be distinguished from anaphors of the form $ana'x$ for purposes of the binding theory, since a skolem term $sk^{(x)}_{p}$ may command x at the level of logical form in an inverted scope, as in example (114). See sections 10 and 10.3 for further discussion of this important point.

[45]Beghelli and Stowell are careful to restrict their examples to "neutral, non-focused intonation", and attribute the general inattention to the anomaly to confusion with the focused versions. In fact the focused versions seem to introduce metalinguistic or semiquotational negation, of a kind that is expressly excluded from consideration here.

We will continue to assume that some version of the syntactic polarity marking accounts developed within other CG frameworks by Dowty (1994), Bernardi (2002), and Szabolcsi (2004) (which are close in spirit to the functional-projection -based account of Beghelli and Stowell themselves) can account for these finer details.

8.2 An Aside on "Frozen Scope"

Aoun et al. (1989), Larson (1990) and Bruening (2001) point out that while universals can bind or take scope over indefinite subjects, as in (114) and (119a) or objects, as in (119b), they do not seem to able to bind a dative or indirect object in the double object construction (119c)—a phenomenon referred to as "Frozen Scope".

(119) a. An editor showed me every article. *(inverting)*
b. The editor showed an article to every reviewer. *(inverting)*
c. The editor showed a reviewer every article. *(non-inverting)*

No such effect is predicted by the present account. However, it only seems to hold for the indefinite article: the following all seem to have inverting readings (cf. Bresnan and Nikitina 2003):

(120) a. The editor showed some reviewer every article. *(inverting)*
b. The editor showed exactly one reviewer every article. *(inverting)*
c. The editor showed at least three reviewers every article. *(inverting)*

This seems to be to do with the fact that the other determiners can attract focal intonation—in fact, such intonation on the indefinite article also seems to make (119c) invert. The missing reading seems therefore to arise from the default information-structural properties of indefinites, rather than intrinsic properties of dative objects *per se* or the scope-inverting properties of universals.

8.3 Asymmetric Scope in English Embedded Subject Universals

Cooper (1983), Williams (1986), Beghelli, Ben-Shalom and Szabolcsi (1997, p.29), and Farkas (2001) point out, sentences like the following seem to lack readings where *every farmer* takes scope over *somebody*.

(121) [Somebody knows (that)]$_{S/_{\diamond}S}$ [every farmer]$_{S/(S\backslash NP)}$ [owns some donkey]$_{S\backslash NP}$.

$\neq \forall x[farmer'x \rightarrow know'(own'sk_{donkey'}x)sk^{(x)}_{person'}]^{\{x\}}$

$\neq \forall x[farmer'x \rightarrow know'(own'sk^{(x)}_{donkey'}x)sk^{(x)}_{person'}]^{\{x\}}$

This three-quantifier sentence has only two readings, with narrow and wide scope donkeys.

The reason that *every farmer* cannot scope over the matrix subject in (121) is simply that *Somebody knows (that)* is not a function over NP, so the type-raised

NP *every farmer* cannot combine with it in advance of combining with the VP *owns some donkey*.

This is one place in the language where scoping possibilities do not exactly mirror extraction possibilities. Although subject extraction is in general disallowed, as in (122a), the subjects of bare complements to verbs like *say* can extract, as in (122b), although we have seen in (121) that they still cannot scope out:

(122) a. *A farmer who they say that owns a donkey
b. A farmer who they say owns a donkey

The origin of this constraint (which is predicted in CCG), and the mechanism by which bare complement verbs escape it is discussed at some length in *SS&I*:53-62. While both the constraint and the fact that English embedded universally quantified subjects cannot extract are related to the fact that English subjects are *leftward* arguments of the verb, they are otherwise unrelated, and the mechanism that allows (122b) offers no possibility for a lexically realized subject to scope out.

The fact that the constraint on scoping out applies to leftward arguments of the embedded verb means that this constraint is even more widespread in fixed-order SOV languages like Dutch and German, as discussed next.

8.4 Asymmetric Scope in German and Dutch

To the extent that the availability of wide scope readings for the true quantifiers depends upon syntactic derivability in this direct way, we may expect to find interactions of phenomena like scope inversion with word-order variation across languages. In particular, the failure of English complement subjects to take scope over their matrix is predicted to generalize to a wider but orthogonal class of embedded arguments in verb-final complements in languages like German and Dutch.

Bayer (1990, 1996), claims that, while both German and English allow scope alternations in sentences like (123a), german examples like (123b) do not, unlike their English counterparts (Bayer 1996, 177-179; cf. Kayne (1998),):

(123) a. (Weil) irgendjemand auf jeden [gespannt ist]$_{(S\backslash NP)\backslash PP}$ *(ambiguous)*
(Since) someone on everybody curious is
"Since someone is curious about everybody."

b. (Weil) irgendjemand [gespannt]]$_{VP/PP}$ auf jeden [ist]]$_{(S\backslash NP)\backslash VP}$ *(unambiguous)*
(Since) someone curious on everybody is
"Since someone is curious about everybody."

Just such an asymmetry is predicted by the present theory. In (123a), *gespannt ist* can form the category $(S\backslash NP)\backslash PP$ by composition, so that the type-raised quantifier PP *auf jeden* can then combine with the whole thing to take scope over the entire tensed clause. The subject *irgendjemand* can then combine and subsequently be specified, to yield the scope-inverted narrow scope reading, or may be specified before reducing, to yield a constant with the appearance of wide scope. By contrast, in (123b), *ist* cannot combine with *gespannt* until the latter has first combined with the intervening generalized quantifier *auf jeden*. The quantifier therefore cannot take wide scope with respect to tense, and hence cannot take inverse scope over *irgendjemand*, for reasons similar to those that limit the earlier English example (121): the only reading is the one with wide-scope *irgendjemand*.

For similar reasons, negation in *kein fenster* in (124a) (from Bayer and Kornfilt 1990) must take narrow scope with respect to *vergessen*, while in (124b), it must be wide:

(124) a. Maria hat [vergessen] kein Fenster [zu schließen].
Maria has forgotten no window to close.
"Maria has forgotten to close no window."

b. Maria hat kein Fenster [vergessen zu schließen].
Maria has no window forgotten to close.
"Maria has forgotten to close no window."

In further support of Bayer's claim, Haegeman and van Riemsdijk 1986, p.444-445, and Haegeman 1992, p.202, cite a number of related effects of "Verb Projection Raising" on scope in West Flemish Dutch and Zurich German subordinate clauses (see Koster 1986, pp.286-288 and *SP* pp.165-166 for discussion).

The latter reference shows that the "equi" verbs that allow related word order alternations in standard Dutch limit scope inversion similarly to Bayer's (123b), making (125b) unambiguous in comparison to (125a):

(125) a. (omdat) iemand iedere lied [probeert te zingen] *(ambiguous)*
(because) someone every song [tries to sing]

b. (omdat) iemand [probeert] iedere lied [te zingen] *(unambiguous)*
(because) someone [tries] every song [to sing]

"because someone tries to sing every song" *(ambiguous)*

For exactly the same reason, we also predict the similar failure to alternate scope in the corresponding Dutch main clause:

(126) Iemand [probeert] iedere lied [te zingen] *(unambiguous)*
Someone [tries] every song [to sing]
"Someone tries to sing every song." *(ambiguous)*

We similarly predict a failure of quantifiers in embedded sentential objects (as well as subjects) to alternate scope with the root subject in German and Dutch, in contrast to the corresponding English examples:

(127) a. Iemand [denkt dat] Marie iedere lied [zingt] *(unambiguous)*
Someone [thinks that] Mary every song [sings]
"Someone thinks that Mary sings every song" *(ambiguous)*
b. Irgendjemand [denkt daß Marie] jeden [liebt] *(unambiguous)*
Someone [thinks that Mary] everyone [loves]
"Someone thinks that Mary loves everyone" *(ambiguous)*

We also predict that, for reasons discussed in connection with example (91), not only universally quantified subjects but embedded universally quantified objects fail to alternate scope with intensional verbs in Dutch sentences like the following:[46]

(128) dat Jan iedere boek van Vestdijk wil lezen
that Jan every book by Vestdijk wants read
"That Jan wants to read every book by Vestdijk."

It is important to notice that all of the above German/Dutch examples involve intensional verbs/predicates, involving relations of control at logical form. It might seem that we must predict a similar asymmetry between Dutch/German main and subordinate clauses involving simple auxiliary verbs, since in main clauses the V2 condition ensures that the object must combine with the main verb in advance of the tensed verb:

(129) a. Iemand [heeft] iedere lied [gezongen]
Someone [has] every song [sung]
"Someone sang every song."

b. omdat iemand iedere lied [heeft gezongen]
because someone every song [has sung]
"Someone sang every song."

