

CHAPTER 2

BACKGROUND

The goal of this study is to develop a theory of how scope ambiguities are resolved. A sentence such as (1) has two interpretations. It can mean that there is some book that Marina showed to each of the children, and it was the same book each time. Or it can mean that for every child there was some book that Marina showed her/him, with the possibility that it was a different book in each case.

- (1) *Marina showed a book to every child.*

Investigating quantifier scope preferences involves consideration of the semantic properties of quantifiers and the syntax of quantifier scope. Essential concepts in these areas are presented in sections 2.1–2.4. Existing work on quantifiers and quantifier scope in psychology and psycholinguistics is reviewed in §2.5.

2.1 Basics

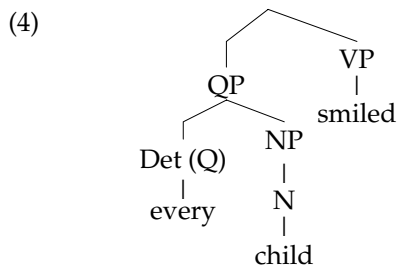
Two major types of quantification have been identified in the literature: determiner quantification, as in (2), where the quantifier (e.g. *some, every, few*) heads a determiner phrase; and adverbial quantification, as in (3), where the quantifier (e.g. *always, usually, seldom*) modifies a clausal projection:

- (2) *Every child smiled.*

- (3) *The cat usually sleeps during the daytime.*

The present study is primarily limited to determiner quantification.

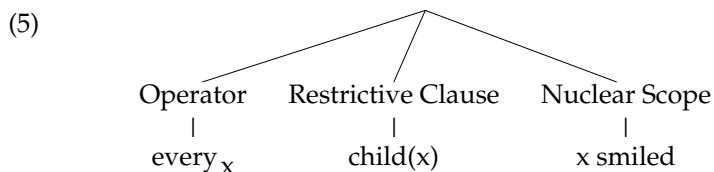
A quantified determined phrase (QP) has the syntactic structure in (4):



In the literature on quantification, the term ‘quantifier’ is sometimes used to refer to the determiner within the QP (*every* in the example) and sometimes to the entire QP (*every child*), in part because some properties are best ascribed to just the determiner while others are best attributed to the whole phrase. I will reserve the term ‘quantifier’ for the determiner and use ‘quantified phrase’ or ‘QP’ for the entire phrase.

The ‘scope’ of a quantified phrase is what it c-commands.¹ A QP ‘scopes over’ all the expressions that occur in its scope. In (4), *every child* scopes over *smiled*.

Semantically, quantifiers are said to occupy the operator position in a tripartite structure, as in (5) (Kamp 1981; Heim 1982). From this position they bind variables in the two other parts of the structure.



The restrictive clause identifies the restriction on the quantifier, the set to which the quantifier applies. At the very least, the restriction consists of the common noun in the QP. Additional content often comes from context. If (2) were uttered after (6), for example, then the set of children would be readily understood as the children in the room, rather than the children in the whole world.

¹A phrase *X* c-commands a phrase *Y* if and only if neither of *X* or *Y* dominates the other and the first branching node dominating *X* dominates *Y*. in (4), NP c-commands Det but does not c-command VP.

(6) *Janetta skipped into the classroom.*

The nuclear scope contains the remainder of the sentence. It corresponds to what is being ascribed to the quantified set. Both the restrictive clause and the nuclear scope can be thought of as identifying sets, with the quantifier characterizing a particular relation between them. In (2), for instance, the quantifier serves to define a relation between the set of children and the set of smilers, saying that all members of the first set belong to the second set, i.e. that the first set is a subset of the second set. Different quantifiers correspond to different relations between sets. In *Most children smiled*, the quantifier *most* says that more than half of the members of the set of children belong to the set of smilers.

Since quantifiers correspond to relations between sets, the semantic type² of QPs is different from that of DPs such as *Vanessa* and *Pedro* which simply refer to individuals and are of type *e*; QPs have the higher semantic type $\langle\langle e,t\rangle,t\rangle$. Because of this, there are some syntactic positions in which QPs are not interpretable unless some sort of special operation, such as Quantifier Raising (QR), is performed. These operations, as well as the ones which take place at the syntax-semantics interface to create the semantic structure in (5) are discussed in §2.4.

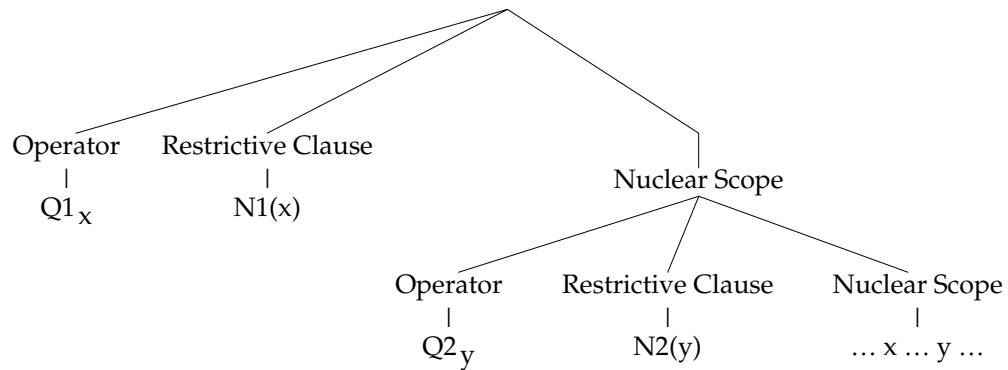
2.2 Relative Scope

Scope ambiguities arise when there are two (or more) quantifiers or operators in a domain at S-structure (such as a single clause³) and one QP c-commands the other. When the semantic representation is constructed, one quantifier will be in the nuclear scope of the other, as sketched below:

²Every word and phrase has a semantic type, corresponding to the kind of semantic value it expresses. There are two basic semantic types: *e*, which is the type of expressions which refer to entities (e.g. *Pedro*), and *t*, which is the type of expressions which refer to truth values (full sentences are of this type). Other, more complicated types are built from these basic two. For example, an expression of type $\langle e,t\rangle$ (such as the predicate *sleeps*) is one which when applied to a type *e* expression results in a type *t* expression. When *sleeps* combines with *Pedro*, the sentence *Pedro sleeps* of type *t* results

³Quantifier scope does not seem to be always clause-bounded. See §2.4.2.

(7)



The ‘relative scope’ of the two quantifiers refers to which quantifier occupies which operator position. In (7), Q_1 scopes over Q_2 ; Q_1 is said to have ‘wide’ scope, and Q_2 is said to have ‘narrow’ scope (when these terms are used in reference to syntactic LF structures, they are defined on QPs rather than quantifiers). The syntactic processes by which the relative scope of two QPs is determined are discussed in §2.4.

Of primary interest to us are scope ambiguities involving two QPs headed by quantificational determiners. (8), repeated from (1), has two interpretations, depending on the relative scope of the QPs *a book* and *every child*. For the interpretation in (8a), *a book* has scope over *every child*; for (b), *every child* has scope over *a book*.

(8) *Marina showed a book to every child.*

- a. There is some book that Marina showed to all of the children; it was the same book each time. *a book > every child*
- b. For each child there is some book that Marina showed her/him; it was possibly a different book in each case. *every child > a book*

The term ‘forward’ scoping is used when the first (left-most) quantifier encountered in a sentence takes wide scope, as in (8a). ‘Reverse,’ or ‘inverse,’ scoping is when the second quantifier has wide scope, i.e. the scoping is the inverse of the linear order of the quantifiers, as in (8b).

A number of other kinds of scope ambiguities exist, such as those involving the relative scope of a determiner-headed QP and a quantificational adverb (9), a QP and clausal negation (10), a QP and a wh-phrase (11), and a QP and an intensional verb (12):

- (9) *Ronny quickly made all the beds.*
- a. Ronny completed the task of making the beds in a short amount of time. *quickly > all the beds*
 - b. Ronny made each of the beds in a short amount of time, but it took a while to complete the whole task. *all the beds > quickly*
- (10) *Every duck did not cross the road.*
- a. None of the ducks crossed the road. *every duck > not*
 - b. Some of the ducks crossed the road but some did not. *not > every duck*
- (11) *Which person did every dog lick?*
- a. There is a single person that all the dogs licked; who is it? *which person > every dog*
 - b. For each dog, there is a person that dog licked; who is the person for dog₁?, who is the person for dog₂?... *every dog > which person*
- (12) *Sophie thinks a friend will come by tomorrow.*
- a. Sophie thinks some friend or other will come by. *think > a friend*
 - b. There is a particular friend, say Emma, that Sophie thinks will come by. *a friend > think*

I have nothing further to say about the ambiguities in (9-12). To my knowledge, little if any rigorous work has been done on scope preferences in these constructions.

2.2.1 Event Readings

An additional dimension is sometimes considered in studying scope ambiguities. (13) can be said to have three readings, not just the two generated by the two possible relative scopings of the quantifiers *all* and *a*:

- (13) *All the comrades sang a victory song.* Ioup (1975b:33-4)

First, it can mean that all the comrades sang the same song (*a > all*) and that the singing occurred as one event, i.e. all the comrades sang at the same time. Second, the same song could be sung by all the comrades (*a > all*) but different comrades could sing the song at different times, resulting in many singing events. Third, different songs could be sung by different comrades at different

times (*all > a*), again yielding many singing events. If (13) is changed to include only one quantifier– *All the comrades sang the victory song*– there is still the possibility of one singing event vs. many singing events. Beghelli & Stowell (1997) derived readings such as these by positing a covert event quantifier which interacts scopally with other quantifiers in the sentence. Event readings are considered in greater detail in Chapter 4.

2.2.2 One Scope Reading May Entail the Other

With many determiner quantifiers, one scope reading is entailed by (follows logically from) the other. For example, in (8) the reading in which the *a*-phrase has scope over the *every*-phrase, (8a), entails the reading in which the *every*-phrase has scope over the *a*-phrase, (8b). If the context is such that (8) is true with reading (8a)– e.g. Marina showed *The Cat in the Hat* to every child– then it must also be true under reading (8b). The latter reading allows the possibility of their being a different book per child, but does not require it.

On the other hand, the reverse entailment does not obtain. The reading in (8b) does not entail the reading in (8a). A context can be found in which (8) is true under reading (8b) but not under reading (8a)– e.g. Marina showed *The Cat in the Hat* to Emma, *Green Eggs and Ham* to Jasper, and *The Lorax* to Orestes.

A number of authors, including Reinhart (1976) and Cooper (1979), argue that because of these entailment properties sentences like (8) are not ambiguous between two readings but vague– one reading is just a more specific instance of the other. One of the (many) situations under which (8b) is true is the specific situation under which (8a) is true. These authors contend that only the more general *every > a* scoping (8b) need be syntactically generated for (8). The pragmatics/context can restrict the meaning to the equivalent of the *a > every* scoping.

