

OPTIMALITY THEORETIC SEMANTICS¹

ABSTRACT. The aim of this article is to elucidate the processes that characterize natural language interpretation. The basic hypothesis is that natural language interpretation can be characterized as an optimization problem. This innovative view on interpretation is shown to account for the crucial role of contextual information while avoiding certain well-known problems associated with compositionality. This will become particularly clear in the context of incomplete expressions. Our approach takes as a point of departure total freedom of interpretation in combination with the parallel application of soft constraints on possible interpretations. These constraints can be contextual, intonational or syntactic in nature. The integration of pragmatic and syntactic/semantic information in a system of ranked constraints is proposed to correctly derive the optimal interpretations in cases of nominal anaphorization, determiner quantification and elliptical comparatives.

INTRODUCTION

One of the key principles in formal approaches to natural language is the principle of compositionality. The principle of compositionality expresses the idea that the meaning of a complex expression is derived from the meanings of its parts in combination with the syntactic structure of the expression. However, in order to yield the intended interpretation for quantified, but incomplete or anaphoric expressions, a compositional interpretation based on syntactic structure alone is not always possible. In the interpretation of these expressions, contextual information plays a crucial role. Consider the following sentence:

- (1) Who wants the first one?

¹ We would like to thank the audiences of the 11th Amsterdam Colloquium, December 1997, the TIN-dag Utrecht, January 1998, the 22nd Annual Penn Linguistics Colloquium, March 1998, our ESSLLI '98 Summer school class in Saarbrücken, August 1998, and the Stanford OT-Workshop "Is syntax different?", December 1998. Special thanks go to Jaap van der Does, Chris Kennedy, Jason Merchant, Henriëtte de Swart, and Frank Wijnen for helpful discussions. We have benefited greatly from the suggestions of two referees of *Linguistics and Philosophy* and Anna Szabolcsi. Helen de Hoop furthermore gratefully acknowledges the Netherlands Organization for Scientific Research, NWO (grant 300-75-020). Charlotte Koster kindly checked the English of this paper.



When (1) is uttered in a linguistic context such as *I have a dozen books here*, then the nominal anaphor *one* is readily interpreted as anaphorically linked to the set of books introduced by the linguistic antecedent in the previous utterance. If there is no linguistic antecedent, but the person asking the question is actually carrying a dozen books, then *one* is just as easily interpreted as referring to this set of books. In the movie with the title *Code of Silence*, (1) was uttered in the absence of any linguistic context. Moreover, in the extra-linguistic context there was no set of entities visible that *one* could be linked to. Yet, there were no doubts about the correct interpretation of (1), either in the minds of the viewers of this movie or in the minds of the opponents of the leading actor in the movie. The fact that this actor, world champion karate Chuck Norris, was holding a gun while uttering (1) was apparently sufficient information to arrive at the interpretation where *one* denotes a set of bullets, a non-visible and perhaps empty set in the real context. In fact, if this particular actor would not have had a gun, then *the first one* might have been interpreted as *the first blow or kick*, thus referring to a set of entities that had not even come into existence at the moment of utterance of (1).

We would like to claim that any theory that tries to derive the interpretation of a quantified sentence in a mechanical (algorithm-based) way runs into problems with examples such as (1) sooner or later. Problematic for most approaches to anaphora resolution are cases in which there is no overt antecedent, the meaning of which can be reused. Another main problem for current approaches to anaphora resolution is that they do not account for the fact that certain (optimal) interpretations actually *block* alternative interpretations. Clearly, *the first one* can only be interpreted as *the first blow or kick* when the speaker is not holding a gun and moreover, when a potential antecedent such as *a dozen books* is absent from the preceding context. In this paper, we hypothesize that the interpretation of a syntactically well-formed structure is in principle free. The set of possible interpretations of a natural language expression is reduced through the application of constraints, which can be contextual, intonational, or syntactic in nature. Crucially, we argue that these constraints must be soft, that is, violable and potentially conflicting.

1. PROBLEMS FOR COMPOSITIONALITY

Within model-theoretical semantics, determiners denote relations between sets of individuals. The determiner *most*, for example, denotes a relation between two sets A and B , such that *most AB* is true if and only if $|A \cap B| > |A - B|$. Semantic relations are assumed to be based on syntactic

structure. In English, a determiner forms a syntactic constituent together with a noun and possible modifiers (a so-called N'). In accordance with the principle of compositionality, the N' supplies the first argument of the determiner, namely set *A*. This set *A* is called the domain of quantification. The second argument, set *B*, is supplied by the predicate, that is, the remainder of the sentence.

Such a strict compositional mapping from syntactic structure to semantic structure, however, does not always yield the correct interpretation. Compare the two sentences in (2):

- (2)a. Most ships unload at night.
- b. Most people sleep at night.

The syntactic structures of the sentences in (2) are absolutely identical. Yet, the most unmarked interpretation for (2b) is that what most people do at night is sleep, whereas the most unmarked interpretation for (2a) is definitely not that what most ships do at night is unload. Instead, the most unmarked reading for (2a) is that most ships that unload, do it at night. World knowledge apparently influences what is considered the unmarked quantificational structure of the syntactically equivalent sentences in (2).

Accordingly, the stress that indicates what is considered the focus, the new information, falls at different places in (2a) and (2b) (cf. Partee, 1995). On the preferred readings, *at night* is focussed in (2a) while *sleep* is focussed in (2b). Note that the reverse interpretations for the sentences in (2) are possible and emerge when the stress patterns are reversed:

- (3)a. Most ships UNLOAD at night.
- b. Most people sleep AT NIGHT.

In (3), the domains of quantification are given by the set of ships that do something at night and the set of people that sleep, respectively. That is, the non-focal part of the sentence is considered to be part of the background information that can further restrict the domain of quantification.

Often, the background information in a sentence can be retrieved from the part that gets stress. In Rooth's (1985, 1992) *alternative semantics*, syntactic phrases do not only get an ordinary semantic value, but also a second semantic value, which is called the *focus semantic value* of the phrase. This focus semantic value can be computed mechanically. That is, the focus semantic value of a phrase α is a set of alternatives of the same type as α , from which the ordinary semantic value of α is drawn. The focus

semantic value of a phrase α that is not in focus is the singleton set containing as its unique element the ordinary semantic value of α . Informally, the focus semantic value of a phrase is the set of alternatives obtainable from the ordinary semantic value by making a substitution in the position corresponding to the focussed part. For example, the focus semantic value of the VP *SLEEP at night* is the set of properties of the form *X at night*, that is, ‘do something at night’. The set of alternatives that is computed on the basis of focus alone, usually has to be further restricted by the context in order to get the correct meaning for sentences. *Most people SLEEP at night* would never be true if we would take into consideration alternatives like *snore at night*, *dream at night*, *breath at night*, *be (themselves) at night*, etc. What is needed is a contextually relevant set of alternatives, such as, for example, *{sleep at night, work at night, drink at night}*. Rooth (1992) advocates the view that this relevant set of alternatives, the so-called *C-set*, is constrained by the focus semantic value of the phrase, thus leaving room for pragmatic considerations to add further information. In De Hoop and Solà (1996), it is argued that the generalized union over the set of alternatives of a focussed constituent can be used to spell out the context set variable that is always part of the first argument of a determiner (see also Westerståhl, 1985; Geilfuß, 1995).