However, on the reasonable assumption that Dutch/German auxiliaries are, like the corresponding English words, raising verbs, these sentences are predicted to have identical logical forms, and to both allow both readings. For example, if we assume, uncontroversially, as in *SP*, that the German/Dutch main clause is VSO and that V2 order arises from the same process as relativization, then the main clause derivation begins as follows:

(130)
$$\begin{array}{cccc}
\text{Iemand} & \text{heeft} & \text{iedere lied} & \text{gezongen} \\
\hline
(S'/VP_{PTP})/((S/VP_{PTP})/NP) & (S/VP_{PTP})/NP & VP_{PTP}/(VP_{PTP}\backslash NP) & VP_{PTP}\backslash NP \\
: skolem'person' & : \lambda y\lambda p.past'(py) & : \lambda q\lambda y.\forall x[song'x \rightarrow qxy] & : \lambda x\lambda y.sing'xy \\
\hline
\multicolumn{2}{c}{S'/VP_{PTP} : \lambda p.p(skolem'person') \;>} & \multicolumn{2}{c}{VP_{PTP} : \lambda y.\forall x[song'x \rightarrow sing'xy] \;>}
\end{array}$$

[46] I am grateful to Gosse Bouma for discussions on a related example. Again one must avoid distraction by the possibility of a non-quantificational reading of the object, of the kind found in sentences like the following, uttered when looking at a pile of books:
(i) Dat is eidere boek van Vestdijk.

At this point, Skolem term specification can occur either before any further reduction, to give wide-scope *Someone* as in (131a), or after as in (131b).

(131) a. $S' : \forall x[song'x \rightarrow sing'x\ sk_{person'}]$

b. $S' : \forall x[song'x \rightarrow sing'x\ sk^{(x)}_{person'}]^{\{x\}}$

In the latter case the generalized Skolem term is bound by the universal, and yields a bound reading. The reader can easily assure themselves that the same will happen for the subordinate clause. Thus, both versions are predicted carry both readings, as in the corresponding English sentences.

It is actually quite hard to establish what the true facts of the matter are. It is difficult to elicit consistent judgments from native speakers, because readings are fugitive and sensitive to the presence of intonational focus. Indeed, Frey (1993) offers a counter-claim, suggesting that there is no true covert quantifier movement in German, and that any apparent alternation effects arise from orthogonal effects of focus. It is worth pausing for a moment to assess the nature of Frey's claim in the light of related work by Krifka (1998).

Frey was concerned to exclude as far as possible the effects of focus and information structure. He therefore based his claims on minimal pairs like the following, in which nuclear stress falls on the tensed verb (see Krifka 1998, 77; cf. Sauerland (2001)):

(132) a.

Mindenstens ein Student	HAT	jeden Roman	gelesen.
At least one student	HAS	every-ACC novel	read

"At least one student HAS read every novel"

b.

Jeden Roman	HAT	mindenstens ein Student	gelesen
Every-ACC novel	HAS	at least one student	read

"At least one student HAS read every novel"

Similar effects are obtained with stress on the complementizer in subordinate clauses:

(133) a.

WEIL	mindenstens ein Student	jeden Roman	gelesen	hat
BECAUSE	at least one student	every-ACC novel	read	has

"because at least one student read every novel"

b.

WEIL	jeden Roman	mindenstens ein Student	gelesen	hat
BECAUSE	every-ACC novel	at least one student	read	has

"because at least one student read every novel"

Frey's claim is that (132a) and (133a) are unambiguous and have only the wide-scope student reading. It is only when the object is scrambled to clause-initial position in (132b) and (133b) that both readings become available. Accordingly he defines a "scope assignment principle" which defines scope possibilities in disjunctive terms of either lf-command or movement. This is not explained by the present theory, which predicts that the former should allow scopes to alternate, for the same reason Bayer's (123a) does.

However, there is more going on in Frey's examples than meets the eye. Suppressing focal accents in the clause does not eliminate information structure. Rather, it imposes one particular information structure. In particular, it seems likely both that the first position in the German clause is a topic or theme position and that the last preverbal argument position in the mittelfeld is the default position for the comment or rheme focus, the intonation in (132a) and (133a) makes *mindenstens ein Student* into a noncontrastive topic–that is, an unmarked or "background" theme in the terminology of Bolinger (1958, 1961) and Steedman (2000a). But if it is an background theme then it is presupposed to be already available and uniquely identifiable in the discourse context. Something that is available and unique cannot also be bound, so a narrow scope reading is unavailable. Of course, if *jeden Roman* is put in the unmarked theme position, as in (132b) and (133b), it is still a true quantifier and can bind or not, and since *mindenstens ein Student* is then in the rheme focus position (albeit unaccented, as in an echo statement) it is free to become bound. But these readings arise as a consequence of the meaning of categories like unaccented theme subjects, rather than of c- or lf-command as such.

Seen in this light, the crucial question about Frey's examples is not whether they allow an inverted reading *with the intonation imposed by Frey*, but rather whether there is *any* intonation that allows inversion. According to Krifka (1998), the Germanic "hat contour," which is well known to induce scope inversion under certain conditions (see Féry 1993 and Büring 1995, 1997) makes both readings available in (132a) and (133a) (Krifka 1998, (16b)):[47]

(134) a. Mindenstens /EIN Student hat \JEden Roman gelesen.
At least ONE student has EVery-ACC novel read.
"At least ONE student read EVERY novel."

The forward slash and uppercasing indicate a rising pitchaccent—realized as L*+H in German and L+H* in English—and the backward slash and uppercasing indicate a falling pitchaccent—realized as H+L* in German and H* in English (Büring 1997; Steedman 2000a; Braun 2005). The former accent is claimed by these authors to mark (the focus or contrastive element of) topic or theme in German, while the latter marks (that of) comment or rheme. A contrastive topic is by definition not background, and this seems to be enough to permit the inverted binding.

It is consistent with these suggestions that in the following, *so mancher*, which is neither accented not in last position in the mittelfeld, does not take wide scope:

[47]This observation leads Krifka (1998, 86) to a movement-based account of focus, which brings the intonationally marked sentences back under the original scope assignment principle of Frey (1993).

(135) a. Mindenstens /EINem Studenten hat so mancher \JEden Roman gelesen.
At least ONE-DAT student has many a person EVery-ACC novel read.
"Many a person has read at least one student every novel."

That is, while *Mindenstens einem studenten* can take either scope with respect to *jeden Roman*, there are no readings for (135) in which the latter outscopes the unaccented *so mancher* (Krifka 1998, 87). But this is a consequence of the information structural interpretation, not merely of syntactic combinatorics, as in the case of certain similar effects for scope interpretation in Czech discussed by Hajičová, Partee and Sgall (1998).

8.5 How Universals Invert Scope Out of NP Modifiers

Examples like the following (from May 1985, via Heim and Kratzer 1998) show universals inverting scope over a matrix indefinite from inside that indefinite's noun modifier:

(136) Some apple in every barrel was rotten.

Such sentence are puzzling for any theory of grammar, since relativization out of NPs, and in particular out of subjects, is usually regarded as unacceptable, although opinions differ as to what degree:

(137) a. #The barrel that some apple in is rotten
b. #Which barrel is some apple in rotten?
c. #Every barrel, some apple in is rotten!
d. #Some apple in, and some cover on, every barrel is rotten.

As May pointed out (1985), any movement analysis that allows *every barrel* to directly adjoin to S in the usual quantifier position requires that we provide some other explanation for the anomaly of (137). The same observation applies to the present theory.

May's solution is to only allow movement to adjoin quantifiers to their matrix NP. However, as Heim and Kratzer (1998:230-235) point out, such a tactic complicates the semantics very considerably, requiring a distinct semantics (and in present terms a different category) for *every*. As May himself points out, restricting the scope of the universal also fails to explain how bound variable anaphora from outside the NP can occur:

(138) Someone from every city$_i$ despises it$_i$/#the dump$_i$

To save the NP adjunction theory, May has to propose considerable further complications to the theory of pronominal anaphora.

In the face of these complications it may be sensible to reconsider the status of the Subject Condition.

There is one case where it is usually accepted that extraction out of subjects is allowed, namely when they are "parasitic" extractions. In CCG terms, it is shown in *SS&I* that examples like (139) require the forward substitution combinatory rule (75), and require that substrings like *Every person from* compose to bear the category $NP^{\uparrow}/NP$. According to this analysis, nouns like *person* must bear a type-raised category $N/_{\diamond}(N\backslash_{\diamond}N)$ as well as N.