However, one reading entailing the other does not hold with all choices of quantifiers. When *every* in (8) is replaced by a non-monotone quantifier such as *exactly half* neither reading entails the other (Fodor & Sag 1982; Ruys 1992):

(14) *Marina showed a book to exactly half the children.*

- a. There is some book that Marina showed to half the children; it was the same book each time.

a book > exactly half the children

- b. For half the children, there is some book that Marina showed her/him; it was possibly a different book in each case.

exactly half the children > a book

If *exactly half* were like *every*, then (14a) would entail (14b). But consider a situation in which there are four children, Emma, Jasper, Orestes, and Chloe. Marina shows *The Cat in the Hat* to Emma and Chloe, and *Green Eggs and Ham* to Jasper, but no book to Orestes. Then (14) is true on the reading in (a): there is a single book that was shown to half the kids (*The Cat in the Hat*); but it is false on the reading in (b), since more than half the kids (three, in fact) were shown some book or other. Thus, at least when certain quantifiers are involved, both scope readings must be derived syntactically.

Many researchers maintain that all doubly quantified sentences are ambiguous and both readings need to be constructed in the syntax. This is the position I adopt. Still, the fact that the *every > a* scoping is vague as to whether it was the same indefinite in each case is an important point, which will resurface later. For an comprehensive review of the ambiguity/vagueness debate see Ruys (1992).

2.3 Semantic Properties of Quantifiers

A number of the semantic properties which have been ascribed to quantifiers are potentially relevant to the question of how quantifiers are processed during natural language comprehension.

2.3.1 Monotonicity

For one, quantifiers fall into different sets according to their ‘monotonicity;’ that is, the kind of inferencing pattern they exhibit. Two separate inferencing patterns are relevant.

Left monotone increasing quantifiers, such as *several, a few, both, at least two, and not all,*

generalize from a more restrictive nominal, such as *children with brown eyes*, to a less restrictive nominal, such as *children* (i.e. they generalize from a subset to a set), as shown in (15a), while left monotone decreasing quantifiers, such as *every*, *neither*, *no*, *at most two* and *few*, generalize from a set to a subset, as exemplified in (15b):

- (15) a. left monotone increasing

If several children with brown eyes smiled, then several children smiled.

- b. left monotone decreasing

If every child smiled, then every child with brown eyes smiled.

Right monotone increasing quantifiers, such as *several*, *a few*, *both*, *at least two*, and *every*, generalize from a more restrictive predicate to a less restrictive predicate (16a), while right monotone decreasing quantifiers, such as *not all*, *neither*, *no*, *at most two* and *few*, generalize from a less restrictive predicate to a more restrictive one (16b):

- (16) a. right monotone increasing

If every child smiled at lunchtime, then every child smiled.

- b. right monotone decreasing

If no child smiled, then no child smiled at lunchtime.

Note that *every* and *not all* (and their synonyms) are the only quantifiers for which leftward and rightward monotonicity do not match (they are increasing in one case, and decreasing in the other).

Some quantifiers, such as *exactly half* are non-monotone, obeying neither inference in (15) and neither in (16):

- (17) a. **If exactly half the children with brown eyes smiled, then exactly half the children smiled.*

- b. **If exactly half the children smiled, then exactly half the children with brown eyes smiled.*

- (18) a. **If exactly half the children smiled at lunchtime, then exactly half the children smiled.*

- b. **If exactly half the children smiled, then exactly half the children smiled at lunchtime.*

Linguistically, monotonicity is relevant in a number of constructions. It is only monotone decreasing quantifiers, for instance, which license negative polarity items such as *any* and *ever*

(Ladusaw 1979):

- (19) a. *No child who has ever seen Claude has smiled at him.*
b. *Every child who has ever seen Claude has smiled at him.*
c. **Several children who have ever seen Claude have smiled at him.*
- (20) a. *No child has ever smiled at Claude.*
b. **Every child has ever smiled at Claude.*
c. **Several children have ever smiled at Claude.*

Since it is monotone decreasing only on the nominal, *every* licenses *ever* when *ever* occurs as part of the nominal (19b) but not when it occurs within the predicate (20b).

Psycholinguistically, (rightward) monotonicity has been proposed to affect which set invoked by a quantifier is “in focus” and therefore which set can be felicitously referred to by a pronoun in a later sentence (Sanford, Moxey, & Paterson 1996; Paterson, Sanford, Moxey, & Dawydiak 1998; see §2.5.1 for a review).

It is hard to see what effect monotonicity might have on scope preferences.

2.3.2 Weak/Strong

Quantificational determiners are also divided into categories according to whether they can occur in the environment in (21).

- (21) *There is/are ___ caterpillars in the garden.*

Quantifiers which can appear here, such as *few*, *several*, *a* and *two*, are called ‘weak’ quantifiers, and quantifiers which cannot, such as *most* and *every*, are called ‘strong’ quantifiers (Milsark 1977).

But the terms ‘weak’ and ‘strong’ are not quite as simple as this distributional test might suggest. Milsark (1977), Diesing (1992), and numerous other researchers hold that weak quantifiers are ambiguous between a weak and a strong interpretation, with only the weak interpretation coming through in existential *there*-sentences. (22) can mean either that a lot of caterpillars are in the garden (weak reading) or that a large proportion of the set of caterpillars is

in the garden, while a small proportion of the set is elsewhere (strong reading) (c.f. Partee 1988).

(23) lacks the latter reading.

(22) *Many caterpillars are in the garden.*

(23) *There are many caterpillars in the garden.*

On their strong interpretation weak quantifiers behave like strong quantifiers, defining a relation between sets (the strong reading of (22) could be given as “a large proportion of the set of caterpillars belongs to the set of things that are in the garden”).

Furthermore, weak/strong is not only a property of the determiner but also of the entire QP. When *of the* is inserted into the QP in (23), making it an overt partitive, the resulting sentence is ungrammatical:

(24) **There are many of the caterpillars in the garden.*

(24) shows that overt partitives have only strong readings. In fact, overt partitives are often used to paraphrase strong readings.⁴

QPs headed by weak quantifiers are often referred to as ‘indefinites’ since on their weak reading they refer to an entity or set of entities which is new to the domain of discourse. Strong QPs are ‘presuppositional’ in that they presuppose the existence of the set of entities which they are applied to. Moreover, this set is generally already known or given in the discourse. A speaker uttering (25) is assuming that the hearer knows about a particular set of caterpillars:

(25) *Many of the caterpillars are in the garden.*

While many (but not all) scholars maintain that indefinites are ambiguous, how the various interpretations are defined differs from researcher to researcher. Much work has yet to be done in this area. I have presented the particular position on weak/strong readings advocated for by Diesing (1992) since I adopt some of her syntactic proposals below.

The weak/strong distinction is an important one because whether a QP is interpreted as

⁴VanLehn (1978:24-5) reported a dialect split with partitives, however. Some of his informants consistently accepted examples like (24). Based on this, he argued that partitives have strong interpretations in some dialects but not others.

weak or strong can affect its position at LF, the level at which scope is determined, and therefore which elements in the structure it scopes over (see §2.4.4).

One other kind of reading that deserves mention is the ‘specific’ reading of an indefinite. In (26), *a new couch* can refer to the type of object that Vera wants, in which case the (a) continuation is appropriate, or to a particular, unique object that Vera wants– a specific couch– in which case continuation (b) is appropriate:

- (26) *Vera wants a new couch.*
- a. *She will buy one tomorrow.*
 - b. *She will buy it tomorrow.*

Specific indefinites are sometimes explicitly indicated by specificity markers like *a certain*. How specific readings align with other readings that indefinites exhibit is a matter of much debate. I will have little to say about specific indefinites.

2.3.3 Distributivity

Some quantifiers (*each, every, both*) are distributive. When a quantified phrase headed by a distributive quantifier is combined with a predicate, the predicate is understood as applying to each individual member in the quantified set rather than to the set as a whole. For example, suppose the set of girls consists of Emma, Essie, and Ali. (27a) is understood as Emma picking up the box by herself, Essie picking up the box by herself, and Ali doing it by herself. On the other hand, *all* in (b) invites a collective interpretation: Emma, Essie, and Ali lifted the box together.

- (27) a. *Each girl picked up the box.*
- b. *All the girls picked up the box.*

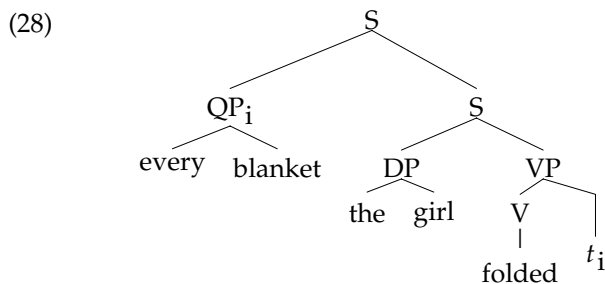
Distributivity is a central topic of Chapters 4 and 5, where the differences between the distributive quantifiers *each* and *every* are investigated.

2.4 The Syntax of Quantifier Scope

In this section I will describe how different relative scopings are generated in the syntax and how weak vs. strong interpretations of indefinites are obtained. I begin with a little history.

2.4.1 Quantifier Raising

It has long been said that QPs are not interpreted in their surface positions, at least not all the time. Chomsky (1976) and May (1977) argued for the rule of Quantifier Raising (QR) which adjoined QPs to S-nodes.⁵ This rule operates at LF in English, generating representations like the following:



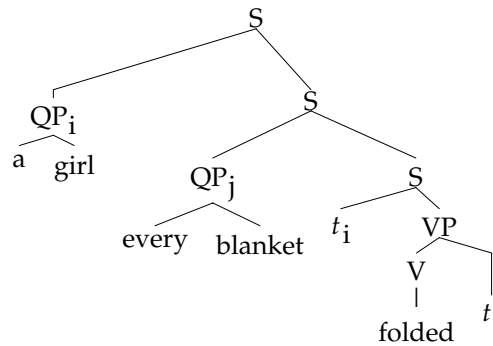
For all intents and purposes, QR as it was originally proposed was obligatory. It was forced to apply because QPs in their surface position violated constraints on the interpretation of LFs. QPs were not of the right semantic type to combine with their sister nodes (e.g. *every blanket* could not combine with *folded*), but they could combine with S-nodes.

Under the QR approach, the two readings of (29) are obtained by adjoining the QPs to S in different orders. For the forward scope interpretation, where the subject QP (*a girl*) has scope over the object QP (*every blanket*), the subject is adjoined above the adjunction site of the object, as shown in (30a). For the inverse scope interpretation, where the object QP has wide scope, the subject is adjoined below the adjunction site of the object, as shown in (30b):

⁵Alternatives to QR which achieve similar results are Cooper storage (Cooper 1983) and Quantifying-in (Montague 1973).