Note, however, that the determination of what is the background information and what is the focus, and hence the determination of the quantificational structure, is not merely established on the basis of stress. In the absence of an indication of where the stress falls (for instance, in the written sentences in (2)), the reader uses her world knowledge rather than a default stress pattern that would be based entirely on syntactic structure (as proposed by Cinque, 1993; Reinhart, 1995) to choose the most unmarked interpretation. Apart from that, it appears that the actual stress pattern does not always lead to the determination of the domain of quantification, as is illustrated by the following text:

- (4) Ships are usually very active during the night. Many of them pass through the lock at night. And most ships UNLOAD at night as well.

The last sentence in (4) does not get the interpretation of the isolated sentence in (3a), that is, most ships which do something at night, unload at night. Instead, the interpretation that is obtained is the unmarked interpretation of (2a), namely that most ships that unload, do it at night. The first sentence of (4) is about the fact that ships are active during the night. This is specified in the subsequent sentences while the quantificational structure is kept constant. In other words, *at night* is linguistically old information,

but it is still part of the information that provides the second argument set for the determiners *many* and *most*. This type of phenomenon is analysed as *second occurrence focus* by Krifka (1995) and Partee (1995). The important thing to note here is that a focussed part of the sentence, which provides new information, can be part of the domain of quantification as well. That is why stress falls on *pass through the lock* and *unload*: Many ships (old) that pass through the lock (new), pass through the lock at night (old). And most ships (old) that unload (new), unload at night (old). The stress does indicate the focus, but this focussed part is nevertheless part of the domain of quantification. That this is possible is in itself not surprising of course, but in the present example the stress falls on an element that is also syntactically part of the second argument. For second occurrence expressions, the explanation could be that the quantificational structure is inherited while the repeated element gets deaccented because of repetition. However, Vallduví (1990), De Hoop (1995), and H. Hendriks (in preparation) all argue that there is no necessary link between focus and the argument structure of quantifiers. There are contexts in which there need not be an explicit mention of the nonfocal part of the sentence in the previous discourse.

The explanation for the intonational pattern in (4) lies in the fact that one function of focus (i.e., indicating what is the new information in a sentence) is more essential than the other one (helping to determine the domain of quantification). In accordance with the observations made in Vallduví (1990), De Hoop (1995), and H. Hendriks (in preparation), we conclude that under contextual pressure (either at sentence level or at discourse level), focus may cease to function as a guide in determining the domain of quantification of a determiner. Although focus can help to determine the contextually needed set of individuals that restricts the domain of quantification by equating it with the set of alternatives for the argument that contains the focus, there is no necessary link between focus and this contextually relevant set of alternatives.

More generally speaking, it can be argued that context always restricts the domain of quantification. In the following quantified expression, context even completely determines the domain of quantification:

- (5) Most were rejected.

The noun which is supposed to provide the domain of quantification has been omitted. Hence, the domain of quantification in (5) is determined by the context, not by lexical information present in the sentence. It might be that the domain of quantification in (5) can be recovered by means of a linguistic antecedent that is functioning as the discourse topic at a given

time. It might as well be, however, that somebody utters (5) out of the blue. In that case, some hearers may assume that the speaker is talking about the abstracts for the 1997 Amsterdam Colloquium, whereas others might think she quantifies over the submissions for a certain grant. In fact, any set of individuals can function as the domain of quantification in (5) as long as the linguistic or extra-linguistic context does not provide us with any clues on which interpretation is actually meant. As soon as the topic of conversation is the abstracts for the 1997 Amsterdam Colloquium, however, this mere fact restricts the set of possible domains of quantification in (5). That is, the Gricean maxim ‘*Be relevant*’ is at work here and reduces the set of possible interpretations (5) can have.

At this point, consider the sentence in (6):

- (6) Most were rejected because of their LENGTH.

In (6), there is no N' to provide the quantificational domain of *most*. If we want to derive the interpretation of (6) compositionally, we must assume the presence of an empty N' . The content of this empty N' is identified by the context, or, alternatively, this empty N' denotes the whole domain of individuals and gets intersected with a context set variable (Westerståhl, 1985). But in fact, we then need two context set variables. One would be equated with the generalized union over the set of alternatives for the syntactic argument that contains the focus (Geilfuß, 1995; De Hoop and Solà, 1996), such that the quantificational domain would become the set of things rejected because of some reason. The other one would be equated with some additional context set, for example, the set of abstracts for the Eleventh Amsterdam Colloquium. Hence, what we get as the domain of quantification is something like $(A/E \cap X \cap C)$. But how many contextual restrictions can or should we add before we may calculate the truth conditions of a quantificational sentence?

The data described above make clear that building interpretation on syntactic structure alone has serious shortcomings. Context as well as intonation play a major part and the question arises when, how and to what extent people use different principles to arrive at the proper interpretation of a quantified expression in a given context.

Similar problems for compositionality arise with comparative constructions. Comparatives are typically analyzed as quantificational expressions, quantifying over degrees (although see Kennedy (1997) for a different view). In such an analysis, the comparative morpheme (i.e., *more*, *less*, *fewer*, *as* or the comparative suffix *-er*) defines a relation between two degrees: one introduced by the matrix clause (this degree is usually referred to as the reference value) and one introduced by the comparative

clause, that is, the complement of *than* or *as* (this degree is usually referred to as the standard value). In particular, these degrees are introduced into the semantics by gradable adjectives, gradable adverbs or quantifiable nouns, which denote relations between objects and degrees (or quantities, in the case of nominal comparison). Although full comparative clauses are possible, elliptical comparative clauses are more common. Indeed, comparative deletion constructions as in (7b) and phrasal comparatives as in (7c) occur more frequently than full comparatives as in (7a) (Rayner and Banks, 1990). This difference is reflected in the fact that young children (4–6 year olds) find it much easier to comprehend comparative deletion comparatives and phrasal comparatives than full comparatives (Snyder et al. 1995). Note that the full comparative in (7a) is in fact incomplete as well, since the compared element in the comparative clause is assumed to be preceded by an empty position, trace or degree variable. This assumption is based on the unacceptability of an overt degree-like element in this position (**Jane ate more peaches than Jacky ate two grapes*). The obligatory absence of a degree-like element in comparatives is referred to by the name ‘subdeletion’ (cf. Bresnan (1975)).