(139)
$$\begin{array}{ccccccc}
\text{A} & \text{city} & \text{that} & \text{every} & \text{person} & \text{from} & \text{despises} \\
\overline{NP^{\uparrow}/_{\diamond}N} & \overline{N} & \overline{(N\backslash_{\diamond}N)/_{\diamond}(S\backslash NP)} & \overline{(S/(S\backslash NP))/_{\diamond}N} & \overline{N/_{\diamond}(N\backslash_{\diamond}N)} & \overline{(N\backslash_{\diamond}N)/_{\diamond}NP} & \overline{(S\backslash NP)/NP} \\
 & & & \multicolumn{2}{c}{\overline{(S/(S\backslash NP))/_{\diamond}(N\backslash_{\diamond}N)}^{>\mathbf{B}}} & & \\
 & & & \multicolumn{3}{c}{\overline{(S/(S\backslash NP))/_{\diamond}NP}^{>\mathbf{B}}} & \\
 & & & & \multicolumn{3}{c}{\overline{S/NP}^{>\mathbf{S}}} \\
 & & \multicolumn{4}{c}{\overline{N\backslash_{\diamond}N}^{>}} & \\
 & \multicolumn{3}{c}{\overline{N}^{<}} & & & \\
\multicolumn{3}{c}{\overline{NP^{\uparrow}}^{>}} & & & &
\end{array}$$

As *SS&I* points out, the analysis potentially allows examples like those in (137)—for example:

(140)
$$\begin{array}{ccccc}
\#\text{A} & \text{city} & \text{that} & \text{every person from} & \text{despises the government} \\
\overline{NP^{\uparrow}/_{\diamond}N} & \overline{N} & \overline{((N\backslash_{\diamond}N)/_{\diamond}(S\backslash NP))/((S/(S\backslash NP))/NP)} & \overline{(S/(S\backslash NP))/_{\diamond}NP} & \overline{S\backslash NP} \\
 & & \multicolumn{2}{c}{\overline{(N\backslash_{\diamond}N)/_{\diamond}(S\backslash NP)}^{>}} & \\
 & & \multicolumn{3}{c}{\overline{N\backslash_{\diamond}N}^{>}} \\
 & \multicolumn{3}{c}{\overline{N}^{<}} & \\
\multicolumn{3}{c}{\overline{NP^{\uparrow}}^{>}} & &
\end{array}$$

What is wrong with the latter seems to be either that it requires an otherwise unmotivated category for the relative pronoun, or that the residue of relativization is not a single constituent or information unit, as it is in the parasitic case (139).

If we accept on the basis of examples like (139) that nouns can bear the category of functions over noun-adjunct PPs, then the facts about inversion of scope out of such complements follow immediately. Two successive compositions allow the assembly of *Some apple in* with type $NP^{\uparrow}/NP$. The generalized quantifier *Every barrel* instantiated as $NP^{\uparrow}\backslash(NP^{\uparrow}/NP)$ can immediately combine with it to give the appropriate generalized quantifier *Some apple in every barrel*, as follows:[48]

[48] This mechanism does not in itself allow the inverted reading of (ia) to bind over stacked modifiers, to yield a reading (ib), as a reviewer points out it appears to be able to:

(i) a. Some student from every department who had failed complained.

b. $\forall x[\mathit{department}'x \rightarrow \mathit{complain}'\mathit{sk}^{(x)}_{\lambda y.\mathit{student}'y \wedge \mathit{fail}'y}]^{\{x\}}$

c. For every department, some student from it complained and had failed.

d. Some student from every department complained who had failed.

e. $\forall x[\mathit{department}'x \rightarrow (\mathit{complain}'\mathit{sk}^{(x)}_{\mathit{student}'} \wedge \mathit{fail}'(\mathit{pro}'\mathit{sk}^{(x)}_{\mathit{student}'}))]^{\{x\}}$

Although the present theory explains how the universal in (ia) gets wide scope, there is no obvious way to make the relative clause part of the restrictor of the generalized Skolem student. However, it seems likely instead that (ia) is only interpretable to the extent that the relative clause is treated as an appositive and ends up equivalent to (ic). This conjecture seems to be supported by the fact that the related explicitly extraposed example (id) carries the same interpretation. The syntax and semantics of appositives and extraposition goes beyond the scope of the present paper, but if they are sentential or

(141)

$$\begin{array}{ccccccc}
\text{Some} & \text{apple} & \text{in} & \text{every} & \text{barrel} & \text{was} & \text{rotten} \\
\hline
(S/(S\backslash NP))/_{\diamond}N & N/_{\diamond}(N\backslash_{\diamond}N) & (N\backslash_{\diamond}N)/_{\diamond}NP & NP^{\uparrow}\backslash(NP^{\uparrow}/NP))/_{\diamond}N & N & (S\backslash NP)/AP & AP \\
:\lambda n\lambda p.p(skolem'n) & :\lambda q.q\ apple' & :\lambda x\lambda n\lambda y.n\ y\wedge in'xy & :\lambda n\lambda p.\forall z[n\ z\rightarrow p\ z]^{\{z\}} & barrel' & \lambda x\lambda p.p\ x & \lambda x.rotten'x
\end{array}$$

$$\xrightarrow{>\mathbf{B}}\quad (S/(S\backslash NP))/_{\diamond}(N\backslash_{\diamond}N) : \lambda q\lambda p.p(skolem'(q(apple')))$$

$$\xrightarrow{>}\quad NP^{\uparrow}\backslash(NP^{\uparrow}/NP) : \lambda p.\forall z[barrel'z\rightarrow p\ z]^{\{z\}}$$

$$\xrightarrow{>}\quad S\backslash NP : \lambda x.rotten'x$$

$$\xrightarrow{>\mathbf{B}}\quad (S/(S\backslash NP))/_{\diamond}NP : \lambda x\lambda p.p(skolem'(\lambda y.apple'y\wedge in'xy))$$

$$\xrightarrow{<}\quad S/(S\backslash NP) : \lambda p.\forall z[barrel'z\rightarrow p(skolem'\lambda x.apple'x\wedge in'zx)]^{\{z\}}$$

$$\xrightarrow{>}\quad S : \forall z[barrel'z\rightarrow rotten'(skolem'\lambda x.apple'x\wedge in'zx)]^{\{z\}}$$

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

$$S : \forall z[barrel'z\rightarrow rotten'sk'^{(z)}_{\lambda x.apple'x\wedge in'zx}]^{\{z\}}$$

The analysis of course also allows a pragmatically anomalous wide scope reading, according to which there is a single Skolem constant rotten apple which is simultaneously in every barrel, since the Skolem term subject can get specified before it combines with anything.[49]

By making the nouns functions over the general noun-adjunct category $N\backslash N$ (rather than more narrowly over PPs) we allow inversion out of NPs to cross *wh*-island boundaries, as in the example in note 3, repeated here:

(142) [The man who builds]$_{(S/(S\backslash NP))/NP}$ [each television set]$_{(S/(S\backslash NP))\backslash((S/(S\backslash NP))/NP)}$ [also repairs it.]$_{S\backslash NP}$

Allowing composition into wh-islands of course means that we must seek other than syntactic explanations for apparent *wh*-island effects like the following:

(143) a. #The place that I like the person who visited us from
b. Some apple which we found in every barrel was rotten. #∀∃/∃∀

However, such a conclusion seems inevitable. It is well-known that right node raising, as in (144a) is not sensitive to islands. It is less often noticed that similar conjoined fragments with similar intonation also seem to licence wh-extraction, as in (144b):[50]

(144) a. JOHNSON likes the person who visited us FROM, and MONBODDO likes the person who gave us a ticket TO, the beautiful island of Capri.
b. The place that JOHNSON likes the person who visited us FROM, and MONBODDO likes the person who gave us a ticket TO

Any overall ban on syntactic composition into relatives (say by stipulating categories like $(N\backslash_{\star}N)/_{\star}(S/NP)$ for relative pronouns in place of (77)) will wrongly exclude (144a,b).

VP modifiers and involve a pronominal anaphor at the level of logical form, which becomes bound to the generalized Skolem term, then the possibility of the alternative reading (ie) is explained.

[49]Heim and Kratzer (1998) relate the availability of this latter reading to the supposed availability of both narrow and wide scope interpretations of *a foreign country* in examples like (110). According to the present account, there is no wide scope reading for (110).

[50]Like many others, Beavers and Sag (2004) overlook this point in their critique of CCG.

The analysis proposed above makes unproblematic the bound anaphora interpretation for (138), *Someone from every city despises it*, since it puts the quantifier into root position.

9 NON-UNIVERSAL (NON-)QUANTIFIERS

The non-quantificational analysis of indefinites immediately explains the fact that most nominals that have been talked of as generalized quantifiers entirely fail to exhibit scope inversion of the kind exhibited for the universal in (114). The data in this area are less clear than one might like, but it is arguable that the only natural quantifiers to alternate scope with any generality are the true universal quantifiers *every*, *each* and their relatives.[51]

9.1 Why Non-Universals ***Don't*** *Invert Scope*

We have already seen that the appearance of a scope inverting reading for examples like (11a) (repeated here), which is often used as an example where neither surface nor inverse scope reading entails the other, can be accounted for as the result of early Skolem specification delivering a constant $sk_{girl'}$ appearing to have "scope everywhere":[52]

(145) Exactly half the boys in my class kissed some girl.

However, such Skolem constant interpretations cannot bind or distribute over the subject, as would be expected if they were true existential generalized quantifiers. For example, the "non-specific" or "non-group-denoting counting" plural quantifiers, including the upward-monotone, downward-monotone, and non-monotone quantifiers (Barwise and Cooper 1981) such as *at least three*, *many*, *exactly five*, *few* and *at most two*, appear not to be able in general to invert or take wide scope over their subjects in examples like the following, which are of a kind discussed by Liu (1990), Stabler (1997), and Beghelli and Stowell (1997):[53]

(146) a. Some linguist can program in few/at most two programming languages.
b. Most linguists speak at least three/many/exactly five languages.
c. Exactly half the boys kissed at most three/many/exactly five girls

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, these sentences lack readings meaning that there are few/at most two programming languages that are known to any linguist, at

[51]We continue to equivocate on the question of whether *most* should be included among the latter.
[52]The source of the narrow scope reading is discussed in section 10.
[53]Of these non-group-denoting quantifiers, the downward monotone ones like (146a) resist inversion the most strongly. The upward monotone and non-monotone quantifiers like (146b) do not yield such firm judgments. It is conceivable that they do have truly quantificational readings, but I will try to argue the stronger position that none of them are truly quantificational.

least three/many/exactly five languages that different majority groups of linguists speak, and three/many/exactly five girls that different sets of boys kissed.