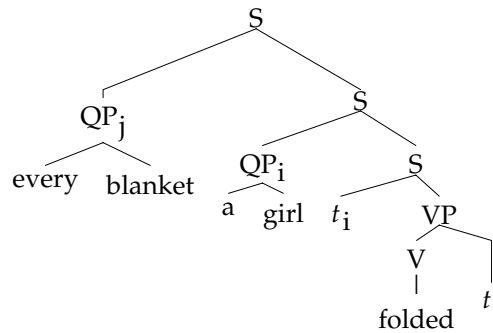
(29) *A girl folded every blanket.*

(30) a.



forward scope:
a girl > every blanket

b.



inverse scope:
every blanket > a girl

In later syntactic work, adjunction sites other than S were proposed to be not only possible, but necessary.

2.4.2 Clause Boundedness

QR is thought to be generally clause-bounded (at least for strong quantifiers): (31), (32), and (33) only have the forward scope reading. The second QP cannot raise to a position above the first QP.

(31) *A private detective acknowledged the fact that every worker was suspicious.*

a. There was one private detective who acknowledged that all of the workers were under suspicion.

a > every

b. *For each worker, there was a possibly different private detective who acknowledged that that worker was under suspicion.

**every > a*

- (32) *Sarit wrote down a song which most of the children sang.*
- a. There was one song which Sarit wrote down and most of the children sang that song.
 - b. *For most of the children, Sarit wrote down one song which that child sang (possibly a different song for each child).
- (33) *Someone believes that every politician is corrupt.* (Reinhart 1997:349)

Yet there are other examples where it seems the clause-boundedness constraint on QR is relaxed, where it is easier to get the inverse scope reading. For example, in (34) it can be a different doctor for each patient, and in (35) it can be a different test for each drug:

- (34) *A doctor will make sure that we give every new patient a tranquilizer.*
(Reinhart 1997:350)
- (35) *A quick test confirmed that each drug was psychoactive.*
(VanLehn 1978:8)

The exact conditions under which QR can apply across a clause boundary have yet to be delineated. I will be using single clause examples in the following chapter, but clause boundedness becomes a potential issue for certain examples discussed in Chapter 5.

2.4.3 Minimalism and Economy

The aim of the minimalist program of Chomsky (1995) was to develop an economical syntactic theory which did not contain any elements that were not needed conceptually. Many operations were trimmed down or abandoned. In this framework, the role of QR has come under scrutiny.

Reinhart has taken an economy view of determining scope preferences. In early work (Reinhart 1976; 1983) she argued that surface c-command relations are critical in determining whether a doubly-quantified sentence is ambiguous or not. She claimed that when there is mutual c-command between the quantified NPs or PPs, the sentence is ambiguous, but when one QP asymmetrically c-commands the other, only the commanding can have wide scope. More recently, she abandoned the no ambiguity approach and used surface c-command to determine the preferred scope interpretation (Reinhart 1983, Chapter 9; 1995; 1997). The C-command

Principle in (36) has been derived from this view:

(36) The C-command Principle

In a doubly-quantified sentence where QP_1 c-command QP_2 at S-structure, the preferred scoping is $QP_1 > QP_2$.

According to Reinhart, all QPs can be interpreted in their surface positions. QR is needed only to generate scopings which do not correspond to surface c-command relations. It is an extra operation. As such, it exacts some cost and the readings generated with it are less economical and thus more marked. They are only available under certain circumstances.

Coming from a more psychological perspective, Pritchett & Whitman (1995) proposed that the representational complexity of LF structures determines the preferred interpretation of sentences which are unambiguous at S-structure but have more than one possible LF. They used doubly-quantified sentences to demonstrate their theory: the preferred reading of such a sentence is the one associated with the less complex (more economical) LF, where complexity is measured by the number of chain links in the structure. For example, the forward scope reading is preferred in *Someone loves everyone* because it involves one fewer chain link than the inverse scope reading (the LF for the latter is identical to the LF for the former, except that *everyone* take a further movement step to adjoin above *someone*). The theory also accounts for graded preferences. When the second QP is an embedded subject, as in *Some professor hopes every student fails*, inverse scope is harder to obtain because it requires an LF with more chain link than the LF for inverse scope in the previous subject/object case.

Hornstein (1995) argued that within a minimalist LF, a separate rule of QR is completely unnecessary. In his theory, DPs move to [Spec,AGRP] positions for Case-checking before LF. QPs can take scope at LF from these positions or their base positions, as long as Diesing's (1992) Mapping Hypothesis (see below) is obeyed. QPs which are interpreted as strong/presuppositional must take scope from outside of VP, in their Case positions.

Hornstein maintained that while *Someone kissed everyone* is structurally ambiguous (with either the LF in (37a) or (b)), *Everyone kissed someone* is not ambiguous but vague, having only the

LF in (38a). This LF corresponds to the *everyone>someone* scoping. Recall from §2.2.2 that this reading entails the *someone>everyone* reading.

- (37) a. [AGRsP *someone*_s [AGRoP *everyone*_o [VP *t*_s [*kissed* *t*_o]]]]
 b. [AGRsP [AGRoP *everyone*_o [VP *someone*_s [*kissed* *t*_o]]]]
 (38) a. [AGRsP *everyone*_s [AGRoP *someone*_o [VP *t*_s [*kissed* *t*_o]]]]
 b. * [AGRsP [AGRoP *someone*_o [VP *everyone*_s [*kissed* *t*_o]]]]

The LF in (38b) is unavailable because *everyone*, being a strong QP, must be interpreted out of VP. In other words, when there is a strong QP as subject and indefinite as object, the inverse scoping of object > subject cannot be generated.

Pica & Snyder (1995) presented a theory of quantifier scope in a minimalist framework as well. Like Reinhart but unlike Hornstein (and most other researchers before him in various frameworks), they offered an account of quantifier scope preferences.⁶ According to them, a scope reading which is dispreferred should not be considered to be entirely grammatical.

The syntax of quantifier scope which Pica & Snyder propose is very similar to Hornstein's. They also have no separate rule of QR. The specifier positions of agreement phrases (AGRP), as well as the VP-internal subject position, are positions from which QPs can take scope. QPs move to [Spec,AGRP] positions for Case-checking, so an independent rule of QR is not needed. Relative quantifier scope is determined by the LF c-command relation between the QPs.

The favored LF position of DPs and argument PPs– i.e. the position in which they are preferentially interpreted– is their Case-checking positions (whether quantified or not). This is [Spec,AGRsP] for subjects, [Spec,AGRoP] for objects, and a position somewhere between Tense

⁶Two early exceptions were Lakoff (1971) and Kroch (1974). Lakoff held that 'command' (a precursor to c-command) is most important– QP₁ preferentially receives wide scope if it commands QP₂– with linear order playing a role if the QPs command each other– QP₁ preferentially receives wide scope if it precedes QP₂. For Kroch, surface syntactic order was primary. He believed that the forward scope reading is always available and is the preferred scoping unless overridden by the preferences and requirements of the particular quantifiers used. He also felt that in spoken language intonation plays a role in determining which scoping is preferred.

and VP for arguments PPs. The preferred scoping of a sentence corresponds to the scoping obtained when the QPs are in these positions. A subject can be interpreted in [Spec,VP], but this is more costly in some way, perhaps because it depends on incorporation, and results in a dispreferred interpretation.

For example, the preferred interpretation of (39), with wide scope on the subject *someone*, follows directly from [Spec,AGRsP] c-commanding [Spec,AGRoP].

(39) *Someone likes everyone.*

The reading in which *everyone* receives wide scope is obtained by interpreting *someone* in the VP-internal subject position, which is below AGRoP. This reading is dispreferred because interpreting *someone* VP-internally is less economical. The same process is needed, and thus the same cost is incurred, in interpreting the ‘weak crossover’ sentence in (40) (the intended meaning of which is Jake’s mother like Jake, Bruno’s mother likes Bruno, etc.):

(40) ??*His mother likes everyone.*

In general, the acceptability of weak crossover sentences containing a QP correlates with the acceptability of the inverse scope reading in corresponding sentences with two QPs (experimental evidence for this claim was reported in Snyder, 1994).

According to Pica & Snyder, in quantified dative sentences like (41) both scope readings are possible but neither is preferred. They account for this by allowing the *to*-phrase to be checked in a position either above or below AGRoP, so the direct object can c-command the *to*-phrase or vice versa.

(41) *Mary gave something to everyone.*

In other cases involving quantified PPs, the choice of preposition plays a role in determining which scopings are available and what the scope preferences are. For example, *Mary presented someone with everything* seems not to allow the reading in which *everything* has wide scope.

Pica & Snyder observe that their theory provides a straightforward account of why S-structure c-command relations seem to play a role in determining scope preferences (Huang 1982; Reinhart 1983). In most cases, the S-structure position of a QP corresponds to its preferred

LF position. The theory of quantifier scope preferences which I develop in Chapter 3 has an explanation in the same vein.

The economy approaches to quantifier scope reviewed in this section have in common the idea that certain relative scopings are costly to obtain. In addition, they maintain that QR is an expensive operation which should be eliminated or scaled back. I will take a similar stance in Chapter 3. Moreover, I will make the association that some of these researchers do between economy and scope preferences. The preferred scoping of a sentence is the one which is more economical.

2.4.4 Structural Determinants of Quantifier Interpretation

Some researchers have proposed that QPs must be in certain positions at LF in order to be interpreted. These proposals have repercussions for when QR is necessary and for which relative scopings should be preferred.

Beghelli (1995) and Beghelli & Stowell (1997) argued for a very articulated LF structure, with numerous functional categories. Different kinds of QPs– e.g. QPs headed by *each* or *every* vs. QPs headed by decreasing quantifiers like *few* vs. indefinites– go to different functional projections to check their features. Some QPs can have various interpretations; these have an option about where to go at LF. Quantifier scope is determined by LF c-command. QR is to the targeted site for a given QP, rather than adjunction to any phrase of right type. Because QPs are constrained as to where they can move at LF, all QPs do not have the same scope possibilities. The tendency for *each* and *every* to take wide scope, for example, is captured by their LF position being relatively high in the tree. Beghelli & Stowell’s proposals will be considered in more detail in Chapters 4 and 5, where the differences between *each* and *every* are investigated.

A second proposal associating certain LF positions with particular interpretations comes from Diesing (1992). Her theory specified how an LF representation is translated into a tripartite semantic structure.

Recall from §2.3.2 that indefinites (QPs headed by weak quantifiers such as *a*, *some*, *one*, *two*,

many) can have either of two interpretations: a weak reading or a strong/presuppositional reading. The weak interpretation of (42), for instance, is roughly “there was one caterpillar in the garden,” and its strong interpretation is something like “one of the caterpillars was in the garden.”