- (7)a. Jane ate more peaches than Jacky ate grapes.
- b. Jane ate more peaches than Jacky ate.
- c. Jane ate more peaches than Jacky.
- d. Jane ate more peaches.
- e. Jane ate more.
- f. Jane more.
- g. More.

According to Rayner and Banks (1990), the most frequently occurring comparatives are discourse comparatives, that is, comparatives without a *than*-clause or *than*-phrase, illustrated in (7d). Note that it is possible to omit even more material from a comparative construction. For example, (7e) and (7f) can be used in response to the utterance *Jacky ate fewer peaches than Jill*, and (7g) is a possible correction of this utterance: *No, more!* In principle, all material except for the comparative morpheme can be omitted from a comparative construction, without the comparative becoming uninterpretable. Of course, since suffixes cannot appear on their

own, the comparative suffix *-er* must always appear together with the compared adjective:

- (8) Q: Can we really bury something this big?
 A: Bigger ... (from the movie *Q & A*, U.S.A. 1994)

So ellipsis can take several forms in comparative constructions. The question is how we can arrive at a principled account of the interpretation of elliptical comparative constructions. Approaches to ellipsis resolution generally aim at either (re)constructing a syntactically complete or a semantically complete representation of the elliptical construction.

The first position includes the deletion approach (already advocated by Bresnan (1975) for comparative deletion and subdeletion), the LF-reconstruction approach (cf. May (1985), Fiengo and May (1994); proposed for comparatives by Hazout (1995) and Kennedy and Merchant (1997), a.o.) and the null proform approach (cf. Chao (1987), Hardt (1992, 1993), Lobeck (1995); see Pinkham (1982) for a null proform analysis of comparatives).

A null proform approach could not account for comparative deletion, since the ellipsis site for comparative deletion must contain a subdeletion variable to account for the interpretation of these constructions (for example, the elided material in (7b) must be of the form *x-many peaches* or *e peaches*, where e_x is the empty position left behind by a null operator which has moved to SpecCP of the comparative clause). Johnson (1996) argues on the basis of similar examples that a null proform approach is not tenable for VP ellipsis, since a structured ellipsis site goes against the basic idea of a proform. The same argument can be used to argue against a null proform analysis of comparative deletion. Problematic for a deletion account as well as a reconstruction account of ellipsis are cases in which the antecedent is syntactically non-identical to the elided material (9) or in which there is no overt antecedent (10).

- (9) Mary ran faster than the world record. (Pinkham, 1982)
- (10) [context: Mabel Minerva, a Central Park rental horse, begins galloping at full speed with the terrified Fred atop]
 Fred: “No, no! Don’t” (Johnson, 1996)

The verb which is missing from the comparative clause in (9) clearly cannot be identical to the finite verb in the matrix clause, since world records do not run. But if the missing material and its antecedent are not identical, unless additional assumptions are made, recovery of the deleted material

or LF-copying will yield the wrong result. Note that if it is assumed that LF-reconstruction takes place under the same conditions as deletion, that is, under identity of some sort, the LF-reconstruction approach can be considered a notational variant of the deletion approach (Heim, 1985). An example which is similar to the VP ellipsis case in (10) is the following elliptical comparative:

- (11) [context: Jane is standing in front of Jacky, holding a full pot of coffee. Jacky is just finishing the coffee in her cup]
Jane: “Would you like some more?”

Clearly, if no antecedent is overtly present in the sentence or direct linguistic discourse, there is no way the deleted material can be recovered or LF-copying can take place.

The second position with respect to ellipsis resolution involves the construction of a semantic representation on the basis of the elements that are actually present in the sentence (instead of on the basis of a null proform or trace). Such a direct interpretation approach is characteristic of categorial grammar (see Jäger (1997), Morrill (1994), Morrill and Solias (1993), for categorial approaches to ellipsis, and Accuosto and Wonsever (1997) and P. Hendriks (1995) for categorial analyses involving comparatives), yet not limited to this framework. For example, Kennedy (1997) argues for a direct interpretation approach to elliptical comparatives within a generative framework. Assuming a direct interpretation approach, compositional interpretation is driven by the lexical semantics of the elements present in the sentence. Therefore, certain lexical elements have to be assigned a new semantic type for every new type of ellipsis. In view of the variation in ellipsis possible in comparatives (see (7) for only a few of the possibilities), this could result in an explosion of semantic types for one lexical element. Furthermore, cases like (9) and (11) above, in which there is no overt antecedent present in the sentence, constitute a major problem for direct interpretation approaches. These approaches account for the interpretation of elliptical sentences by re-using meanings that have been introduced elsewhere in the sentence, either by copying these meanings as part of the proof derivation (Jäger, 1997) or through unification of the anaphoric term and the antecedent term (Kennedy, 1997; Morrill, 1994; Morrill and Solias, 1993). When there is no antecedent present in the sentence, however, there is no meaning available that can be re-used.

Multiple head comparatives as in (12) and (13) form a challenge to all approaches to ellipsis resolution discussed so far.

- (12) Less land produces more corn than ever before. (Von Stechow, 1984)

- (13) Nowadays, more goods are carried faster.

To see this, consider the following multiple head comparatives with a non-reduced comparative clause:

- (14) More dogs ate more rats than cats ate mice.
(Von Stechow, 1984)

- (15) *Fewer dogs ate more rats than cats ate mice.

According to Von Stechow (1984) and Corver (1990), multiple head comparatives involve two independent instances of comparison. Thus, in (14) the number of dogs that ate rats is compared to the number of cats that ate mice, and the number of rats that were eaten by dogs is compared to the number of mice that were eaten by cats. The first comparison is established by not taking into account the second occurrence of the comparative morpheme, and the second comparison is established by not taking into account the first occurrence of the comparative morpheme. However, this does not explain the unacceptability of (15), which differs from (14) only minimally in that the first occurrence of *more* is replaced by *fewer*. Moreover, it does not make the correct predictions with respect to the interpretation of an acceptable sentence like (13). This sentence does not have an interpretation in which the amount of goods that are carried fast is compared to some other amount. Because comparatives do not entail that the property predicated of the compared elements is true in the absolute sense, the conclusion is not warranted that the goods in (13) are carried fast in an absolute sense. It only follows that the goods are carried faster than some standard value of comparison, which is not what Von Stechow and Corver would predict. Von Stechow convincingly argues against an analysis of multiple head comparatives as involving just one comparison, namely a comparison between two events, for example a rat-eating event and a mouse-eating event in (14); this sentence seems to be false if three dogs share one rat and one cat ate two mice. As a consequence, the only option remaining is that multiple head comparatives involve two *dependent* instances of comparison.² This option, defended by P. Hendriks (1994),