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 nounphrases have the same category as any other but in semantic terms they are set-denoting terms rather than quantifiers, like *some, a few, six* and the like. This in turn means that they cannot engender dependency of the interpretation arising from *some linguist* in (146a). As a result the sentence has a single meaning, to the effect that there is a specific linguist who can program in at most two programming languages.

Since the determiner *no* is a non-universal, its failure to invert scope is no surprise. Thus the following seem to lack inverting readings:

(147) a. Some/any error was found in no program.
b. At least two/as many as two errors were detected in no program.
c. At most two/as few as two errors were detected in no program.

However, the negation operator in the logical form of the determiner *no* (106) behaves like the universal quantifier in that of *every*, correctly predicting two readings for sentence (148), arising from distinct derivations (149) and (150)

(148) They asked us to review no book. $(ask\neg/\neg ask)$

(149)
$$
\begin{array}{ccc}
\text{They asked us} & \text{to review} & \text{no book} \\
\hline
S/VP_{to-inf} & VP_{to-inf}/NP & VP_{to-inf}\backslash(VP_{to-inf}/NP) \\
:\lambda v.ask'(v(ana'us'))us'they' & \lambda x\lambda y.review'xy & :\lambda p\lambda y.\neg p\; sk_{book'}y \\
\hline
 & \multicolumn{2}{c}{VP_{to-inf}:\lambda y.\neg review' sk_{book'}y \quad <} \\
\hline
\multicolumn{3}{c}{S:ask'(\neg review' sk_{book'}(ana'us))us'they' \quad >}
\end{array}
$$

(150)
$$
\begin{array}{cc}
\text{They asked us to review} & \text{no book} \\
\hline
S/NP:\lambda x.ask'(review'x(ana'us'))us'they' & S\backslash(S/NP):\lambda p\neg p\; sk_{book'} \\
\hline
\multicolumn{2}{c}{S:\neg ask'(review' sk_{book'}(ana'us'))us'they' \quad <}
\end{array}
$$

For reasons identical to those for the universal in (121), negation is predicted not to scope out of complement subject position, a fact noted by Gärtner and Błaszczak (2003), as in:

(151) They revealed that no-one had reviewed our book. $(reveal\neg/*\neg reveal)$

10 DISTRIBUTIONAL SCOPE OF PLURALS

We noted connection with example (36) in section 3 that the possibility of downward distribution of the the nonspecific and counting existentials cannot arise from generalized quantifier semantics of the nominals, since they cannot in general invert scope. This section argues that such downward distributivity arises from the verb.

10.1 Distributivity

We will assume that, as well as having the normal translation (152a), many transitive verbs with plural agreement like *read* have a "distributivizing" category like (152b).[54]

(152) a. read := $(S\backslash NP_{PL})/NP : \lambda x\lambda y.read'xy$
b. read := $(S_{DIST}\backslash NP_{PL})/NP : \lambda x\lambda y.\forall w[w \in y \rightarrow read'xw]^{\{w\}}$

Note that we assume here that plurals like *Three boys* translate as set individuals which we can quantify over directly, rather than plural individuals of the kind proposed by Link (1983). In other words, plural generalized Skolem terms are set-valued.

We will assume that categories like (152b) arise by the application of the following lexical rule to standard (non-collective) verbs, where as usual $(S\backslash NP)/\$$ denotes any member of the set of categories including $S\backslash NP$ and any rightward function into $(S\backslash NP)/\$$ (cf. (64)):

(153) $(S_{-COLL}\backslash NP)/\$: \lambda \ldots \lambda y.p \ldots y$
$\Rightarrow_{LEX}\ (S_{DIST}\backslash NP)/\$: \lambda \ldots \lambda y.\forall w[w \in y \rightarrow p \ldots w]^{\{w\}}$

In English, this rule is not morphologically realized, but we must expect other languages to mark the distinction, morphologically or otherwise. Greenlandic Eskimo appears to be an example, in which the transitive form of the sentence *Three boys ate a pizza* with the unmarked form of the verb and an ERG-NOM subject has only the collective reading. To get the distributive reading the antipassive form of the verb and a NOM-INS subject is required (Bittner 1994). Chinese, a language in which distributivity is morphologically marked on the verb, and where such marking is obligatory for distributive readings, is another example (see Aoun and Li 1993). The possible occurrence of verbs in English like *gather* which have only the collective meaning and require set individuals as subject is also predicted, along with that of the following asymmetry, first pointed out by Vendler (1967) and discussed by Beghelli and Stowell (1997) and Farkas (1997c):[55]

(154) a. All/Most (of the)/No participants gathered in the library.
b. #Every participant gathered in the library.

---

[54]In invoking a "subordinated" use of universal quantification, this proposal resembles the treatment of distributive non-quantifiers in Roberts 1991, Kamp and Reyle 1993, p.326-8, and Farkas 1997c.

[55]Similarly, the English floating "A-type" quantifier *each* seems to disambiguate verbs and verbphrases and/or the nounphrases raised over them as the distributive version:

(i) a. Three boys each read a book.
b. Three boys read a book each.
c. ?*A boy read three books each
d. ?*Three boys each gathered in the library.

Under this account, subjects in examples like (36), as well as having a collective reading arising from a set-individual subject undertaking a single act of reading a given book, can optionally distribute over the function that applies to them at the level of logical form, such as $read'(skolem'book)$, to yield not only standard forms like a, below, but also b:[56]

(155) a. $read'sk_{book'}sk_{boy'\ ;\ \lambda s.|s|=3}$

b. $\forall z[z \in sk_{boy'\ ;\ \lambda s.|s|=3} \rightarrow read'sk^{(z)}_{book'}z]^{\{z\}}$

Thus, the subject can distribute over more oblique arguments, as in (156):[57]

(156)

$$
\begin{array}{cccc}
\underline{\text{Three}} & \underline{\text{boys}} & \underline{\text{read}} & \underline{\text{a book}} \\
NP^{\uparrow}_{PL}/_{\diamond}N_{PL} & N_{PL} & (S_{DIST}\backslash NP_{PL})/NP & NP^{\uparrow} \\
:\lambda n\lambda p.p(skolem'n\ ;\ \lambda s.|s|=3)) & :boy' & :\lambda x\lambda y.\forall z[z\in y \rightarrow read'xz]^{\{z\}} & :\lambda p.p(skolem'book') \\
\multicolumn{2}{c}{\overline{NP^{\uparrow}_{PL} : \lambda p.p(skolem'boy'\ ;\ \lambda s.|s|=3))}{>}} & \multicolumn{2}{c}{\overline{S_{DIST}\backslash NP_{PL} : \lambda y : \forall z[z\in y \rightarrow read'(skolem'book')z]^{\{z\}}}{<}} \\
\multicolumn{2}{c}{\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots} & & \\
\multicolumn{2}{c}{NP^{\uparrow}_{PL} : \lambda p.p(sk_{boy'\ ;\ \lambda s.|s|=3}))} & & \\
\multicolumn{4}{c}{\overline{S_{DIST} : \forall z[z\in sk_{boy'\ ;\ \lambda s.|s|=3} \rightarrow read'(skolem'book')z]^{\{z\}}}{>}} \\
\multicolumn{4}{c}{\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots} \\
\multicolumn{4}{c}{S_{DIST} : \forall z[z\in sk_{boy'\ ;\ \lambda s.|s|=3} \rightarrow read'sk^{(z)}_{book'}z]^{\{z\}}}
\end{array}
$$

(The same mechanism allows *exactly half the boys* to distribute over *some girl* in example (145), to yield the "surface scope" reading.)

Since Skolem specification is a free operation, it can apply early in derivations like the above, to give a third reading, in which a plural subject distributes over a Skolem constant object, so that there are distinct acts of different boys reading the same book.

10.2 Counting Quantifiers

The possibility of plural subjects distributing over skolem constant counting plural objects noted in connection with example (156) explains the asymmetry noted by Szabolcsi (1997a) (cf. (12) and (13), and note 4 in section 2.1):

(157) a. Every boy read exactly two books. $(\#2,\forall/\forall,2)$

b. Three boys read exactly two books. $(=2,3/3,=2)$

The model theory of section 4 will rule the relevant reading of (157b) true in a model in which there are just three boys, $\mathfrak{Freeman}$, $\mathfrak{Hardy}$, and $\mathfrak{Willie}$, all of whom read the same two books and no others. The model theory will rule it false in a model where one or more of the three—say, $\mathfrak{Willie}$—read a further book.

The reason for this result (which seems to be linguistically correct) is that for such a boy, under rule 3a, the crucial extension to Skolem terms like

[56] The connective ";" in the Skolem term is needed because cardinality is a property that applies separately to the *maximal* set of boys reading books that has been identified as the referent of the generalized Skolem term, as in the model theory of section 4—see section 3.4.