(42) *One caterpillar was in the garden.*

Diesing argued that the weak reading arises when an indefinite is in a VP-internal position at LF, while the strong/presuppositional reading arises when an indefinite is in a VP-external position at LF. From its LF position, an indefinite gets mapped by a ‘tree splitting’ procedure called the Mapping Hypothesis into the corresponding part of the tripartite structure:

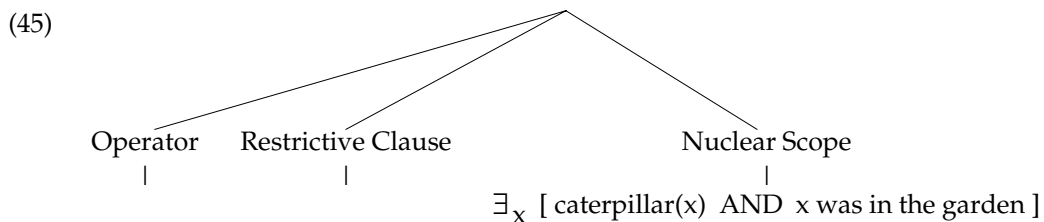
(43) Mapping Hypothesis

Material within VP is mapped into the nuclear scope of the tripartite structure.
Material outside of VP is mapped into the restrictive clause of the tripartite structure.

The S-structure for (42) is given in (44a). In order for *one caterpillar* to receive a weak interpretation, it must lower back into the VP-internal subject position at LF, as shown in (44b) (for simplicity, verb movement is not shown in these structures). Following the Mapping Hypothesis, it is then mapped into the nuclear scope of the tripartite representation (45).

(44) a. [IP *One caterpillar*_i [VP *t*_i *was in the garden*]] S-structure

b. [IP *t*_i [VP *One caterpillar*_i *was in the garden*]] LF for weak reading



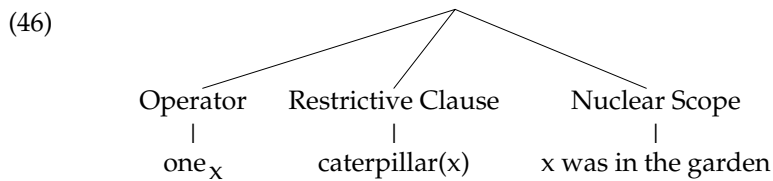
Indefinites in the nuclear scope are bound by the existential closure operator (\exists). Such indefinites introduce the existence of an entity or set of entities into the discourse. Accordingly, weak readings are also called ‘existential’ readings.

For *one caterpillar* to receive a strong interpretation, it does not need to move at LF. From its

S-structure position in [Spec,IP] it is mapped into the restrictive clause of the tripartite structure.

The quantificational determiner then raises further to serve as a quantificational operator; see

(46). Strong/presuppositional readings are thus also called ‘quantificational’ readings.



In contrast to indefinites, QPs headed by strong quantifiers such as *every* are always mapped into the restrictive clause. Because of their presuppositional nature, they require a restrictive clause for their interpretation. As such, they must always be outside of VP at LF, so that the Mapping Hypothesis maps them into the correct part of the tripartite structure. (An alternative reason why strong QPs have to move out of VP is that there is a semantic-type mismatch– strong QPs are of type $\langle\langle e,t\rangle,t\rangle$, but their base position is type e – they must be sister to a clausal projection (a phrase of type t) in order to be interpreted. Diesing & Jelinek, 1995, take this approach.)

In Diesing’s theory, Quantifier Raising is obligatory for all QPs which receive a strong/presuppositional/quantificational interpretation and are in VP at S-structure, whether they are headed by strong or weak quantifiers. It does not apply to indefinites which receive a weak/existential interpretation. In this system, strong QPs are predicted to always have scope over weak QPs.

I will adopt the Mapping Hypothesis in Chapter 3, along with the view that QR operates on only some QPs (strong QPs which are in VP at S-structure).

2.5 Quantifiers and Quantifier Scope in Psychology and Psycholinguistics

In this section I review the research that has been conducted in psychology and psycholinguistics on the interpretation of quantifiers and quantifier scope.

It should be clear from the above discussion that both syntax and semantics should be considered in studying the processing of quantifiers. Surface syntactic representations have been considered in psycholinguistics since its inception. Underlying, or deep, structure has also sometimes played a role, e.g. in the Derivational Theory of Complexity (Fodor, Bever, & Garrett 1974). However, LF representations, semantic representations, and formal semantic properties of words and constructions have been largely ignored in the field until fairly recently. In this section, I will very briefly review some of the work that has been done in this area.

Crain & Steedman (1985) and Altmann & Steedman (1988) spawned a line of psycholinguistic research concerned with how the building of a discourse representation can affect the processing of sentences containing referential phrases like *a psychologist* and *the psychologist*. Within that framework, Ni & Crain and colleagues (Crain, Ni, Shankweiler, Conway, & Braze 1996; Ni, Crain, & Shankweiler 1996) considered the semantic/discourse needs of *only*. Portner (1989) followed up some of Crain & Steedman's studies, formalizing the notion of discourse representation based on the semantic work on discourse structure by Kamp (1981) and Heim (1982). Percus (1995) reinterpreted Portner's work and other related results, also informed by semantic research.

In other domains, Dwivedi (1991) looked at the processing of modal auxiliaries like *could* and *might* in discourse, drawing on semantic work of Roberts (1987b). Trueswell & Tanenhaus used the semantics of tense to make predictions about syntactic processing in various contexts. Radó (1997) examined the effect of syntactically marked topic and contrastive focus on the interpretation of Hungarian sentences.

2.5.1 Non-scope Studies

A number of studies in the psychological and psycholinguistic literature focus on individual quantifiers but are not concerned with scope issues. I turn to these now, then move on to a review of scope studies themselves.

Two main lines of research on quantifiers exist in the psychological literature. First, Johnson-

Laird (1969; 1983) has looked at syllogistic reasoning with quantifiers (primarily logical \forall and \exists) in his work on mental models. In more recent research he has considered doubly-quantified sentences (Johnson-Laird, Byrne, & Tabossi 1989; c.f. Greene 1992; Johnson-Laird, Byrne, & Tabossi 1992), yet still from a deductive reasoning perspective rather than a language processing one. Gillen (1991) has applied some of their ideas in her studies on scope preferences (see below).

Second, various researchers have studied how numbers and proportions are assigned to quantifiers like *many* and *few* in various contexts (e.g. for *Many kids are sleeping*, what number or proportion of kids is intended, fifteen, two-thirds, etc.) and whether quantifiers are mapped onto mental scales (e.g. Parducci 1968; Pepper 1981; Newstead & Collis 1987; see Moxey & Sanford 1993 for a thorough review). This research is not relevant to the syntactic and (formal) semantic processing of quantifiers.

Moxey and Sanford and colleagues conducted a few of the small number of on-line reading experiments involving quantifiers that have been conducted. They investigated which set possibly invoked by a quantifier can be felicitously referred to by a pronoun in a later sentence. For example, the second sentence in (47b,c) are intuitively incompatible with the previous quantified sentence:

- (47) Context sentence: *Local MPs were invited to take part in a public inquiry about proposals to build a new nuclear power station.*
- a. *A few of the MPs attended the meeting. Their presence helped the meeting to run more smoothly.*
 - b. *A few of the MPs attended the meeting. #Their absence helped the meeting to run more smoothly.*
 - c. *Few of the MPs attended the meeting. #?Their presence helped the meeting to run more smoothly.*
 - d. *Few of the MPs attended the meeting. Their absence helped the meeting to run more smoothly.*

Using self-paced sentence-by-sentence reading (Sanford et al. 1996) and eye-tracking (Sanford, Moxey, & Paterson 1994; Paterson et al. 1998), the researchers found slower reading times in the second sentence in (47b,c) vs. (a,d), in line with intuitions. Their account of these results is based on the claim that a pronoun following a QP can only refer to the set which the quantifier “puts

into focus" (directs the attention of the reader/listener to). *A few* focuses the 'reference set': those MPs who attended the meeting; thus *their presence* is appropriate. *Few* focuses the 'complement set': those MPs who did not attend the meeting; thus *their absence* is appropriate. Quantifiers which focus the complement set can marginally refer to the reference set, but quantifiers which focus the reference set have no access to the complement set. Thus, the continuation in (c) is not quite as bad as the continuation in (b). Sanford et al. (1994) suggested that the quantifiers which focus the complement set are those which are (right) monotone decreasing.

Percus, Gibson, & Tunstall (1997) conducted a follow-up study using a wider range of quantifiers. They argued that the complement set is never made available for reference by any quantifier and that the differences between quantifiers with respect to anaphora should not be traced back to monotonicity. Rather, the data can be accounted for by considering the conditions under which a property can be ascribed to a group. One of the considerations is the number of exceptions which are permitted, i.e. how many members of the group are allowed not to have the property while the group as a whole is still said to have the property. This varies from quantifier to quantifier.

2.5.2 Psycholinguistic Studies of Scope Preferences

Scope preferences have been the topic of a number of psycholinguistic studies in child and adult language. I will review the adult research presently. Although the acquisition studies often used adult controls, because the goals of these studies are different than those of adult studies, the adult results reported in them are not particularly informative. Few connections have yet been made between the adult and child literature.

Also of note are computational linguistic approaches to the resolution of quantifier scope ambiguities. In contrast to earlier work (Schubert & Pelletier 1982; Allen 1987), Poesio (1994) considered psycholinguistic results in constructing his system. He argued for a discourse-based theory of quantifier scope interpretation and preferences, using underspecified representations. Perhaps in the future this area will have something to offer psycholinguistics as well.

The adult studies into scope preferences fall into three groups. Ioup (1975a,b), VanLehn (1978), and Gil (1982) gathered intuitive judgements. Catlin & Micham (1975) and Micham et al. (1980) used more controlled experimental settings but the tasks they used invited problem solving by the participants. Gillen (1991) and Kurtzman & MacDonald (1993) employed tasks which more closely mirrored normal reading and comprehension, though they still involved a judgement component. I will review each of these studies in turn.

2.5.2.1 Ioup (1975)

Ioup (1975a,b) is well-known for her view that the intrinsic character of the individual quantifiers is a prime factor in determining scope preferences. She constructed a hierarchy of the tendency of (unstressed) quantifiers to take wide scope (from greatest to lowest tendency):

(48) Ioup's Quantifier Hierarchy

each > every > all > most > many > several > some_{pl} > a few

This hierarchy only includes quantifiers over plural sets. From it, Ioup derived the following generalization: the larger the set defined by the quantifier, the greater tendency for wide scope. She noted that the quantifiers over singular sets, *some_{sg}* and *a*, are apparent exceptions to this generalization. They seem to fit in between *every* and *all* on the hierarchy, but Ioup felt she lacked conclusive evidence to place them there .

The Quantifier Hierarchy was constructed from examples like the following (Ioup 1975b:73-4). Ioup claimed that in (49) *each/every* are preferentially (if not obligatorily) given wide scope over *a*, but when *each/every* are replaced by *all* in (50) the sentences are very ambiguous and the indefinite preferentially receives wide scope.