² Note that the two compared elements in (13) are not each compared to some implicit element independently, since they are related by the same predicate. That is, (13) does not mean that more goods than there used to be are carried faster than they used to be carried. Clearly, this sentence does not refer to goods in general, but rather to goods that are carried with a certain speed. Sentence (13) would be false if at a certain point in time two boxes are carried at 20 mph, and at a later point in time there are four boxes, only two of which are carried at 40 mph, whereas the other two boxes are not carried at all. Instead, the most

would explain the unacceptability of (15). If the two instances of comparison are mutually dependent, the first one cannot be interpreted without the second one being interpreted and *vice versa*. According to this claim, the number of dogs that ate more rats than the cats ate mice is compared to the number of cats that ate fewer mice than the dogs ate rats. The mutual dependency lies in the fact that *the cats* in the previous sentence refers to the cats that ate fewer mice than the dogs ate rats, and *the dogs* refers to the dogs that ate more rats than the cats ate mice. Thus, the interpretation of the NP *the cats* is dependent on the interpretation of *the dogs* and *vice versa*. Interpretation thus results in infinite regress, and hence in unacceptability. The acceptability of (14) must then be the result of a vacuous occurrence of *more* analogous to cases of double negation (cf. P. Hendriks (1994)), or possibly of a *more = a lot of* strategy. A consequence of the assumption that multiple head comparatives involve two dependent instances of comparison, however, is that comparatives without a comparative clause or with a highly reduced comparative clause cannot be construed as a complete comparative construction on the level of syntactic representation nor on the level of semantic representation. Thus, the interpretation of the well-formed multiple head comparatives in (13) and (14) is a mystery for strictly compositional, reconstruction-based, approaches to ellipsis resolution.

At this point, we may conclude that in many cases syntactic information is not sufficient to arrive at the correct interpretation of elliptical comparative constructions. The question arises what other factors determine interpretation in this domain. As we saw in the beginning of this section, the interpretation of quantified sentences is strongly influenced by world knowledge and intonation. This can also be observed in comparatives. Sentence (16), for example, has the preferred interpretation that Slonimsky hit more than sixty home runs last year, according to McCawley (1998), who terms this the ‘atemporal stereotype’ interpretation.

- (16) Last year, Slammer Slonimsky hit more home runs than Babe Ruth. (McCawley, 1998)

But this interpretation only prevails if one knows that Babe Ruth died years ago, which makes a comparison between the number of home runs that Slonimsky hit last year and the number of home runs that Babe Ruth hit last year (namely zero) rather meaningless. Note that the atemporal stereotype interpretation is a violation of the constraint on identity of the elliptical

likely interpretation of (13) is that more goods are carried with a certain speed now than were carried with a certain (but lower) speed earlier, and the speed with which these goods are carried now is higher than the speed with which a smaller amount of goods was carried earlier. This clearly reflects the mutual dependency of the two instances of comparison.

material and the antecedent material (which is, in some form or another, crucial to the deletion approach and the LF-reconstruction approach to ellipsis, see the discussion of example (9) in Section 1), unless specific assumptions are made about the representation of tense. In particular, the anaphoric clause must be interpreted outside the scope of the temporal adverb *last year*.

Intonation also plays a role in the interpretation of comparatives. Intonation can reduce the number of interpretations of a potentially ambiguous comparative:

- (17)a. JANE gave Jacky more books than JILL.
 b. Jane gave JACKY more books than JILL.

If *Jane* is focussed in the matrix clause, the comparison is between the number of books that Jane gave to Jacky and the number of books that Jill gave to Jacky. If, on the other hand, *Jacky* is focussed, the comparison is between the number of books that Jane gave to Jacky and the number of books that Jane gave to Jill (cf. Rooth (1992) and Gawron (1995)).

We claim that the information provided by the semantic relation itself is crucial to ellipsis resolution. As was illustrated earlier (see the examples in (7)), in principle all material except for the comparative morpheme, which introduces the semantic relation, can be omitted from a comparative construction. Yet the arguments involved in the relation of comparison can be retrieved from the context quite easily in most cases. Note that the meaning of the comparative morpheme already conveys the information that a comparison is made between two degrees. Material that is present in the sentence is used in determining these degrees, in accordance with the semantics of comparatives. In the absence of lexical material, these degrees have to be determined by other information. The meaning of the comparative morpheme plays an important role here. In case there is no comparative clause present to provide the standard value of comparison, for example, the presence of the comparative morpheme nevertheless makes it clear that what has to be retrieved from the context must be of the appropriate semantic type, namely a description of a degree.

Summarizing, several problems and limitations were pointed out for current approaches to ellipsis resolution applied to comparatives. The semantic relation expressed by a quantifier or a comparative morpheme as well as context appear to play a crucial role in the interpretation. In general, there seems to be no straightforward way to construe a compositional interpretation procedure for elliptical quantified constructions (i.e., for simple quantified sentences as well as for comparatives). Context, intonation and

syntax all interact in the determination of the argument structure of a semantic relation. In Section 3, we will formalize this interaction, but first we will introduce in the next section the necessary tools.

2. SOFT CONSTRAINTS ON INTERPRETATION

The data described in the previous section raise the question whether a line by line constructed compositional meaning based on syntactic structure is feasible at all. P. Hendriks and De Hoop (1997) hypothesized that all possible elements of a certain semantic type may serve as the elements between which a relation can be established by a relational type in a complex expression. Henceforth, we will refer to this hypothesis as the *Free Interpretation Hypothesis*.

The Free Interpretation Hypothesis proceeds from a total freedom in interpretation. That means that an utterance is associated with an, in principle, infinite number of possible interpretations. However, hearers are usually very fast in arriving at one or two optimal interpretations of a syntactic structure. We claim that the possible interpretations are evaluated with respect to certain constraints in a parallel fashion. The constraints that apply are generally of the form: *If there is syntactic material, then use it to determine interpretation; If there is a discourse topic, then use it to determine interpretation*, etc. Crucially, we will see in the next section that many of these constraints can be violated during the interpretation process. So, actually, the constraints should be of the form: *If there is . . . , use it, unless . . .*. The last part should then contain another constraint or several other constraints that also play a role and that are able to overrule the constraint under discussion. An elegant way of capturing such an interaction of conflicting constraints is provided by the framework of Optimality Theory (Prince and Smolensky, 1993, 1997). In the next section, we will formulate constraints that play a role in the interpretation of anaphoric expressions contained in the argument structure of determiners and comparatives. In this section we will outline the basic insights of Optimality Theoretic Semantics, that is, Optimality Theory applied to the interpretive domain.