[57] The relevant subject and object type-raised categories are once again abbreviated as $NP^{\uparrow}$ to save space and reduce typographical clutter.

$sk_{book' \; ; \; \lambda s.|s|=2}$ found in evaluating $answer'(sk_{book' \; ; \; \lambda s.|s|=2})z'$ for $z = \mathfrak{Will}$ by rule 1 will be rejected under rule 1c, because there is a superset of three books that satisfies the atomic formula involving this boy.[58]

There is also of course a standard narrow scope reading, with a dependent set of two possibly different books per boy, and of course there is no inverting reading in which the set of two books distributes over possibly different sets of three boys.

It remains to be explained why universals cannot similarly distribute over a Skolem constant set of books, as in (157a) (cf. (12)). The latter example seems to require the Skolem constant object to be *referential*, that is, a *specific* indefinite, whereas the involvement of an distributive operator in (157b) seems to allow it to be non-referential, a non-specific or arbitrary indefinite. Counting quantifiers appear to be non-referential, as Webber (1978) pointed out. However, it is not clear whether this constraint is syntactic, semantic, or pragmatic in origin.

Winter (2001):108 argues on the basis of conditional examples like the following that counting quantifiers differ from specific indefinites in being sensitive to islands, and hence that they must be quantificational, or what he calls "rigid nominals".

(158) a. If some woman I know gave birth to John, then he has a nice mother.
b. If exactly one woman I know gave birth to John, then he has a nice mother.

Winter points out that (158a) has, and (158b) lacks, a reading implying that there is a specific nice woman I know who might be John's mother, and that the latter has only a pragmatically anomalous narrow-scope reading implicating that people might have more than one birth-mother. However, since singulars are not subject to the maximal participants condition, and plurals *are* subject to it, this presuppositional difference is already predicted, and has nothing to do with islands. Conversely, if counting quantifiers are indeed generalized quantifiers, then their failure to yield wide-scope readings of any kind, including in examples like (157a), which do not involve islands, remains unexplained.

10.3 An Aside on Distributivity and Word Order

Given the verb category in (159b), which along with one other category (159a) for *show* is derived by a similar lexical process to (152b), datives can distribute over more oblique objects, as in (160), but not vice versa:

(159) a. showed := $(S_{DIST}\backslash NP_{PL})/NP)/_{\diamond}NP : \lambda x\lambda y\lambda z.\forall w[w \in z \rightarrow show' yxw]^{\{w\}}$
b. showed := $(S_{DIST}\backslash NP)/NP)/_{\diamond}NP_{PL} : \lambda x\lambda y\lambda z.\forall w[w \in x \rightarrow show' ywz]^{\{w\}}$

[58] I am grateful to Livio Robaldo for drawing this example to my attention. Related examples are discussed in a very different Skolem-based framework by him in Robaldo 2007.

(160)
$$\begin{array}{ccc}
\text{I showed} & \text{three boys} & \text{a movie} \\
\hline
(S_{DIST}/NP)/NP_{PL} & NP^{\uparrow}_{PL} & NP^{\uparrow} \\
: \lambda x \lambda y.\forall w[w \in x \rightarrow show' yw\ me']^{\{w\}} & : \lambda p \lambda x.px(skolem'(boy'\ ;\ \lambda s.|s| = 3)) & : \lambda p.p(skolem' movie') \\
 & \cdots\cdots\cdots\cdots & \\
 & NP^{\uparrow}_{PL} : \lambda p \lambda x.px\ sk_{boy'\ ;\ \lambda s.|s|=3} & \\
\hline
\multicolumn{2}{c}{S_{DIST}/NP : \lambda y : \forall w[w \in sk_{boy'\ ;\ \lambda s.|s|=3} \rightarrow show' yw\ me']^{\{w\}}} <& \\
\hline
\multicolumn{3}{c}{S_{DIST} : \forall w[w \in sk_{boy'\ ;\ \lambda s.|s|=3} \rightarrow show'(skolem' movie')w\ me']^{\{w\}}} < \\
\multicolumn{3}{c}{\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots} \\
\multicolumn{3}{c}{S_{DIST} : \forall w[w \in sk_{boy'\ ;\ \lambda s.|s|=3} \rightarrow show' sk^{(w)}_{movie'} w\ me']^{\{w\}}}
\end{array}$$

The question arises of why English does not allow further lexical categories that allow plurals to distribute over c-commanding indefinites, giving rise to inverting readings. There is a temptation to attribute this restriction by analogy to some effect of the binding theory, forbidding Skolem terms from lf-commanding a variable. However, scope-inverting examples like (114) show that this cannot be the reason, and in fact other languages with freer word-order do in fact allow such categories, as briefly discussed next

The present theory, unlike the version in *SP*, expressly permits lexical entries for verbs that distribute more oblique arguments over less. Such a category for the transitive verb, parallel to (152b), but distributing object over subject, as in (161a), would in English wrongly give rise to inverting interpretations like (161b) for *A boy read three books*:

(161) a. *read := $(S\backslash NP_{PL})/NP : \lambda x \lambda y.\forall w \in x[read' wy]^{\{w\}}$

b. $*\forall w \in sk_{\lambda s.\forall x \in s[book' x]\ ;\ \lambda s.|s|=3}[read' w\ sk^{(w)}_{boy'}]^{\{w\}}$

While the account so far for English might have made distribution look like binding, subject to a condition like conditions A or C of the binding theory forbidding distribution over c-commanding arguments at the level of logical form ilustrated in (62), other languages such as Japanese allow distribution of this kind.

The Japanese word *daremo* is often translated as English *everyone*.[59] However, in contrast to the inverting example (3), *Someone loves everyone*, the following Japanese example is unambiguous, and fails to invert scope (Hoji 1985; Nakamura 1993; Miyagawa 1997), suggesting in present terms that it is not a generalized quantifier but a plural generalized Skolem term:

(162) Dareka-ga daremo-o aisitei-ru.
Someone-NOM everyone-ACC loves
'Someone loves everyone.' $(\exists\forall / *\forall\exists)$

Not surprisingly, *daremo* can take wide scope in the following example (Kuno 1973:359):

[59] The putative quantifier determiner here is *-mo*. The stem *dare* is related to a *wh*-item.

(163) Daremo-ga dareka-o aisitei-ru.
Everyone-NOM someone-ACC loves
'Everyone loves someone.' $(\forall\exists/\exists\forall)$

Thus far, the behavior of Japanese *daremo* looks much like English distributivity over generalized Skolem terms like *three boys*. However, if the object in (162) is "scrambled" in first position, it can distribute over the subject (Hoji 1985; Nakamura 1993, 2b):

(164) Daremo-o dareka-ga aisitei-ru.
Everyone-ACC someone-NOM loves
'Someone loves everyone.' $(\forall\exists/\exists\forall)$

Three strong conclusions follow immediately from these observations under the present theory. First, the universal quantifier implicit in distribution must be associated with the verb in Japanese, as we have claimed for English, rather than the nounphrase *daremo-o*. Second, the different locally scrambled orders of the Japanese clause must arise from distinct lexical entries, possibly schematized as in the approach of Baldridge (2002) to free word-order. Third, these lexical entries are free to make any scrambled argument distribute over other arguments, regardless of case and c-command relations at the level of logical form. [60]

It is not entirely clear from the somewhat conflicted literature exactly how to state the relevant lexical rule, but it seems to obey a generalization due to Reinhart (1983) that such lexical entries favor arguments earlier in the sentence scoping over later ones. The omission from the English lexicon of categories like (161a) seems to reflect this tendency, rather than command-based binding-theoretic conditions on logical forms as was incautiously suggested in *SP*.[61]

Thus, the property claimed here for English, that distributivity is a property of verbs rather than quantified nounphrases, seems to be shared with a great many other unrelated languages, including Japanese, Greenlandic, and Chinese,

10.4 The Canadian Flag Anomaly

If the rules (64) and (65), are applied to verbs that have been distributivized by rule (153), then we get verbs like the following (cf. (159a)):

(165) hang := $((S_{DIST}\backslash NP)/PP)/NP : \lambda x\lambda y\lambda z.\forall w \in z[hang'yxw]^{\{w\}}$
$\Rightarrow_{LEX}$ hang := $S_{DIST,MID}\backslash NP : \lambda x\lambda y.\forall w \in one'[hang'yxw]^{\{w\}}$

One of the readings that this category will give rise to for example (17), repeated here (slightly simplified) as (166a), is (166b):

[60] It seems likely, in fact, that Japanese is a language in which true generalized quantifier NPs are entirely lacking, and a verb-based distributivity system does all the work of universal quantifiers.
[61] The reason for this (defeasible) cross-linguistic tendency is probably to do with considerations of "functional dynamism" and information structure of a kind discussed by Hajičová, Partee and Sgall (1998).

(166) a. A flag hung in at least three windows.

b. $S_{DIST,MID} \backslash NP : \forall w \in one'[hung'(in'(skwindow'; \lambda s.|s| \geq 3 sk^{(w)}_{flag'}\ w]^{\{w\}}$

This reading arises from early Skolem specification of *at least three windows*, giving a global specific indefinite set of windows, followed by late Skolem specification of *a flag*, giving a dependent Skolem functional flag. The fact that the preferred model distributes acts of hanging dependent flags over the windows follows from pragmatic considerations, just as it does *Harry read three books* and in the following paraphrase of (166b):

(167) Someone had hung a flag in at least three windows.