- (49) a. *I saw a picture of each child.*
b. *She knows a solution to every problem.*
c. *Ethel has a dress for every occasion.*

- (50) a. *I saw a picture of all the children.*
 b. *She knows a solution to all problems.*
 c. *Ethel has a dress for all occasions.*

More quantifiers were compared in (51) (Ioup 1975b:75). Ioup observed that with the quantifier *some* in (a), the total number of handouts is a few (i.e. the scope is *a few > some*), while with *all* and *every* in (d,e), each pedestrian got a few handouts (*all, every > a few*). The intervening cases are said to offer less strong judgements towards one scope or the other.

- (51) a. *Joan gave a few handouts to some pedestrians.*
 b. *Joan gave a few handouts to several pedestrians.*
 c. *Joan gave a few handouts to many pedestrians.*
 d. *Joan gave a few handouts to all pedestrian.*
 e. *Joan gave a few handouts to every pedestrian.*

Ioup argued against linear order playing a role in determining scope preferences. After the inherent properties of the quantifiers themselves, she believed the grammatical functions of the quantified phrases to be the critical secondary factor. A QP in a position higher on the hierarchy in (52) will have a greater tendency to take wide scope than one lower on the hierarchy:

(52) Ioup's Grammatical Function Hierarchy

topic > deep and surface subject > deep subject or surface subject > prepositional object
 > indirect object (IO) > direct object (DO)

Ioup's conclusions were based on intuitions she gathered from informants in numerous languages. For English items, participants indicated the reading they obtained for a sentence by selecting a point on a scale of interpretations: 1. unambiguous "collective" interpretation (= wide-scope indefinite), 2. ambiguous with preference for collective interpretation, 3. ambiguous with no preference, 4. ambiguous with preference for "individual" interpretation (= wide-scope universal), 5. unambiguous individual interpretation. The scale was used in order to make the task easier on the informants and because Ioup believed that ambiguity should be viewed as a continuum. Ioup reported that any indecision by participants was always between adjacent

points on the scale, and that no two informants in the same language gave judgements more than two levels away from each other. It is unclear how many informants she had. For English sentences it seems that sometimes she presented simply her own intuitions.

Among the comparisons she made in English to support the Grammatical Function Hierarchy were those below (Ioup 1975b:78-81):

- (53) Support for deep and surface subject > deep subject or surface subject
- | | | |
|----|--|-------------------------------|
| a. | <i>Every girl took a chemistry course.</i> | <i>every > a</i> only |
| b. | <i>A chemistry course was taken by every girl.</i> | <i>every > a</i> preferred |
| c. | <i>Every chemistry course was taken by a girl.</i> | <i>every > a</i> preferred |
| d. | <i>A girl took every chemistry course.</i> | <i>a > every</i> preferred |
- (54) Support for Prep O > DO
- | | | |
|----|--|-------------------------|
| a. | <i>I had many conversations with a friend.</i> | <i>a > many</i> only |
| b. | <i>I had a conversation with many friends.</i> | ambiguous, no pref. |
| c. | <i>Freddy hit many balls with a bat.</i> | <i>a > many</i> only |
| d. | <i>Freddy hit a ball with many bats.</i> | ambiguous, no pref. |
- (55) Support for IO > DO
- | | | |
|----|---------------------------------------|-------------------------------|
| a. | <i>I told every child a story.</i> | <i>every > a</i> preferred |
| b. | <i>I told a story to every child.</i> | <i>every > a</i> preferred |
| c. | <i>I told every story to a child.</i> | <i>a > every</i> preferred |
| d. | <i>I told a child every story.</i> | <i>a > every</i> preferred |
- (56) Support for Prep O > IO
- | | | |
|----|---|----------------------------------|
| a. | <i>Joan told someone the story at every intersection.</i> | <i>every > some</i> preferred |
| b. | <i>Joan told everyone the story at an intersection.</i> | <i>a > every</i> preferred |

It is unclear whether Ioup looked at other examples within each category to further corroborate her findings on these examples.

In looking at other languages, Ioup compared the scope preferences of the equivalent of three plural English quantifiers: *some_{pl}* (or *a few*), *all*, and *each*. In each item, one of these quantifiers was

paired with the quantifier corresponding to *a*. She had informants translate six sentences into their native language and then asked them questions about its interpretation. She also asked whether the sentence could be expressed with another word order and how that affected its interpretation. In all six sentences, the singular QP was the direct object. The results of this research supported the positioning of *each* above *all* and *some* on the Quantifier Hierarchy and the relative rankings of subject, indirect object, and direct object on the Grammatical Function Hierarchy.

The predictions of Ioup's Quantifier Hierarchy and Grammatical Function Hierarchy were tested in some of the studies reported below. I will further discuss the Quantifier Hierarchy in Chapter 5, where the influence of individual quantifiers on scope preferences is investigated.

2.5.2.2 Gil (1982)

Like Ioup, Gil (1982) examined quantifier scope preferences cross-linguistically. He used sentences with numerical quantifiers, like *Three boys saw two girls*. Data was gathered from informants in three languages by asking them whether the sentences were true relative to diagrams that depicted particular interpretations. Gil found that this kind of doubly-quantified sentence has a least four different types of readings, depending in part on whether the verb is related to the whole group of boys (or girls) or to each individual boy (or girl) in the group. For instance, the readings for the example above include (i) each of the three boys seeing each of the two girls; and (ii) each of the three boys seeing one girl, with the total number of girls that were seen adding up to two. In contrast to Ioup (who used different kinds of sentences), Gil found "widespread" disagreement about judgements within a homogeneous speech community, variation within subjects, and cross-linguistic variation. Yet there were non-random patterns in his data, which correlated with grammatical relations in various ways. He presented three semantic/pragmatic models which could account for his findings. I know of no other studies which examined the types of sentences Gil used, though there is a fair amount of research on them in the semantics literature.

2.5.2.3 VanLehn (1978)

VanLehn (1978) gathered data in two ways. First, he conducted a corpus analysis, selecting doubly-quantified sentences from technical reports on Artificial Intelligence research. For each sentence he determined the intended scoping, sometimes using the context in which the sentence had occurred to help him and sometimes asking assistance from the author of the sentence.

Second, he asked informants for scope judgements on a set of sentences that he constructed which controlled for lexical content and surface structure (since by its nature the corpus study did not control for such factors). The items were typed individually on cards and given to participants to read. The informants were first asked to paraphrase the sentence. If it was unclear from the paraphrase which reading they had arrived at, then VanLehn asked them clarifying questions. For the sentence *Every guy kissed a girl*, for instance, the questions were like: *Did they all kiss the same girl? If there are 5 guys, how many girls does this imply got kissed? Is there a different girl per guy?* The scope judgements were described using the relations 'different/per' (equivalent to wide-scope universal) and 'same/per' (equivalent to wide-scope indefinite). E.g., a different girl per guy vs. the same girl per guy (note that the noun associated with the universal quantifier is the "object" of the per relation in both cases). For the examples he discussed in the text, the percentage of different/per responses was reported.

It is unclear how many items VanLehn gathered judgements on and how many participants judged each item. He reports collecting more than 1500 total judgements, but also states (p. 23) that "the addition of another couple of judgements sometimes made the percentages swing up or down by 5 or 10 percentage points, but rarely more than that," suggesting a small number of informants for a given item.

VanLehn's position was that quantifier scope preferences are "epiphenomena" and do not correspond to any syntactically real processes. He claimed (p. 9) "the informant must 'misuse' one of the real processes to disambiguate Q scope," saying that the difficulty that informants had in coming up with paraphrases for and answering questions about doubly-quantified sentences supported his position. Drawing on both the corpus data and the judgement data, he examined

the effects of three factors on scope preferences: quantifier choice, embedding, and linear order/c-command relations.

In terms of individual quantifiers, VanLehn constructed a hierarchy of how likely quantifiers are to occur as the object in the different/per relation as opposed to the same/per relation, i.e. how likely quantifiers are to take wide scope. Only strong quantifiers (or weak quantifiers with strong readings) were included. A position higher on the hierarchy corresponds to a greater tendency for wide scope (p. 23).

(57) VanLehn's Quantifier Hierarchy

each > every > all of the > all the > other plurals (e.g. many of the)

This hierarchy is consistent with that of Ioup, although it does not incorporate as many quantifiers.

VanLehn looked at the effect of the syntactic position of QPs from two standpoints. For one, he examined scope preferences in sentences where the QPs were in different clauses, varying the embedded positions used. Recall from §2.4.2 that QR is considered to be generally clause-bounded, though there are some examples which challenge this idea. VanLehn found further exceptions. He observed that the difficulty of scoping out of a relative clause depends on whether the wh-operator was overt or not and on the choice of quantifier (p. 31):

- | | | |
|---------|--|--|
| (58) a. | <i>At the conference yesterday, I managed to talk to a guy who is representing each/every raw rubber producer from Brazil.</i> | 0% <i>each > a</i>
0% <i>every > a</i> |
| b. | <i>At the conference yesterday, I managed to talk to a guy representing each/every raw rubber producer from Brazil.</i> | 50% <i>each > a</i>
0% <i>every > a</i> |

These findings suggest that a purely grammatical account of clause-boundedness phenomena would likely be inadequate. VanLehn himself argued that it should not be grammatically based at all.

Syntactic position effects were also examined for sentences in which the QPs were in the same clause. The linear order of the QPs and the c-command relation between were considered. In evaluating the role of c-command, he defined the C-command Hierarchy as follows (a

refinement of a similar hierarchy proposed by Reinhart, 1976):

(59) VanLehn's C-command Hierarchy

preposed PP & topicalized NP > subject > sentential PP & adverbial NP >
verb phrase PP > object

Only the last three positions on the hierarchy differ when linear order is used to construct it rather than c-command: object > verb phrase PP > sentential PP & adverbial NP. The hierarchies predict scope preferences in the same way: If the universal QP is higher on the hierarchy than the indefinite then a wide-scope universal reading is predicted, and if the indefinite is higher then a wide-scope indefinite reading is predicted. If the QPs are at the same level (e.g. both verb phrase PPs), then no preference is predicted. VanLehn found that both linear order and c-command correlated well with his scope preference data. As mentioned above, c-command will play an important role in the theory of scope preferences which I develop in Chapter 3.

2.5.2.4 Catlin & Micham (1975)

Catlin & Micham (1975) used three different off-line measures to determine which quantifier (*every* or *some*) was assigned wide scope in active and passive subject-object sentences like those in (60). Subject quantifier was crossed with voice, to yield four conditions.

(60) *Every man knew some woman.*

Some woman was known by every man.

For each of four items, participants were asked: (i) which noun category the sentence was "about," (ii) which noun category the person would want to examine, one member at a time, in order to determine whether the sentence was true or false, and (iii) how the person would choose to negate or deny the sentence. For question (iii), two choices were given; (61) gives the choices for the sentences in (60):

(61) *Some man did not know any woman.*

No woman was known by every man.

The researchers believed that the noun which was the subject of the denial that was chosen in question (iii), and the noun given as the answer to questions (i) and (ii), would correspond to the

noun in the quantified phrase which was given wide scope in the target sentence.