In Optimality Theory (OT), a grammar consists of a set of well-formedness constraints which apply simultaneously to representations of structures and which are soft. An important subset of these constraints is shared by all languages, forming part of Universal Grammar. Individual languages rank these universal constraints differently in their language-specific hierarchies in such a way that higher ranked constraints have total dominance over lower ranked constraints. The output candidate for an underlying form that best satisfies the constraints is the optimal or winning

candidate. OT has its source in connectionism, or parallel distributed processing, a view on cognition that emerged in the 1980s (cf. Rumelhart et al. 1986).

Crucially for OT is Smolensky's idea of identifying a connectionist notion of well-formedness (Smolensky's (1986) *Harmony*) with linguistic well-formedness. In a connectionist network, the harmony of an activation pattern is a number that measures the degree to which the pattern is well-formed according to the connections in the network. A harmonic grammar can be viewed as a set of soft well-formedness constraints. That these constraints are soft, that is, violable and typically conflicting, implies that an output can never be rejected because it violates certain constraints or too many constraints. An output can only be rejected if there is a better (more harmonic) output available. In OT, no amount of success on weaker constraints can actually compensate for violation of a stronger constraint.

In phonology, morphology and syntax, OT has already proven a powerful and fruitful new tool in linguistic analysis.³ In this paper, we take an OT perspective on semantics and aim to show this to be an improvement compared to the classical compositional interpretation of semantic relations in context. In Section 3, we will review several contextual, intonational and syntactic constraints that play a prominent role in arriving at the optimal interpretations of anaphora and ellipsis. But before that, we would like to elaborate upon the basic assumptions with respect to the role of syntactic structure in the input and output that underlie our Optimality Theoretic perspective on semantics.

In OT syntax, the input is usually considered to be a semantic structure (e.g., a predicate-argument structure), which gives rise to an, in principle, infinite number of syntactic structures of which the most harmonic or optimal one is eventually realized as the grammatical structure that syntactically expresses the semantic input. Thus, OT syntax optimizes syntactic structure with respect to a semantic input. One might say that OT syntax takes the perspective of a speaker, therefore, who has a certain thought and wants to express this correctly and optimally in a syntactic structure.

OT semantics, on the other hand, takes the point of view of a hearer, who hears (or reads) an utterance with a certain syntactic structure and wants to interpret this structure correctly and optimally. In OT semantics, the input is a well-formed syntactic structure, which is associated with an, in principle, infinite number of possible interpretations (in accordance with

³ Interested readers may consult the Rutgers Optimality Archive on the world wide web at <http://ruccs.rutgers.edu/roa.html>, which contains a bibliography as well as many papers in OT.

the Free Interpretation Hypothesis) of which the most harmonic or optimal one is eventually arrived at as the correct interpretation of the syntactic input. The constraints that play a role in this interpretation process can be syntactic, phonological, pragmatic or semantic in nature. Since the set of constraints is assumed to be universal, some constraints may play a role in OT syntax as well. Obviously, then, the crucial difference between OT syntax and OT semantics does not lie in the nature of the constraints under consideration, but in the nature of the input and output forms. That is, in OT syntax, the candidates which are evaluated with respect to the relevant constraints are syntactic structures. In OT semantics, on the other hand, the candidate outputs that are subject to evaluation are interpretations.

3. OPTIMAL INTERPRETATIONS

Given the OT semantics framework outlined in the previous section, the aim of the present section is to develop an analysis of the possible interpretations of elliptical or anaphoric quantificational expressions. Below, we will discuss several general constraints that govern interpretation. The constraints we discuss are not new; they have been linguistically motivated in the literature. What is new is our conception of these constraints as soft. We will show that the constraints are indeed soft, since they can be overruled. When people interpret quantified expressions, they try to satisfy these universal constraints as much as possible and they only violate constraints when this allows them to satisfy the stronger ones.

One very general pragmatic constraint captures the fact that in the unmarked case, (sets of) individuals that are already available in the discourse are chosen as the implicit arguments of semantic relations denoted by determiners and comparatives. One appropriate formulation of such a constraint is found in Williams (1997):

- (20) *DOAP*: Don't Overlook Anaphoric Possibilities. Opportunities to anaphorize text must be seized.

This principle accounts for the fact that there is a general preference to interpret elements as anaphors, related to the previous discourse. *DOAP* can be overruled by other constraints, however. For instance, the syntactic constraint known as *Principle B* is obviously stronger than *DOAP*. We formulate this constraint as a principle that accounts for the syntactic marking

of reflexivity (cf. Farmer and Harnish 1987 and Reinhart and Reuland 1993 for slightly different formulations).

- (21) *Principle B*: If two arguments of the same semantic relation are not marked as being identical, interpret them as being distinct.

Principle B accounts for the strong tendency found in language that a semantic relation is always established between different objects. If a relation is intended to hold between coreferential objects, this has to be linguistically marked if possible. This constraint shows up in the context of transitive verbs as well as determiners and comparatives. Consider for example:

- (22) Has any king ruled as long as Gustav V?

Rayner and Banks (1990) point out that the answer *Yes, Gustav V did* is considered to be very misleading by most people. If the two arguments of a comparative are not explicitly given, hearers obey *Principle B* and interpret the implicit argument as non-identical to the overt argument.

In the following example, the NP *the doctor* and the pronoun *him* cannot both be interpreted as anaphoric to the preceding NP *a doctor*, as observed by Krahmer and Van Deemter (1997):

- (23) Often when I talk to a doctor, the doctor disagrees with him.

Krahmer and Van Deemter claim that the anaphoric interpretation is ruled out because of the implausibility of the resulting reading. If that were the case, however, *the doctor* would not be interpreted as anaphoric in (24) either, but in fact, in (24) the anaphoric reading is obvious:

- (24) Often when I talk to a doctor, the doctor disagrees with himself.

In our view, the anaphoric interpretation in (24) satisfies both *DOAP* and *Principle B*. In (23), however, the anaphoric interpretation is ruled out because it would cause a violation of *Principle B*, thus, *DOAP* is violated, but obviously only in order to satisfy *Principle B*. This can be illustrated in an OT semantics constraint tableau. The inputs are the sentences in (23) and (24). The candidate outputs are the possible interpretations. Only the relevant aspects of the interpretations are indicated, here by means of indexing. The optimal interpretations are marked by the sign α . Violations are indicated by *, fatal violations by !.