Similar arguments can be brought to bear on the other examples in (18).

Since the windows are not distributing, and are a global specific indefinite, it is not too surprising that they can undergo anaphoric ellipsis, as in Hischbüller's (19).

10.5 Distributivity and the Proportion problem

Turning to the English determiner *most*, if we assume, following discussion in section 3.1, that it has the category in (168) then the proportion problem-inducing example (47a) is derived analogously to (156), as in (169).

(168) most := $NP^{\uparrow}_{agr} /_{\diamond} N_{agr} : \lambda n \lambda p.p(skolem'(n\ ;\ \lambda s.|s| > 0.5 * |all'n|))$

(169)

Most	farmers who own a donkey	feed it
$NP^{\uparrow}_{PL} /_{\diamond} N_{PL}$	N_{PL}	$S_{DIST} \backslash NP_{PL}$
$: \lambda n \lambda p.p(skolem'n\ ;\ most')$	$: \lambda x.farmer'x \wedge own'(skolem'donkey')$	$: \lambda y.\forall z[z \in y \rightarrow feed'it'z]^{\{z\}}$

$$\xrightarrow{\quad >\quad} NP^{\uparrow}_{PL} : \lambda p.p(skolem' \lambda x.farmer'x \wedge own'(skolem'donkey')\ ;\ most')$$

$$\xrightarrow{\quad >\quad} S_{DIST} : \forall z[z \in (skolem' \lambda x.farmer'x \wedge own'(skolem'donkey')\ ;\ most') \rightarrow feed'it'z]^{\{z\}}$$

$$\cdots\cdots\ S_{DIST} : \forall z[z \in sk_{\lambda x.farmer'x \wedge own' sk^{(z)}_{donkey'}\ ;\ most'} \rightarrow feed'it'z]^{\{z\}}$$

$$\cdots\cdots\ S_{DIST} : \forall z[z \in sk_{\lambda x.farmer'x \wedge own' sk^{(z)}_{donkey'}\ ;\ most'} \rightarrow feed'(pro' sk^{(z)}_{donkey'})z]^{\{z\}}$$

(The function *most′* is a space-saving abbreviation for the cardinality property given in full in (168).) Since the resulting logical form quantifies over farmers rather than farmer-donkey pairs, it does not suffer from the proportion problem. Since the pronoun is a pronoun rather than a definite, it does not suffer from the uniqueness problem. Because of the universal quantifier contributed by the distributive verb, and rules 3a and 2d of the model theory in section 4, it embodies the strong reading rather than the weak reading, meaning that the majority of farmers who own a donkey feed all the donkeys they own.

It important to notice that these results are independent of the decision (taken on the basis of phenomena like (154)) to treat determiners like "most" as plural existentials rather than universal generalized quantifiers. The same consequences for the proportion and uniqueness problems would follow if this decision were reversed.

11 COORDINATION

The distinction that we have drawn between true universal generalized quantifiers and generalized Skolem terms explains the asymmetry noted in section 2 in their interactions with syntactic coordination. Thus, the fact that universals distribute over "and" and not over "or", as in (4), is simply a consequence of the standard Generalized Quantifier semantics for universal quantifier determiners in (82), and the standard rule 3a for the universal quantifier of the model theory in section 4 (cf. Montague 1973, Dowty, Wall and Peters 1981:200-201).

More interestingly, the reversed asymmetry for existential nominals illustrated in (5) is a similarly direct consequence of the non-standard generalized Skolem term semantics (88) proposed here for existentials, together with the independently-motivated distributive condition in rule 2c for coordination in the model theory, and the lack of such a condition on rule 2b for disjunction.

For example, the translations of *Some man walks and talks* and *Some man walks or talks* are as follows:

(170) a. $walk' sk_{man'} \wedge talk' sk_{man'}$
b. $walk' sk_{man'} \vee talk' sk_{man'}$

Condition 2c of the model theory, defining the semantics of coordination, ensures that in the models satisfying (170a), both instances of the generalized Skolem term denote the same individual, who both walks and talks. The lack of a parallel condition on rule 2b ensures that (170b) means that some individual can be found who does one or the other.

That same difference between rules 2c and 2b, coupled with the scope of negation defined in the semantics of "no" (106) and the semantics of negation in rule 2a which mean that *No man walks and talks* and *No man walks or talks* respectively translate meaning that you can you cannot find any instance of the same man walking and talking, or that you cannot find any man with either property:

(171) a. $\neg(walk' sk_{man'} \wedge talk' sk_{man'})$
b. $\neg(walk' sk_{man'} \vee talk' sk_{man'})$

However, the plural existentials are a little more complicated. While it might seem at first that *three men walk and talk* and *most men walk and talk* do indeed mean that there is a set of men of the appropriate cardinality who all walk, and that the same set all talk, this interpretation will give anomalous results, because it will distribute the maximal participants condition 1c of the model theory to the two conjuncts. For example, it will wrongly yield the value *false* for models in which all men walk, and three/most of them talk.

It is not the maximal participants condition that is at fault here. The related disjunction *Three men walk or talk* does not mean that either there are three man who walk or there are three men who talk, regardless of that condition. Nor does *Most men walk or talk* mean either most men walk or most men talk. The latter is false in a model where a third of men walk, a third talk, and a third do neither, but the former is true.

Instead, it must be the case that "and" and "or" have a distinct distributive category parallel to (152b), distinguished by plural agreement from the singular case that yields (170),thus:

(172) a. and := $((S_{DIST}\backslash NP_{PL})\backslash(S\backslash NP_{PL}))/(S\backslash NP_{PL})$
$: \lambda p\lambda q\lambda x.\forall z \in x[qz \wedge pz]^{\{z\}}$
b. or := $((S_{DIST}\backslash NP_{PL})\backslash(S\backslash NP_{PL}))/(S\backslash NP_{PL})$
$: \lambda p\lambda q\lambda x.\forall z \in x[qz \vee pz]^{\{z\}}$

This is not an extra assumption: the distributivizing lexical rule (153) *already* applies to the conjunction category (79) when the syntactic variable T is instantiated as $S\backslash NP_{PL}$ to yield the following category, because it is an instance of the verb schema $(S\backslash NP_{PL})/\$$:

(173) and := $((S\backslash NP_{PL})\backslash_{\star}(S\backslash NP_{PL}))/_{\star}(S\backslash NP_{PL}) : \lambda p\lambda q\lambda y.qy \wedge py$

So conjunction categories like (172) are a prediction, not an additional assumption.

(172a) yields the following interpretations for *Three men walk and talk* and *Most men walk or talk*:

(174) a. $\forall x \in sk_{man';\lambda s.|s|=3}[walk'x \wedge talk'x]$
b. $\forall x \in sk_{man'\,;\,\lambda s.|s|>0.5*|all'man'|}[walk'x \vee talk'x]$

The categories in (172) map nondistributive verbs onto a distributive verb. Collective VPs can also coordinate, via the standard conjunction category schema (79):

(175) a. Three boys met in the library and lifted a piano.

Rule 2c makes (175) mean that the same three boys met in the library and lifted the piano. The maximal participants condition predicts that this sentence will be deemed false in models where more than three boys met in the library, but only three of them lifted the piano. In contrast to the distributive cases (174), this seems to be correct.

The standard coordination schema (79) also allows mixed distributive and collective conjunctions like the following, with the same prediction from the maximal participants condition:

(176) Three boys met in a bar and had a beer.

Further discussion of such examples is deferred until section 11.2 below.

11.1 Quantifier Coordination

It is clear that conjunction on occasion forms set individuals from singular NPs, since it can change grammatical number:

(177) Johnson and Monboddo like/*likes each other.

We might represent such a subject as follows:

(178) $S/(S\backslash NP_{PL}) : \lambda p.p\{johnson', monboddo'\}$

(The NP *Johnson and Monboddo* has other type-raised categories of course, with related meanings). As in section 10, distributive and non-distributive readings of sentences like the following arise from a single set individual sense of plurals like *Three boys* and *Johnson and Monboddo*:[62]

(179) Johnson and Monboddo went to London.

This is defined by Hoeksema (1983) as "collective" conjunction, which is nonassociative, and correctly predicts multiple distinct readings for NPs such as "Freeman and Hardy and Willis".

Coordination of so-called existentials is similarly collective. For example, *some man and some woman* has the following categories, where $\{skolem'man', skolem'woman'\}$ when specified in the scope of a universal binding $\forall x$, say, yields $\{sk^{(x)}_{man'}, sk^{(x)}_{woman'}\}$—a set individual consisting of a dependent man-denoting generalized Skolem term and woman-denoting generalized Skolem term represented by the following category, among others allowed by the schema (82):[63]

(180) $S/(S\backslash NP_{PL}) : \lambda p.p\{skolem'man', skolem'woman'\}$

Such mixed set individuals as "Fred and a/some/at least one woman" are constructed by the same collective conjunction, as in:

(181) Fred and some woman went to Paris/like each other.