The three measures were found to be highly correlated; on 85% of the items the same noun was chosen as the answer to all three questions. The results from the trials where all three measures agreed indicated that the (surface) subject of the sentence was given wide scope reliably more often than the object. This preference was significantly larger when the subject quantifier was *every* than when it was *some*. It was marginally bigger in actives than in passives. The effects of quantifier and voice did not interact.⁷

Catlin & Micham suggested that the main effect of subject quantifier, where *every* preferred wide scope to a greater extent than *some* may be due to *every* being more definite, citing a finding by Grieve & Wales (1973) that definiteness contributes to indicating what a sentence is about.

2.5.2.5 Micham et al. (1980)

Micham et al. (1980) noted that the preference for wide-scope on the first QP in active and passive sentences with quantified subjects and objects (like those Catlin & Micham studied) could be due either to linear order playing a strong role in determining scope preferences or to surface subject position playing such a role. To determine which of these factors has more influence, they examined doubly-quantified sentences in which both QPs occurred postverbally in the underlying structure. Double object/dative verbs were used, as in (62), as well as verbs that take double PP complements, as in (63), where a full set of conditions is given. Within each item, half of the conditions were active sentences and half were passive, where one of the underlying objects became the surface subject. Voice was crossed with quantifier order and with

⁷In addition to sentences like those in (5), Catlin & Micham looked at unambiguous sentences such as in (i), where the same quantifier appears twice. Participants either saw all ambiguous sentences or all unambiguous sentences.

- (i) *Some man knew some woman.*
Every man was known by every man.

For the unambiguous sentences, the three measures agreed 73% of the time. The results cited in the text are for the ambiguous and unambiguous conditions combined. There was no main effect of ambiguity, nor any interactions involving it. The authors argued that this result indicates that there are similar procedures for verifying or disconfirming doubly quantified sentences, whether or not they are ambiguous.

which quantifier occurred within the underlying indirect object (first object for double object items, object of *to* for other items). In all cases the quantifiers were *every* and *some*.

- (62) a. *Bill told some child every joke.*
 b. *Bill told some joke to every child.*
- (63) a. *John spoke to some girl about every problem.*
 b. *John spoke about some problem to every girl.*
 c. *John spoke about every problem to some girl.*
 d. *John spoke to every girl about some problem.*
 e. *Some girl was spoken to about every problem by John.*
 f. *Some problem was spoken about to every girl by John.*
 g. *Every problem was spoken about to some girl by John.*
 h. *Every girl was spoken to about some problem by John.*

Participants saw only a single sentence each. Scope preferences were determined by how participants judged matrices representing possible situations the target sentence might refer to (this task was based on that used by Johnson-Laird, 1969). A sample matrix for (63a) is given in (64). The X in a row A–column 1 indicates that John spoke to girl A about problem 1. An O in a given row and column indicates he did not speak to that girl about that problem.

(64) Sample Matrix for Item (63a)

		problems		
		1	2	3
girls	A	X	X	O
	B	O	O	X
	C	X	O	O

Participants judged the truth or falsity of the sentence as they understood it in relation to ten matrices. For example, if a participant saw matrix (64) and interpreted (63a) with wide- scope *every*, he or she would answer “true.” If the sentence were interpreted with wide-scope *a*, the

response would be “false.” On the two critical trials, the matrices were consistent with the *every* > *some* scoping. The matrices in four of the remaining trials had a full column of X’s, which were consistent with either reading of the sentence.⁸ The last four matrices corresponded to neither reading.

Only data for the critical trials was reported. The vast majority of participants were consistent in their interpretation across these trials (i.e. in both cases they gave the same response). There was an overall preference for wide-scope *every* (75%), corresponding to the answer “true.” The effect of which quantifier occurred in the indirect object was significant. With *some* in the indirect object (conditions (a,c,e,g)), *every* was given wide scope 53% of the time, and with *every* in the indirect object (b,d,f,h), *every* was given wide scope 96% of the time.

From this pattern, Micham et al. concluded that *every* prefers wide scope more than *some* does and that a QP which is underlying an indirect object (IO) is more likely to receive wide scope than a QP which is underlying a direct object (DO). They noted, however, that in all their items the IO was animate and the DO was inanimate, so that it may be animacy rather than grammatical role which influenced scope preferences.

The results for the active conditions mirrored the general results. *Every* received wide scope significantly more often than *some*, IOs received wide scope significantly more often than DOs, and *every* received wide scope significantly more often when *every* occurred in the IO (95%, conditions (b,d)) than when *some* did (60%, (a,c)). Moreover, the effect of quantifier order was not reliable. The authors took this last result as indicating that linear order does not play a strong role in determining scope preferences in these kinds of sentences.

Responses to the passives items generally matched responses to the corresponding actives. The researchers compared pairs of active/passive conditions in which the quantifier order and the coupling of quantifier with underlying grammatical role were held constant ((a) and (e); (b) and (f); etc.). The only significant difference was between conditions (a) and (e). From this,

⁸Since the *every*>*some* scoping allows it to be the same problem for every girl and the *some*>*every* scoping requires it to be the same one (see §2.2.2).

Micham et al. concluded that a QP in surface subject position does not favor wide scope more than QPs in other positions.

Micham et al.'s results and conclusions are generally consistent with Ioup's position, including the idea that scope preferences are not strongly influenced by linear order, the claim that IOs take wide scope more often than DOs, and the claim that *every* takes wide scope more often than *some*. They differ, however, on whether surface subject position is a favored position for wide scope. Micham et al. concluded that underlying grammatical function is more important than surface position.

Given the syntactic differences among the different constructions used in this experiment (double objects, datives, double PPs), it would have been beneficial to be able to examine the results from the two sets of verbs separately. Unfortunately, the authors do not present the data in this way. Although they report no significant differences in scope preferences according to verb type (PP PP vs. double object/dative), it is unclear what analysis they performed. Their phrasing implies they tested for effects of individual verbs rather than between the two verb types.

2.5.2.6 Fodor (1982)

J. D. Fodor (1982) considered what the mental representation of quantified sentences might be. She was interested in identifying a representation which would be useful to psychologists. One of her aims was to be able to predict from the representation which interpretations of quantified sentences are easy to compute. The representations that she proposed are called 'models of the world.' They are like mental models or discourse representations in that they schematically show the relations between various elements in the sentence.

Fodor argued against QR playing a role in interpreting quantified sentences. She proposed that the processor maps sentences directly from surface structure into models of the world representations. The preferred scoping of a doubly-quantified sentence is the one which is easier to compute at the model of the world level. Construction of the model proceeds step by step as

the words in the sentence are read. In general, forward scope is predicted to be preferred. This preference may be mediated by the specific quantifiers involved. Some quantifiers have a 'hunger' for inducing multiple interpretations of other elements (equivalent to taking wide scope). *Each* is said to be the hungriest, followed by *every*, then *all*. She also believed that prosody plays a role in resolving ambiguity.

2.5.2.7 Gillen (1991)

Gillen (1991) presented a series of studies on doubly-quantified sentences. She tested the predictions of Johnson-Laird and colleagues (especially Johnson-Laird, Byrne, and Tabossi, 1989), who employed mental models and predicted that the linear order of the quantifiers should be a major factor in determining scope preferences, and Ioup (1975a,b), who predicted that the individual quantifiers and the grammatical functions of the QPs should affect scope preferences.

Gillen used a variety of tasks. Her first five experiments involved either drawing a diagram representing the quantified sentence or choosing which of two diagrams best represented the sentence. The number of participants for these studies was quite low (10-24). In later experiments, she had participants either evaluate whether a (single) diagram was a good representation of the meaning of the target sentence or read target/continuation pairs, where the continuation was meant to be consistent with only one scoping of the quantified sentence. In presenting Gillen's work, I will concentrate on the three experiments which I feel offer the strongest and most important results.

In her Experiment 6 Gillen compared the active and passive versions of subject-object sentences in the same study, as Catlin & Micham (1975) did. Participants first read sentences like those in (17) on a computer screen (the entire sentence was presented at once), and pressed a button. They then evaluated whether a diagram depicting either the wide-scope indefinite reading or the wide-scope universal reading was an accurate representation of the quantified

sentence they had just read. Sample diagrams are given in (66).⁹ The time it took to read the quantified sentence, the time it took to evaluate the diagram, and the response to the diagram were recorded for each item.

(65) *All boys befriend a girl.*

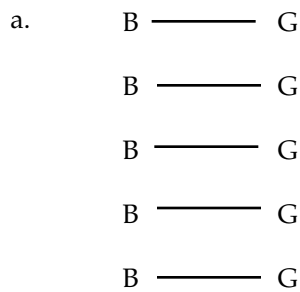
Some boy befriends all girls.

Every boy is befriended by some girl.

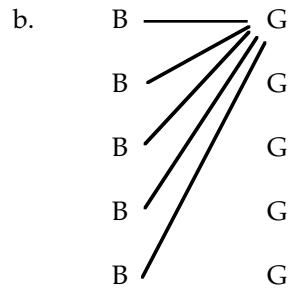
A boy is befriended by every girl.

(66) Sample diagrams

(for sentences where *boy* is universally quantified)



Wide-scope Universal



Wide-scope Indefinite

There were five 2-level factors in the experiment, fully crossed, yielding 32 conditions. The factors were quantifier order (universal first or indefinite first), type of universal (*all* or *every*), type of indefinite (*a* or *some*), voice (active or passive), and type of diagram (wide-scope indefinite or wide-scope universal).

In terms of diagram acceptance, participants were significantly more likely to accept a wide-

⁹Note that the wide-scope universal diagrams like (66a) depicted a strict distributive interpretation where each boy was associated with a different girl. This is a much stronger interpretation than the *every>some* scoping requires. I have already noted that this scoping is in fact consistent with a scenario in which each boy is associated with the same girl. Beyond that, when multiple girls are included, it's certainly possible that particular girls are associated with more than one boy (e.g. boy1 and boy2 befriend girl1, boy3 and boy4 befriend girl2). It is unclear what effect this strict kind of wide-scope universal diagram may have had on the results of the study.

scope indefinite diagram than a wide-scope universal diagram overall (80% vs. 54%).¹⁰ There was a main effect of quantifier-order (marginal by participants), with universal-first sentences having a higher diagram-acceptance rate than indefinite-first sentences (69% vs. 66%), and a main effect of voice (marginal by items), with passives having a higher diagram-acceptance rate than actives (69% vs. 66%).

There was no main effect of type of universal, but there was a significant interaction between this factor and type of diagram: the rate of acceptance was about the same for the wide-scope universal diagram, whether the quantifier was *every* or *all*, but the wide-scope indefinite diagram was accepted more often for *all*. This finding may indicate that *all* is happier receiving narrow scope than *every*. The type of indefinite also had some effect. Participants were significantly more likely to accept a diagram when the indefinite quantifier was *a*. This effect interacted with diagram type: the acceptance rate for *a* with the wide-scope indefinite diagram was reliably higher than the other combinations of factors. These results may indicate that *a* has a stronger preference for wide scope than *some*.