(25) *Constraint tableau for the interpretations of (23) and (24)*

Input	Output	Principle B	DOAP
(23) Often when I talk to <i>a doctor</i> <i>the doctor</i> disagrees with <i>him</i>	a doctor ₁ the doctor ₁ him ₁	*!	
	<i>a doctor</i> a doctor ₁ the doctor ₂ him ₁		*
	<i>the doctor</i> a doctor ₁ the doctor ₁ him ₂		*
	disagrees with a doctor ₁ the doctor ₂ him ₂	*!	*
	<i>him</i> a doctor ₁ the doctor ₂ him ₃		**!
(24) Often when I talk to <i>a doctor</i> <i>the doctor</i> disagrees with <i>himself</i>	<i>a doctor</i> a doctor ₁ the doctor ₁ himself ₁		
	<i>a doctor</i> a doctor ₁ the doctor ₂ himself ₁		*!
	<i>the doctor</i> a doctor ₁ the doctor ₁ himself ₂		*!
	disagrees with a doctor ₁ the doctor ₂ himself ₂		*!
	<i>himself</i> a doctor ₁ the doctor ₂ himself ₃		*!*

As can be read off the tableau in (25), two optimal interpretations are obtained for (23), such that *Principle B* is satisfied while the weaker *DOAP* is violated only once (which is the case when either *the doctor* or *him* is coreferential with *a doctor*). For (24) only one optimal interpretation is found. Here *Principle B* is satisfied and the winning candidate also satisfies *DOAP*.

Let us now return to the argument selection of determiners, as discussed in Section 1. If no other constraints apply, then we expect *DOAP* to hold for quantified expressions as well. Consider the following example (italics are ours):

- (26) The buildings are all two and three stories running half a block deep with brick and glass fronts. *Most* were built together, *a few* have narrow alleys between them. *Many* are still boarded up, a *couple* were burned out years ago.
(John Grisham, *The Rainmaker*)

If we assume that argument selection is essentially free, then Williams's *DOAP* will ensure that the incomplete NPs in (26) try to establish an

anaphoric relation with a linguistic antecedent. In general, topics such as the set of buildings introduced in the beginning of the fragment, like to function as the domain of quantification of quantifiers. Hence, if no other constraints apply, then the incomplete NPs are preferably anaphorically linked to the accessible discourse topic *the buildings*.

- (27) *Topicality*: As the antecedent of an anaphoric expression, choose a topic.⁴

Satisfaction of *DOAP* does not depend on the presence of an obvious discourse topic, however. Nerbonne, Iida, and Ladusaw (1990) discuss the difference between sentences like (28) and (29), where different sets of individuals function as the domain of quantification for the second determiner:

- (28) Ten students attended the meeting. Three spoke.

- (29) Most deliveries were on time, but some weren't.

In (28), the preferred domain of quantification for the second determiner is the set of students that attended the meeting. Thus, the set that is chosen as the first argument set of the second determiner is in fact the intersection of the two argument sets of the first determiner. When we look at the formal properties of determiner denotations, this cannot be a coincidence.⁵ Notoriously, one of the basic constraints which are to be satisfied by logical determiners is *Conservativity*:

- (30) *Conservativity*: $Det AB \leftrightarrow Det A(B \cap A)$

That is, in order to determine the truth values of determiner sentences, we only need to be concerned with the set that the noun refers to (i.e., A , the domain of quantification), and the intersection of the sets denoted by the noun and the predicate (i.e., $A \cap B$), whereas we can ignore the rest of set B , that is, $B - A$. In other words, hearers tend to use the relevant part of the second argument set of the first determiner, $A \cap B$, as the domain of quantification of the second determiner. Interpreting the incomplete second NP as such guarantees continuity in topichood, as $A \cap B$ is always a subset of A , and hence always interpretable as a (shifted) topic, cf. H. Hendriks

⁴ Cf. Vallduví (1990) and H. Hendriks and Dekker (1996) for relevant topic definitions.

⁵ Thanks to Ken Drozd for pointing this out to us.

(in preparation) and thereby satisfaction of *DOAP*.⁶ As a matter of fact, the reduction of A to $A \cap B$ can be conceived of as a reduction of a topic range, which results in an increase of informativeness in the framework of Van Kuppevelt (1996). Van Kuppevelt refers to these cases (where $A \cap B$ is taken to be functionally dominating A) as *Forward Directionality* of the discourse. Directionality appears to be a topic structural property of discourse. We use the name *Forward Directionality* for the following constraint:

- (31) *Forward Directionality*: The topic range induced by the domain of quantification of a determiner (set A) is reduced to the topic range induced by the intersection of the two argument sets of this determiner ($A \cap B$).

Using the intersection of two argument sets of a previous determiner rather than its domain of quantification A might furthermore speed up processing (since $A \cap B$ is the last activated set of individuals).

So, if we simply assume that the argument sets of a determiner are preferably anaphorically linked to the intersection of the two argument sets of a preceding determiner, in accordance with *Forward Directionality*, then we account for the interpretation that is preferred in (28). In (32), however, we cannot get this reading (because $12 > 10$) and another interpretation emerges, namely the one where the first argument set of the preceding determiner (the set of all students) determines the domain of quantification of the second determiner as well.

- (32) Ten students attended the meeting. Twelve spoke.

Similarly, the determiner *some* in (29) takes as its domain of quantification the same set of deliveries that functions as the domain of quantification for *most*. Nerbonne, Iida, and Ladusaw actually claim that what they call the *restrained* reading in (28) is impossible in (29) due to the true quantificational nature of the quantifier *most* (as opposed to referential indefinite and definite NPs). In fact, however, it is the contrast between the two predicates in (29) (*most were*, *some weren't*) that triggers the unrestrained reading here. Using the second argument set $A \cap B$ of the first determiner as the domain of quantification of the second, would imply a violation of the pragmatic constraint *Avoid Contradiction*.

- (33) *Avoid Contradiction*.

⁶ An expression is a shifted topic when its discourse referent Y is anaphoric to an antecedent discourse marker X , such that Y is a proper subset of X , $Y \subset X$ (cf. H. Hendriks (in preparation)).

This constraint also triggers the unrestrained reading in a configuration with a weak determiner. By the way, satisfaction of this constraint goes hand in hand with satisfaction of a constraint that favors parallel interpretation (an extensive discussion of this constraint is given in the next section).

- (34) *Parallelism*: As the antecedent of an anaphoric expression, choose a parallel element from the preceding clause.

But if the predicate of (28) is used, then the restrained reading is the preferred one, also in the context of *most*, that is, *Parallelism* is violated in order to satisfy *Forward Directionality*.

- (35) Ten students attended the meeting. Three didn't.
 (36) Most students attended the meeting. Three spoke.

In (36), the most unmarked reading is that three of the students who attended the meeting spoke, contrary to what Nerbonne, Iida, and Ladusaw would predict.