Coordination of universally quantified NPs by contrast does not create set individuals:[64]

[62] Not all conjunctions of existentials produce set individuals. For example, *or* conjunction of singulars like *Johnson or Monboddo* produces a similar family of disjunctive singular individuals starting with the following:

(i) $S/(S\backslash NP_{3SG}) : \lambda p.(p\ johnson') \vee (p\ monboddo')$

[63] *Some man or some woman* is a disjunctive singular individual parallel to that in note 62.

[64] There is considerable cross-linguistic and cross-dialect variation to confuse the picture here. My own dialect is very strict in this respect but many speakers tolerate plural individual readings of *every*. In the terms of the present theory this means that the word "every" is ambiguous in these dialects between a quantificational and plural reading.

(182) Every man and every woman likes chocolate/thinks he or she is a genius/#like each other/#gathered in the library.

Every man and every woman can therefore be represented by the following category, among others allowed by the schema (82):

(183) $S/(S\backslash NP_{3SG}) : \lambda p.(\forall x[man'x \rightarrow px]^{\{x\}}) \wedge (\forall y[woman'y \rightarrow py]^{\{y\}}$

Similarly, *Every boy admires and every girl detests* in sentence (10) must bear the following category:

(184) $S/NP : \lambda z.\forall x[boy'x \rightarrow admire'zx]^{\{x\}} \wedge \forall y[girl'y \rightarrow detest'zy]^{\{y\}}$

This is the variety of conjunction that Hoeksema calls "intersective."

Both categories can be obtained by schematizing the coordination rule over the different types, along lines first laid out by Partee and Rooth (1983), and discussed in more detail than we need here by Hoeksema (1983), Hendriks (1993), Jacobson (1996a), and Carpenter (1997).

Interestingly, as Hoeksema points out (1983, 77), mixing universal and non-universal conjuncts does not yield a truly quantificational result. The characteristics of true universal quantifiers and quantificational readings are: a) that when conjoined they have singular agreement; b) they can bind bound-variable pronouns; c) they can invert scope; and d) they do not support collectivizing predicates like *gather*. None of the following seem to pass these tests:

(185) a. #Every farmer and Monboddo feeds donkeys.
b. #Every farmer and at least one lawyer thinks that she deserves a subsidy.
c. Some donkey loves every farmer and Monboddo. (#∀+∃/∃∀+)
d. Every farmer and Monboddo gathered in the library.

Nevertheless, Winter (1996, 2001) offers a convincing argument against Keenan and Faltz and followers' claim that conjunctions like "and" are lexically ambiguous between the collective and intersective readings, on the grounds that no attested language distinguishes these putative meanings with different lexical conjunctions. He provides a semantics for the coordination that derives both varieties via coercion from a single sense. The details are somewhat technical, and we will simply assume for present purposes that interpretation of $\wedge$ in the category in (79) embodies this analysis and imposes the restriction illustrated in (185).

It follows from the set-individual nature of coordinated existentials that they behave like plurals. In particular, (186a,b) involve a single boy:

(186) a. Some boy ate a peach and a pizza.
b. I gave some boy a peach and a pizza.
c. I gave some boy a pizza on Saturday and on Sunday.

On the other hand, (186c) can involve different boys (and pizzas). Temporal adverbial conjunction is intersective, and each adverbial contributes a distinct situational variable in which different instances of $skolem'boy'$ become bound.[65]

11.2 The Across-the-Board Constraint on Scope

The assumption that all so-called quantifiers other than true universals translate as generalized Skolem terms provides everything we need to account for the across-the-board constraint on scope exemplified by the Geach sentence (10), *Every boy admires and every girl detests some saxophonist*.[66]

As in *SP*, the "narrow-scope saxophonist" reading of this sentence results from the type-raised object category (88) applying *before* Skolem specification to *Every boy admires and every girl detests* of type S/NP (whose derivation is parallel to that in (81)), as in (187), repeated here in the new notation:

(187)

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

Since Skolem specification happens *after* the syntactic combination and semantic reduction, both become generalized Skolem terms dependent on the respective quantifiers of the two conjuncts. Each term therefore denotes a potentially different individual, dependent via the Skolem terms $sk^{(y)}_{sax'}y$ and $sk^{(z)}_{sax'}z$ upon the boys and girls that are quantified over, yielding the narrow-scope reading

The "wide-scope saxophonist" reading arises from the same categories and the same derivation, when Skolem term specification occurs *before* the combination of *Every boy admires and every girl detests* and the object, when the latter is not in the scope of any operator. Under these circumstances, specification yields a a Skolem constant, as in the following derivation, repeated from *SP* in current notation:

[65]The interaction of these properties with argument cluster coordination is discussed by Crysmann (2003).

[66]Fox (1995) and Sauerland (2001), following Ruys (1993), note a number of cases in English and German where quantifiers appear to scope out of one conjunct alone, in violation of the across-the-board generalization. In particular Fox (1995, (56)) claims the following asymmetry:

(i) a. Some student likes every professor and hates the Dean. (#∀∃)
b. Some student likes every professor and hates her assistant. (∀∃)

Such examples do not seem to offer a very clear generalization, given the general tendency of scope to "leak" anaphorically, as discussed in section 7.6, and the fact that under the epithet substitution test discussed in section 3.1, the pronoun in (ib) does not seem to be universal-bound. We will pass over them here.

(188)
$$\dfrac{\dfrac{\text{Every boy admires and every girl detests}}{S/NP : \lambda x.\forall y[boy'y \rightarrow admires'xy]^{\{y\}} \wedge \forall z[girl'z \rightarrow detests'xz]^{\{z\}}} \quad \dfrac{\text{some saxophonist}}{\begin{array}{c} S\backslash(S/NP) : \lambda q.q(skolem'sax') \\ \cdots\cdots\cdots \\ : \lambda q.q(sk_{sax}) \end{array}}}{S : \forall y[boy'y \rightarrow admires'sk_{sax}y]^{\{y\}} \wedge \forall z[girl'z \rightarrow detests'sk_{sax}z]^{\{z\}}}<$$

These categories do not yield a reading in which the boys all admire the same wide scope saxophonist but the girls each detest a different narrow scope one. Nor, despite the anytime nature of Skolem term specification, and even the possibility of specification intervening between syntactic combination and β-normalization that was explored but rejected in (93), do they yield one in which the girls all detest one wide scope saxophonist, and the boys all admire another different wide scope saxophonist. Both facts are necessary consequences of the combinatorics of CCG derivation, and require no further stipulation of parallelism conditions.

A similar prediction of parallel scopes in coordinate structures to that for (187) and (188) follows for (189):

(189) a. Some woman detests every saxophonist and every trombone player.
b. Some woman detests every saxophonist and likes every trombone player.

In both cases, *some woman* must either undergo specification before syntactic combination with the conjoined universals, giving rise to a reading with a single wide-scope woman, or after, yielding a reading with dependent generalized Skolem terms—that is, narrow-scope women in both conjuncts. Mixed readings are again impossible.

A similar across-the-board prediction to that for the Geach sentence is made about *de dicto/de re* readings in examples like the following:

(190) Harry wants to date, and Louise wants to marry, a Norwegian.

That is, the only available readings involve either a single *de re* Norwegian (paraphrasable in some dialects by the specific indefinite “this Norwegian”), or different dependent *de dicto* ones. There is no reading with two different *de re* Norwegians, much less readings with mixed *de dicto/de re* ones.[67]

The binding of pronouns by quantifiers via rule (98) is also an anytime operation, and is forced by Skolem term specification under rule (99). The ambiguity between free and bound pronoun readings therefore arises from a similar possibility of skolem specification and binding before or after combination with the verb, with the same characteristic of obligatory binding in the environment defined by the derivation so far. It follows that a related across-the-board effect is predicted for this ambiguity in examples like the following, which are of a kind analyzed in Jacobson 1996a, where it is wrongly claimed that CCG allows ATB violations for

[67]Again, we can ignore for present purposes the finer distinctions on this dimension noted by Geach (1967).

related examples):

(191) Every boy detests and every man admires, his saxophone teacher.

A similar range of readings subject to the across-the-board constraint is predicted for the following kinds of example, given the category (183) for *every man and every boy*:

(192) Every man and every boy admires/wants to marry a/his saxophone teacher.

However, we predict only wide-scope negation in the following example related to (148), since only the left branching derivation parallel to (150) is available:

(193) You asked us to read and they asked us to review no book. $(\neg ask/\#ask\neg)$

It has on occasion been argued that the across-the-board condition on scope can be captured instead via transderivational parallelism constraints on coordinate structures of the kind proposed by Goodall (1987) and applied more recently by Fox (2000) to some rather different elliptical and anaphoric constructions. Quite apart from the theoretically problematic nature of such constraints for other than purely anaphoric or copy-based processes (see Jacobson 1998 and Potts 2001 for recent discussions), one would want to have such constraints emerge from the basic principles of the grammar, as they do in present terms from the fact that the conjunction categories like (79) apply to like types.