Because of the main effect of type of diagram in the experiment, it is not revealing to compare the rates at which the two different kinds of diagrams were accepted for a given condition in order to determine interpretation preferences. Rather, it is more useful to examine the two diagram types separately. On the following measures, *every* and *all* patterned together, as did *a* and *some*. For ease of discussion, I use *every* for referring to a universal quantifier and *a* for referring to an indefinite quantifier.

For the wide-scope universal diagrams (*every* > *a*), the acceptance rate was higher when the quantifier order was *every-a* than when it was *a-every* (60% vs. 49%), indicating that it is easier to give *every* wide scope when it precedes *a*. This effect was bigger in passives than in actives (passives: *every-a* 63%, *a-every* 48%; actives: *every-a* 57%, *a-every* 52%).

¹⁰Reading times and evaluation times were reported only for trials in which the participants accepted a wide-scope indefinite diagram. I will not discuss these results since they do not seem particularly enlightening.

Wide-scope indefinite diagrams (*a > every*) were accepted more often after sentences in which *every* occurred second than after sentences in which it occurred first (83% vs. 78%). This finding indicates that it is more difficult to give the indefinite wide scope when it is preceded by the universal at S-structure. There was no effect of voice in this measure, suggesting that actives and passives were processed similarly.

From these results Gillen concluded that there is support for Johnson-Laird et al.'s hypothesis that the order of the quantifiers plays a critical role in determining relative scope preferences, with the quantifier which is encountered first preferentially receiving wide scope. However, Ioup's hypothesis that the grammatical function of the universal quantifier affects scope preferences was not supported. Under this hypothesis, there should have been weaker support for wide-scope on the subject in passives than in actives, since the surface subject of actives is also the deep subject (and thus has the strongest preference for wide scope) while the surface subject of passives is the deep object (with a somewhat weaker preference for wide scope). Furthermore, although Gillen does not mention this, the results also support Reinhart's C-command Principle.

In her final experiments, Gillen investigated scope preferences in double object and DP-PP sentences like those in (67). In these experiments, a wider range of quantifiers was employed than in the active/passive study just discussed, in order to evaluate Ioup's Quantifier Hierarchy along with the word order and grammatical function hypotheses. Gillen was also interested in further testing Johnson-Laird's word order hypothesis.

(67) DP-PP (indefinite first)	Double Object ("universal" first)
<i>Margaret served a scone to some customers.</i>	<i>Margaret served some customers a scone.</i>
<i>Bob suggested a schedule for all teachers.</i>	<i>Bob left all teachers a schedule.</i>
<i>Charlie bought a tie from many salesmen.</i>	<i>Charlie bought many soldiers a uniform.</i>

In Experiment 8, Gillen used the same reading and evaluation task she used for her active/passive study. There were three factors in the experiment: type of universal/multiple quantifier (*some_{pl}, several, many, most, all, every, each*), quantifier order (universal first or indefinite first), and type of diagram (wide-scope indefinite or wide-scope universal). The indefinite

quantifier was always *a*. The two quantifier orders were not tested in exactly the same environment; the indefinite-first order was tested in the DP-PP construction, and the universal-first order was tested in the double object construction. Note that the preposition in the DP-PP structure varied from item to item (sometimes yielding a *to*-dative), and that the verb and/or common nouns sometimes differed in the two structures.

In terms of diagram acceptance, participants were significantly more likely to accept a wide-scope universal diagram than a wide-scope indefinite diagram overall (83% vs. 69%). This effect interacted with quantifier order, showing up more strongly when the universal occurred second (DP-PP) (84% wide-universal, 60% wide-indefinite), in contrast to the prediction of the word order hypothesis. For sentences in which the universal occurred first (double object), the acceptance rates for the two diagrams were quite close (82% wide-universal, 78% wide-indefinite).¹¹

Reading times and evaluation times were analyzed for Yes responses to wide-scope universal diagrams only. On both measures, universal-first sentences (double objects) were faster than indefinite-first sentences (DP-PP). This finding is consistent with the word-order hypothesis.

As for quantifier effects, the acceptance rate for wide-scope universal diagrams was highest for *each* (92%) and *every* (91%), followed by *most* (87%), *all* (83%), *many* and *several* (both 79%), and *some_{pl}* (71%). The acceptance rates for the wide-scope indefinite diagram reversed this hierarchy; they were highest for *some_{pl}* and lowest for *each*. Individual statistical tests between pairs (or subsets) of quantifiers were not performed. These results supported Ioup's Quantifier Hierarchy but for the relative positions of *all* and *most*. Discussion of these effects is postponed to Chapter 5.

For her Experiment 10, Gillen used materials very similar to those used in the study just described, but the task was somewhat different. Diagram evaluation was replaced by the reading of a continuation sentence. The continuations for the first example in (67) are given in (68). The

¹¹Note that this is the reverse of the main effect of diagram in the passive/active study, though numerically the effect is not quite as large here. This difference could be due to the different constructions tested or perhaps to the wider range of quantifiers used here.

time it took to read the quantified sentence and the time it took to read the continuation sentence, both of which were presented all at once, were recorded.

- (68) a. *The scone was hard and dry.*
b. *The scones were hard and dry.*

Analysis of reading times for the quantified sentence revealed that universal-first (double object) sentences were read significantly faster, as in her Experiment 8. Singular continuations ((68a), wide-scope indefinite) were read significantly faster than plural continuations (68b). Continuation and quantifier-order did not interact in the continuation sentence, and the means for the interaction of these factors are not presented, but Gillen states (p. 176) that the effect of singulars being faster than plurals is especially evident in the universal-second conditions.

There was a reliable effect of quantifier in the quantified sentence, but no interaction with quantifier-order. In the continuation sentence, there were no significant effects of quantifier. The main effect of the singular continuation being faster than the plural holds for all quantifiers.

Gillen noted an effect of task in these studies. In Experiment 8, where a diagram had to be evaluated, the wide-universal diagram was accepted more often. But in Experiment 10, without direct judgement, the wide-scope indefinite continuation was favored (read faster). Gillen argued that readers were adopting the wide-scope indefinite interpretation by default while they were reading the quantified sentence, because this interpretation was easier. In Experiment 10, this default scope sufficed, but in Experiment 8 participants had to truly assign scope and flesh out the representation into a mental model in order to evaluate the diagram. Gillen concluded that doubly-quantified sentences are not disambiguated unless the task requires it.

Overall, Gillen found the word-order hypothesis inconsistently supported by the results of her experiments. She concluded that it has some effect, but is mediated by other factors such as the quantifiers involved, context, and general knowledge.

The task which Gillen used in her Experiment 10 is the closest to normal reading of all the methods she employed, but the design of that experiment is problematic. For one, it would have been better to not have had the different quantifier orders associated with two different

constructions (DP PP vs. double object), since the syntax of the constructions is not the same and could be playing a role in determining scope preferences. These constructions will be discussed in detail in Chapter 3. Second, the singular continuation sentences could be compatible with either scoping in the quantified sentence. This point is addressed in the following section, since it is relevant there as well.

2.5.2.8 Kurtzman & MacDonald (1993)

The first published computer-controlled studies of quantifier scope preferences were reported by Kurtzman & MacDonald (1993) (hereafter K&MacD).¹² Their goal was to evaluate a number of the structural-based principles proposed in the literature to account for scope preferences:

(69) Linear Order– the leftward phrase prefers wide scope.

Surface Subject– the surface subject prefers wide scope.

External Argument– the external arguments prefers wide scope.

C-command– the NP which asymmetrically c-commands the other NP at S-structure prefers wide scope.

Topic– the topic phrase prefers wide scope.

Thematic Hierarchy– the NP higher on the θ -hierarchy prefers wide scope (Agent > Experiencer > Theme).

In their first experiment, they tested active sentences in which the subject and object were quantified, using the quantifiers *every* and *a*. Each item consisted of two sentences: the quantified sentence (S1) followed by a continuation (S2) intended to be consistent only with one interpretation (relative scoping) of S1. Interpretation was crossed with quantifier-order and with ambiguity to yield 8 conditions. Sample materials for the ambiguous conditions are given in (70a-d), along with the scoping which the continuation sentence was intended to be compatible with. In the corresponding unambiguous conditions in (e-h) the quantifier *a* was replaced by *a different*

¹²Gillen (1991) used a similar technique and design in her final studies, but her results have not had a wide impact because they have never been available outside her dissertation.

(for wide-scope *every*) or *the same* (for narrow-scope *every*).

(70) Ambiguous Conditions

a/b. *A kid climbed every tree.*

a. *The kid was full of energy.*

forward scope: *a > every*

b. *The kids were full of energy.*

inverse scope: *every > a*

c/d. *Every kid climbed a tree.*

c. *The tree was full of apples.*

inverse scope: *a > every*

d. *The trees were full of apples.*

forward scope: *every > a*

Unambiguous Conditions

e. *The same kid climbed every tree. The kid was full of energy.*

f. *A different kid climbed every tree. The kids were full of energy.*

g. *Every kid climbed the same tree. The tree was full of apples.*

h. *Every kid climbed a different tree. The trees were full of apples.*

Participants read the quantified sentence, which was presented all at once, pressed a button, then read the continuation sentence and indicated if it was a good continuation for the quantified sentence by pressing a key. K&MacD reported the percentage of cases where subjects judged the continuations compatible.

The results indicated that the forward scoping of subject over object was significantly preferred in the ambiguous sentences. Continuation (a) was judged compatible more often than continuation (b) in (a/b) (about 81% vs. about 23%) and continuation (d) was judged compatible more often than continuation (c) in (c/d) (about 74% vs. about 46%). Furthermore, the preference for forward scoping was bigger for the *a-every* order (a/b) than for the *every-a* order (c/d). This difference between orders primarily came from the difference in the compatibility rates for the inverse-scope continuation. While the forward-scope continuation was accepted marginally more often in the *a-every* order than in the *every-a* order, the inverse-scope continuation was accepted significantly less often in the *a-every* order.

The passivized versions of the quantified sentences from Experiment 1 were used as

materials for K&MacD's second experiment. The continuation sentences did not change. Thus (70a) became: *Every tree was climbed by a kid. The kid was full of energy.* The same design and procedure were employed. The results yielded a slight preference for wide scope on the subject in the ambiguous conditions, significant by participants but not by items. Overall, the compatibility judgements for the ambiguous passive items were in the 50-70% range, compared to 20-80% for the ambiguous active items in Experiment 1. The compatibility rate for the unambiguous items was comparable for the two experiments (75-95%).