So far, the principles that appear to direct the hearer towards choosing certain sets in the discourse as the argument sets of a determiner cannot be analyzed as hard constraints. That is, we have observed that the constraints that play a role can be overruled in certain circumstances. The constraints that restrict the set of possible interpretations must be soft in nature, that is, violable. Hence, the derivation of the final (set of possible) interpretation(s) of an incomplete expression is not simply a matter of the syntactic or semantic properties of the elements in the sentence but it also involves taking into consideration the context in order to decide whether alternative interpretations are to be preferred or not on the basis of the constraints that apply. So far, we have not given an explicit ranking of the constraints involved. The partial rankings that are implicitly present in the discussion above can be reflected as follows:

- (37)a. Principle B \gg DOAP
 b. Avoid Contradiction \gg Forward Directionality \gg Parallelism

The interaction between *Forward Directionality* and another pragmatic constraint might be used to explain some results from psycholinguistic studies with respect to the interpretation of plural discourse anaphora (cf. Kamp and Reyle, 1993) as described in Sanford, Moxey, and Paterson

(1994). The relevant constraint that conflicts with *Forward Directionality* in certain cases should state that anaphors are not linked to sets that are or may be empty.

- (38) *Emptiness*: As the antecedent of an anaphoric expression, do not choose a set that is or may be empty.

Sanford et al. discuss the fact that subjects who were asked to continue a sentence such as in (39), choose a continuation such as in (b) far more often than one like in (a) (in fact, in nearly 100% of the cases, a continuation such as the one in (b) is chosen):

- (39) Not all of the linguists went to the party. They . . .
- a. They drank a lot.
 - b. They stayed at home instead.

Note that the continuation in (40b) (with the determiner *some of the* instead of *not all of the*) does not occur, as it is not acceptable:

- (40) Some of the linguists went to the party. They . . .
- a. They drank a lot.
 - b. #They stayed at home instead.

The difference between (39b) and (40b) can be explained once we take into consideration the fact that *not all of the linguists went to the party* would be false in a situation in which all the linguists went to the party. This does not hold for *some of the linguists went to the party*: these can be all the linguists there are in a certain context:

- (41) Some of the linguists went to the party, in fact all of them did.

In other words, the set of linguists that did not go to the party can be empty in (40), but it cannot in (39). A pronoun such as *they* refers to a contextually relevant set of individuals. In a context such as in (39) there are two subsets of A available, the set of linguists that did go to the party ($A \cap B$) and the set of linguists that did not go there ($A - B$). We have seen that the first one is an obvious antecedent and using it for the reference of *they* would satisfy *Forward Directionality*. Yet, this set can be empty, whereas by definition the second set (i.e., $A - B$) cannot be empty. This can account for the fact

that people choose a continuation as given in (39b) more often than one like in (39a). In (40), on the other hand, it is the set of linguists that went to the party that cannot be empty. The choice of this set as an antecedent for *they* satisfies both *Forward Directionality* and *Emptiness* and hence, the alternative can never be optimal.

At this point, we make explicit a syntactic constraint on determiner interpretation that appears to be so strong that it has been implicitly satisfied so far.

- (42) *Syntactic Structure*: If there is an N' that constitutes an NP together with a determiner, use this N' to restrict the domain of quantification of that determiner.

This constraint requires all material in the N' to end up in the first argument set, set A . This in itself accounts for the fact noted with respect to sentences such as (43) by Partee (1995), among others. That is, the set of individuals denoted by the N' always restricts the domain of quantification, whether it contains an element in focus or not. The domain of quantification of *most* in (43) cannot just be the set of people that sleep at night, therefore.

- (43) Most LAZY people sleep at night.

In our judgement, *Syntactic Structure* remains undominated. There have been proposals in the literature, however, that seem to suggest that *Syntactic Structure* can be overruled under certain conditions as well (see for discussion on this matter, Herburger, 1997; Eckardt, 1999; De Hoop and Solà, 1996; Geilfuß, 1995).

Finally, we need to address the question of the role of intonation in the determination of the argument structure of a determiner. In Section 1, we pointed out that the domain of quantification of a determiner can be restricted by a contextually determined set of alternatives to a constituent that contains an element in focus, following De Hoop and Solà (1996). We will follow H. Hendriks (in preparation), who proposes a unified theory of shifted topic and focus, arguing that topics come with their own contextual restrictions which subsume the so-called association with focus effects of focus-sensitive quantifier expressions. Obviously, a contextually determined set of alternatives can be assimilated with an antecedent set X for an anaphoric set Y , such that $Y \subseteq X$ (cf. H. Hendriks and Dekker (1996)). In other words, we do not need a separate constraint to handle the influence of (intonational) focus in the determination of the argument structure of a determiner. This influence is subsumed under the general constraints *Topicality* and *Forward Directionality*. Extensions of this general approach that also handle presuppositions (cf. Van der Sandt (1992) and Beaver (1997)) have to await the results of future research.

To sum up, the domain of quantification of a determiner is preferably a set of individuals Y that is anaphoric to an antecedent set X , in accordance with *DOAP*. *DOAP* is satisfied whenever the anaphoric relation satisfies *Topicality*, *Forward Directionality*, or *Parallelism*. Constraints that interact with these constraints on anaphoricity are *Avoid Contradiction*, *Emptiness*, and the unbeaten constraint *Syntactic Structure*.

4. PARALLELISM

In this section, we will elaborate on the constraint on parallelism. As is well-known from the literature, parallelism plays an important role in the interpretation of ellipsis and anaphora (Dalrymple et al., 1991; Gawron, 1995; Hobbs and Kehler, 1997; Kehler, 1993; Prüst, 1992; Sag and Hankamer, 1984). As we already suggested above, parallelism is in fact a soft constraint. When there are more interpretations possible, interpretations that respect parallel relations between anaphors and possible antecedents are to be preferred, but only as long as they are not ruled out by other, stronger, constraints. In our view, parallelism is a constraint on interpretation in general, and not a property of the mechanism for ellipsis resolution. Indeed, as psycholinguistic experiments reveal, parallelism cannot be the result of LF-copying since parallelism effects also occur with *do it* anaphors, as shown by Murphy (1985) and Tanenhaus and Carlson (1990). These authors found that syntactic parallelism affects the speed with which both implicit VP anaphors and overt *do it* anaphors are interpreted, an effect that cannot be explained by assuming a distinction between the way surface anaphors (for example, VP anaphors) are being processed and the way deep anaphors (such as *do it* anaphors) are being processed (cf. Sag and Hankamer (1984)), but which seems to be in accordance with the Optimality Theoretic semantics approach defended here. That is, parallelism reduces the set of possible interpretations of a sentence to one, namely the parallel interpretation, in cases where no stronger constraints are in conflict with parallelism. Note that if parallelism indeed is a soft constraint, it cannot determine the contrasted elements in a comparison in all cases, *contra* the underspecification approach to comparative ellipsis proposed by Gawron (1995).