It follows that we make a number of predictions concerning the acceptability of *non*-parallel scope interpretations arising from conjunctions of so-called existentials, related to the possibility of conjoining narrow scope or dependent existentials with wide scope quantifiers and specific-referential NPs, as in the following:

(194) a. Some woman likes, and every man detests, every saxophonist.
b. Some woman likes, and the man I met yesterday detests, every saxophonist.
c. Some woman likes, and Johnson detests, every saxophonist.
d. Monboddo and some woman attended every rally.

In fact, non-parallel mixed-scope readings do seem to be available for coordinate sentences involving explicit multiple existentials, although in general they are pragmatically disfavored, as in the following relatives of the Geach sentence:

(195) Every boy admires a certain saxophonist called John Coltrane and detests at least one trombone player.

(196) A certain saxophonist I know likes and at least one trombone player detests every tune by Miles Davis.

(197) Sally wants to marry a certain judge called Monboddo and to date at least one Norwegian.

The mechanism of distribution over plurals described in section 10 also makes strong predictions concerning both parallel and non-parallel scopes that would be hard to duplicate with any global parallelism constraint. Thus, it is a prediction of the theory that, unlike the universal quantifiers in the Geach sentence (10), the scope effects of distributivity need not be parallel in clauses conjoined under right node raising. For example, the following sentence, uttered in a discussion of the activities of a set of boys, seems to have a reading where the three boys distributively read different books and the two boys collectively wrote the same book:

(198) Three boys read, and two boys wrote, a book.

Similarly, the following sentences have readings where the same three boys act collectively in one disjunct but distributively with respect to pizzas in the other (cf. Massey 1976):

(199) a. Three boys ate a pizza and lifted a piano.
b. Three boys gathered in the bar and ate a pizza.
c. Three boys met each other and ate a pizza.

The verb-lexical basis for distributivity forces parallel scoping in examples like the following:[68]

(200) I showed three boys a movie, and two girls a video.

But again, the possibility of non-parallel scoping is predicted in sentences like the following:

(201) I showed three boys a movie and gave three girls a pizza

12 Conclusion

The above observations imply that among the so-called quantifier determiners in English, the only ones that have interpretations corresponding to generalized quantifiers are those that engender dependency-inducing scope-inversion, refuse to combine with collective predicates like *gather in the library*, have singular agreement only, and undergo intersective conjunction. These genuine quantifier determiners—*every*, *each*, and their relatives—give a universal quantifier scope over the matrix predicate at the level of logical form as defined in the lexical categories for these determiners.[69] This mechanism achieves the effect of "covert movement" of the quantifier. However, it is not a derivational or structure-changing operation: the declaratively-stated scope relations defined in the lexicon at the level of logical form are merely projected onto sentence-level logical forms by the combinatorics of monotonic CCG syntactic derivation. (In the terms of the

[68]The mechanism given in *SP* whereby argument clusters such as *Two girls a video* can coordinate in CCG is discussed in *SP*:46, Ch.7.
[69]We continue to leave open the possibility that these include *most*.

Minimalist Program, CCG, like GPSG, reduces all varieties of movement, copying, and deletion, to merger.)

No other so-called quantifiers are truly quantificational at all. Existentials rather denote various types of individual translated as generalized Skolem terms. These give the appearance of taking narrow scope when they are bound by true quantifiers and/or intensional operators, and of taking wide scope when they are unbound. In the latter case, they are constants and "take scope everywhere" without any equivalent of movement, covert or otherwise. In addition, set-denoting generalized Skolem terms can distribute over or bind other Skolem terms that they command at the level of logical form, via another lexicalized mechanism associated with verbs. In some respects, there is a general kinship to the approaches of Kratzer and Winter. However, the present approach differs in assuming that both the indefinites and the other non-universals entirely lack quantificational readings (cf. Kratzer 1998:192 and Winter 2001:118-119,166-167).

A number of correct predictions follow concerning Universal Grammar. Since the majority of so-called quantifier determiners entirely lack a generalized quantifier reading, we correctly avoid predicting the existence of languages in which existentials like "someone" are differently lexicalized for narrow and wide scope readings in sentences like (1), "Everyone loves someone," since these readings arise from a single sense defined in terms of an underspecified Skolem term and the process of specification.

However, we continue to allow the possibility that certain lexical items may be categorially specified as required to be within the derivational scope of certain syntactically marked operators. Examples are negative polarity items including English *any* discussed in categorial terms above and in *SS&I*, 55-57, and the Hungarian reduplicating dependent indefinite determiners discussed by Farkas (1997a, 2001). In contrast to the normal indefinite determiners, which are predicted to be ambiguous between the bound and unbound readings, the latter are restricted to binding contexts and dependent readings, and appear to be analyzable in syntactic terms similar to the negative polarity items.

In contrast, it is consistent with the above account to assume that any narrow scope or dependent readings of the true quantifiers *every*, and *each* would have to arise from distinct non-quantificational senses. Accordingly, the theory predicts that languages might exist in which the wide generalized quantifier reading and the narrow non-quantificational reading are differently lexicalized, or in which one reading or the other is simply unavailable.

These predictions also appear to be correct. In English itself (and many other languages—see Gil 1995 and Haspelmath 1995), it can be argued that non-quantificational universal set-denoting expressions are specified by lexically distinct determiners like "all," which achieve their universal readings through the distributivity apparatus described earlier. The asymmetry noted at (154) suggests that English true quantifiers in fact entirely lack plural readings, at least in certain dialects.

It also seems likely on the basis of Baker 1995, Bittner 1994, Aoun and Li 1993, and Hoji 1985, that Mohawk, Greenlandic Eskimo, Chinese, and Japanese are examples of languages in which true universal generalized quantifiers are entirely lacking, the work of wide scope universal quantification being done by the plural specifier corresponding to "all," aided by distributivity, Skolem-functional dependent entities, and the rest of the apparatus described above. Indeed, languages with true nominal universal quantifier determiners like English and other European languages may even be a minority.

The apparent scopal anomaly of donkey sentences both acts as a forcing function for almost every detail of the model theory that underpins the present theory, and provides independent support for the view of existentials as generalized Skolem terms. While the present proposal has been presented as a non-dynamically scoped version of DRT, under the very broad definition of DRT proposed by Heim 1990, it is the interpretation of existentials as generalized Skolem terms that allows a semantics that avoids the Scylla of the proportion problem without foundering on the Charybdis of the uniqueness problem. It also permits a theory of donkey anaphora in which the strong reading arises from the standard meanings and properties of both indefinites and pronouns, without recourse to construction of covert definites and attendant minimal situations (as in E-type accounts), context-dependent translation of existentials as universals (as in early versions of standard DRT), or binding-theoretically problematic dynamic generalizations of the notion of scope itself (as in the DPL version).

The present theory assumes some version of the DRT theory of unbound pronoun reference. This account remains incomplete in a number of details, as do all others, and remains a subject for further research. The categorial grammar-based account of pronominal anaphora by Jacobson (1996a) remains an attractive alternative. However, it has so far proved resistant to combination with present syntactic assumptions.

Under these assumptions, the available scoped readings, including certain notorious cases involving inversion out of NPs discussed in section 8.5, can be computed directly from the combinatorics of syntactic derivation in CCG alone, together with an "anytime" operation of Skolem term specification of the uninterpreted terms associated with indefinite NPs.

The process of Skolem term specification bears a family relationship to the process of enumerating the possible scopal readings for underspecified quantifiers in UDRT (Reyle 1992). However, Skolem specification is entirely integrated within the grammatical derivation. In this respect, Skolem specification is also reminiscent of the idea of "retrieval from storage,"—in particular, from Nested Cooper Storage (Keller 1988). However, the present proposal includes no storage memory independent of the memory required for the logical form itself, and the extended push-down automaton implicated by the grammar itself (EPDA, Vijay-

Shanker and Weir 1993, 1994).

It follows that the only determinant of the number of available readings is the notion of syntactic derivation embodied in CCG. All logical-form level constraints on scope orderings can therefore be dispensed with. As Park 1995 and *SP* point out, this is a stronger result than that in related work of Hobbs and Shieber (1987), Keller (1988), and Pereira (1990), as extended in Shieber, Pereira and Dalrymple (1996), and the combinatory continuation-passing approach of Barker (2002, 2001). That same combinatorics of CCG means that sentences like the following (adapted from Hobbs and Shieber 1987) are predicted to have only *four* scoped readings, resulting from alternating movies with the alternation of farmers and donkeys, rather than five as predicted by those earlier accounts.

(202) Every farmer who owns some donkey likes some movie.

Some, but not all, of these results can be transferred to other syntactic frameworks. Thus, the LTAG derivation tree -based approach to quantifier scope of Joshi and Vijay-Shanker (1999), Kallmeyer and Joshi (2002), and Joshi, Kallmeyer and Romero (2003), imposes the same limitation on examples like (202), using underspecification. By adopting the view of indefinites as generalized Skolem terms, related semantic frameworks such as standard DRT (Kamp and Reyle 1993; van Eijck and Kamp 1997; cf. Bos et al. 2004) could also in principle capture their non-inverting character. However, the interaction of scope and coordinate structure exemplified by Geach's example (10) and the many variants considered here appears to demand the specific grammatical combinatorics of CCG to explain when conjoined scopes must exhibit parallelism, and when they may not.

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