In addition to the factors already discussed, K&MacD also manipulated the type of verb in the quantified sentence. The verb was either an action verb like *climb* (where the subject receives an agent thematic role) or a perception verb like *see* (where the subject receives an experiencer thematic role). For both verb-types the object is assigned a theme role. This manipulation was included in order to test the Thematic Hierarchy Principle. It predicted that stronger scope preference should be found with action verbs than with perception verbs, since the thematic roles of the QPs in action-verb sentences were farther apart on the hierarchy. There were some effects of verb type (action/perception) in both actives and passives which suggested that the Thematic Hierarchy Principle was playing a role in determining the preferred scoping.

From the combined results of these two experiments, Kurtzman & MacDonald concluded that more than one principle is involved in determining quantifier scope. At least one principle which favors forward scoping in both actives and passives (such as the Linear Order or C-command Principle) is needed, as well as at least one which favors forward scoping in actives but inverse scoping in passives (such as Thematic Hierarchy Principle, which also can account for verb-type effects). K&MacD suggested that the two scope interpretations of a quantified sentence are initially considered in parallel. When the scope principles converge on a particular scoping, as in actives, that scoping is strongly preferred. When two principles are in conflict, as in passives, one scoping is chosen at random, so that there is no consistent preference for one

scoping or the other.¹³

K&MacD ran two other experiments, employing sentences containing complex NPs in which one quantified phrase was contained within another (such as, *George has every photograph of an admiral*). The review of these experiments is postponed until Chapter 5.

Single Reference and Discourse Subordination. Kurtzman & MacDonald's Experiment 1 finding that a subject *a*-phrase seems to have a stronger preference for wide scope than a subject *every*-phrase deserves some discussion. To handle this result they formulated the Single Reference Principle, which says that "when an *a*-phrase in the surface subject or topic of a sentence is received it is immediately interpreted as referring to just a single entity" (p.257; see also J. D. Fodor, 1982). They argued that this principle is plausible "because single reference is easier to represent than multiple reference and because single reference is always possible and often obligatory." (p.257) They noted that in (71a/b) (repeated from (70)) it is only at the point where the object *every tree* is encountered that it makes sense to consider the possibility that the subject *a kid* may have multiple reference. But by that time the processor, guided by the Single Reference Principle, has already adopted a single reference interpretation of *a kid* and switching to representing multiple reference would be complex and difficult. As a consequence, the preference for wide scope on *a kid* in (71a/b) is strong.

- (71) a/b. *A kid climbed every tree.*
- a. *The kid was full of energy.*
 - b. *The kids were full of energy.*
- c/d. *Every kid climbed a tree.*
- c. *The tree was full of apples.*
 - d. *The trees were full of apples.*

On the other hand, when the processor reaches the object *a tree* in (71c/d) it has a choice of

¹³While there is a difference between actives and passives in K&MacD's study which should be accounted for, recall that Catlin & Micham (1975) and Gillen (1991, Experiment 6) did not find such a contrast, suggesting caution.

interpreting it as referring either to a single entity or to multiple entities without having to undo any of the previously established representation. Hence, although subject phrases in general prefer wide scope, this preference is not as strong in (71c/d) as it is in (71a/b) since in (71c/d) other factors can override it without much cost.

A number of criticisms can be raised in regard to the Single Reference Principle. First, from a processing point of view, if the reasoning behind it is sound, the Single Reference Principle ought to fall out of more general processing considerations, such as some form of an Immediate Interpretation Principle.

Second, in an approach to processing which is informed by linguistic theory, one which posits semantic and discourse-based levels of representation, the issue of switching from single to multiple reference does not arise. For example, in Discourse Representation Theory (DRT) (see Kamp 1981; Heim 1982) it is not more complicated to represent multiple reference than it is to represent single reference for a sentence like *Every kid climbed a tree*. To be more precise, multiple reference is simply not represented in this case. On the reading in which *every kid* has scope over *a tree* it is possible that there are different trees for different kids but it is not required, so only a single variable is set up for *a tree*. As a later step, at a higher, non-linguistic, level, there may be inferencing to a group of trees, but this is not represented in the discourse structure and is unlikely to effect the cost of linguistic analysis. (Subsequent sentences may require that the group be represented, but in that case any cost is associated with the sentence which requires it, not with the original sentence.) In other words, single reference is the only possible representation for an *a*-phrase, no matter what its position.

This reasoning undermines the Single Reference Principle and Kurtzman & MacDonald's account of the finding that in subject position an *a*-phrase prefers wide scope more than an *every*-phrase does. As mentioned above, this finding arises from the inverse scope continuation having a lower acceptance rate in the *a-every* order (plural; about 23%) than in the *every-a* order (singular). Rather than take the acceptance of the singular continuation in the *every-a* order as

evidence for the *a>every* scoping, as K&MacD do, I would like to suggest that it could be evidence for the *every>a* scoping.

First, as just noted, semantically the singular continuation is not necessarily compatible only with a wide-scope indefinite reading. *Every* could be given wide scope in (71c/d) but it could turn out that it was the same tree for each kid (despite the fact that multiple trees would also be allowed). Kurtzman & MacDonald acknowledged this point, but claimed that to achieve the same-tree reading the indefinite must receive a specific interpretation (e.g. reference to a particular tree). They argued that a specific reading would be extra work for the processor, involving the inclusion of a specificity marker in the representation, so it is unlikely to be employed. However, the assumption that the indefinite must be specific is not supported. The *every>a* scoping allows the indefinite to be associated with a single entity when it is interpreted existentially/weakly as well, as paraphrased below:

(72) *For every kid, there was a tree that that kid climbed. (It turned out that) it was the same tree that all the kids climbed.*

Second, continuation (71c) also makes sense when it is given the interpretation in (73). This interpretation is only available when *every* is given wide scope.

(73) *In each case the tree that was climbed was full of apples.*

This reading is obtained through a semantic process called ‘discourse subordination’ (Kadmon 1987; Roberts 1987b) by which the second sentence (S2) is construed as part of the first sentence (S1) rather than as independent. A result of this construal is that the variable which is set up in the discourse structure for *a tree* in S1 can be picked up anaphorically by *the tree* in S2. What is said about *the tree* in S2 is then applied to that variable. In this particular case, *was full of apples* falls under the scope of *every* in the discourse structure just as *a tree* does. Anything which is a tree and which was climbed by a kid must also be full of apples. (Without discourse subordination, each sentence would be independent in the discourse representation, and *a tree* would be too embedded in the representation of S1 to be picked up by *the tree* in S2.)

Many noted examples of discourse subordination contain modals such as *could, would, might* ('modal subordination,' Roberts 1987b): *There might be a thunderstorm. It probably would destroy our peas.* In this instance, *would* in S2 must be interpreted under S1, as if the sentence read: *If there were a thunderstorm, it would probably destroy our peas.* Kadmon (1987:190) notes that the subordination process is often "triggered by the need to find an antecedent for an anaphoric element in [S2], and licensed by plausible narrative continuity between [S1] and [S2], and by a match in mood and reference time between them." Given these restrictions, it is unclear how common a semantic phenomenon discourse subordination is.

Similar to (71c), there is a subordinated reading available for the continuation in (71a) when *every* is given wide scope in the initial sentence:

(74) *A kid climbed every tree. In each case the kid in question was full of energy.*

Discourse subordination is more difficult here, where the anaphora is back to the subject variable, than in (73), where the anaphora is to the object. Sells (1985) suggests that in general subordination is easier with objects because it is usually the object DP which is the phrase which anaphora is expected to pick up. Another possible reason for the difficulty here is that subordination requires the dispreferred scoping for S1, with wide scope on *every*.

Once the fact that the *every kid > a tree* scoping does not require multiple trees is acknowledged and/or the possibility of discourse subordination is admitted, we have an alternative account of the finding that the so-called inverse-scope continuation is accepted more often in the *every-a* order than it is in the *a-every* order (i.e. why (c) is accepted more often than (b)). Now, we must consider the Yes responses for (c) to be a combination of two things: first, cases where the reader gave *a tree* wide scope, and second, cases where the reader gave *every kid* wide scope and assigned the same tree to each kid or subordinated the continuation. This brings the Yes responses up overall. There is no corresponding way for (b) to be considered acceptable more of the time.¹⁴

¹⁴Ted Gibson (p.c) notes that the plural continuation (b) is compatible with the *a>every* scoping in (a/b) if one assumes there are other kids around who didn't climb trees. Such an
(footnote continued ...)

2.5.2.9 Summary of Experimental Results on Scope Preferences

The results of the experiments reviewed above support the notion that individual quantifiers have an effect on scope preferences. Exactly why certain quantifiers seem to want wide scope more than others and how this interacts with other factors has yet to be determined. Evidence for the role of linear order, c-command, and grammatical function or thematic role in resolving scope ambiguities is mixed. VanLehn, Fodor, Gillen, and Kurtzman & MacDonald argued that linear order of the QPs and/or c-command relation between them are critical factors. K&MacD felt that the thematic roles of the QPs (which are related in part to their grammatical functions) is a determinant as well. On the other hand, Ioup, Catlin & Micham, and Micham et al. maintained that the grammatical functions of the QPs (at deep and/or surface structure) is more important than linear order and/or c-command. Why any of these factors should matter was often not addressed.

As for the studies themselves, a few comments are in order. First, in Ioup's, VanLehn's, and Gil's gathering of intuitive judgements, the number of informants and items used is unknown. This fact makes it hard to judge the generality of their results. Second, because the tasks used by Catlin & Micham and Micham et al. (and by Gillen in some of her experiments) invited the participants to reason about the quantified sentences, it is unclear whether their findings will extend to cover how people deal with scope ambiguities when they are simply reading. Although K&MacD's method was the much closer to a normal reading task, it still involved a judgement component, which they themselves note may have induced participants to resolve the scope ambiguities earlier than usual.

assumption is likely only in certain contexts, such as where a group of kids went to a park. Furthermore, the same observation can be made with respect to continuation (d) in (c/d), so this idea does not increase the relative acceptability of (b) vs. (d).

2.6 Research Aims

In this chapter I have reviewed some semantic properties of quantifiers, including weak vs. strong interpretations and the tripartite structure that quantifiers enter into in the discourse/semantic representation. I have described the notion of relative scope of two quantifier phrases, the meanings associated with various scopings, the way in which different relative scopings are obtained in the syntax, and the idea that some scopings are costly to obtain. In addition, I have surveyed the studies which have been conducted in psychology and psycholinguistics on the processing of quantifiers and quantifier scope.

How the processor arrives at a particular scoping has not been specified in detail in previous work on scope preferences. In the psycholinguistic literature, the building of an LF representation for scope has generally not been considered. Yet the relative scoping of two QPs is defined at the level of LF, so this issue is critical. In the following chapter, I will argue that the general process for constructing LF representations is the primary factor in determining the preferred scoping of a doubly-quantified sentence. The observation that c-command often plays a strong role in determining scope preferences will fall out of this theory.

In later chapters, I will consider the influence of particular quantifiers in resolving scope ambiguities. I will show that *each* wants wide scope more than *every*, but only under certain circumstances. The differences with respect to scope between *each* and *every* will be traced to differences in the semantic conditions which are part of their meaning.