Before we start our discussion of parallelism in the context of quantified sentences, first note that parallelism is not a single constraint but rather a family of constraints. Different types of parallelism have been proposed that all seem to play a role in the interpretation of elliptical and anaphoric sentences: structural parallelism between an anaphoric element and its antecedent, thematic parallelism between these elements, parallelism in

the linear order of these elements, focal parallelism, structural parallelism between the remaining material in an anaphoric clause and corresponding material in the antecedent clause, and parallelism between the attachment site of an anaphoric clause and of its antecedent clause. On the other hand, it has been observed that no notion of parallelism seems to hold in all cases (van Leusen, 1994; Williams, 1997). This already suggests that parallelism must be a family of soft constraints. In the remainder of this article, we will show the effects of parallelism on the interpretation of elliptical quantified expressions and elliptical comparatives.

A type of parallelism that was already witnessed to play a role in simple quantified expressions is the parallelism between the two argument sets of determiners in two successive sentences. If, in the second sentence of two successive sentences, the noun which is supposed to provide the first argument set has been omitted, the domain of quantification of the determiner in this sentence might be determined by the noun in the preceding sentence that provides the first argument set in that sentence. This type of parallelism indeed holds for the following sentence, where *deliveries* in the first conjunct provides the first argument set for the determiner *some* in the second conjunct:

- (29) Most deliveries were on time, but some weren't.

Now consider the following two Dutch sentences:

- (44)a. Er zijn in Nederland maar weinig vrouwen hoogleraar.
 there are in the Netherlands only few women full professor
 'There are only a few female full professors in the Netherlands'
- b. De meesten zijn nog altijd mannen met baarden of brillen.
 most are still always men with beards or glasses
 'Most of them are still men with beards or glasses'

In (44b), no noun is present to provide the first argument set for the determiner *de meesten* 'most'. The constraint *Forward Directionality* would favor the second set of the preceding determiner, $A \cap B$, as the domain of quantification of *de meesten* 'most'. Alternatively, *Parallelism* would favor the domain of quantification, A , of the first determiner to provide the domain of quantification of the second determiner as well. However, if in accordance with these constraints, either the first argument A or the second argument set $A \cap B$ of the preceding determiner is chosen as the domain of quantification for the determiner *de meesten* in (44b), a contradictory

interpretation arises for (44b), namely the interpretation that most female professors or most women are men (with beards or glasses). Therefore, to avoid a violation of the pragmatic constraint *Avoid Contradiction*, the quantificational domain of the determiner *de meesten* is provided by the second syntactic argument set of the determiner *weinig* ‘few’, that is, *B*, the set of full professors in the Netherlands. As a result, (44b) is interpreted as meaning that most full professors are men with beards or glasses, which is an interpretation that makes sense and still satisfies *DOAP*. Thus, *Parallelism* must also be a soft constraint, one that is overruled by *Avoid Contradiction*, in accordance with the partial ranking proposed in (37b).

Now let us take a look at comparatives. We will restrict ourselves to comparatives without a comparative clause. In these elliptical comparatives, a comparison is made between a degree associated with an element expressed by the matrix clause and a degree associated with an element which is left implicit but can be expressed by a *than*-clause in a non-elliptical comparative. This implicit compared element can be anaphoric to a structurally parallel element in the preceding sentence:

- (45) A: Jane is taller than Jacky.
B: No, you're wrong. Jane is shorter.

The incomplete comparative in (45) is interpreted as meaning that Jane is shorter than Jacky. The implicit compared element in (45) is anaphoric to the structurally parallel phrase *Jacky* in the preceding sentence. However, as the sentence in (46) shows, this does not always give us the correct interpretation.

- (46) Jane smokes more than Jacky, but Jacky drinks more.

The interpretation of the incomplete second conjunct is that Jacky drinks more than Jane. Here, *Parallelism* is in conflict with the constraint that a semantic relation (of comparison) is always between two different elements, unless marked otherwise (i.e., *Principle B*). To avoid violations of the constraint *Principle B*, the only other present argument in the preceding sentence, *Jane*, must be interpreted as the antecedent of the compared element in the second sentence in order to satisfy *DOAP*. This shows that structural parallelism is not an absolute constraint, but rather a soft constraint that can be overruled by other constraints.

Thematic parallelism does not hold in all circumstances either. Although *Robert* is a theme in (47), it is interpreted as the antecedent of the missing agent in the second conjunct.

- (47) Robert was instructed better, but because Jane worked harder, she got the award.

The above examples show that parallelism, although it has a clear effect on the interpretation of incomplete quantified and comparative constructions, certainly does not constitute a hard constraint on the interpretation of these expressions.⁷ Parallelism can be violated to avoid a violation of *Principle B*. In (48), a formulation is given of this soft constraint on parallelism:

- (48) *Parallelism*: As the antecedent of an anaphoric expression, choose a (logically, structurally or thematically) parallel element from the preceding clause.

This constraint interacts with the constraint *Principle B* to arrive at the correct interpretation for comparatives without a comparative clause. Consider the following example:

- (49) Jane gave more presents to Jill than to Jacky,
 a. and Jill gave more presents to Jacky. (= more than to Jane)
 b. and Jill gave more presents to Mary. (= more than to Jacky)
 c. and Jacky gave more presents to Jane. (= more than to Jill)
 d. and Jacky gave more presents to Mary. (= more than to Jane or Jill)

The context sentence ‘Jane gave more presents to Jill than to Jacky’ is followed by four possible elliptical continuations in (49a–d). The interpretation of the implicit compared element is presented between brackets. The interpretation of this implicit compared element differs for the four continuations, depending on whether or not the constraint *Parallelism* is in conflict with the constraint *Principle B*. The interaction between these constraints is illustrated by the following tableau:

⁷ That *Parallelism* is a soft constraint is confirmed by a series of psycholinguistic experiments by Smyth (1994). These experiments show that pronoun resolution is subject to (at least) two interacting constraints. The first constraint that plays a role in pronoun resolution is the family of constraints on parallelism. The second constraint is a constraint that has the effect of preferring a subject as the antecedent of a pronoun. Important to note is that all of the subject NPs in Smyth’s examples were topics, suggesting that it is, in fact, *Topicality* that is at work here.

(50) *Constraint tableau for the interpretation of (49)*

Input	Output	Principle B	Parallelism
(49a) and Jill gave more presents to Jacky	...[than to Jane]		*
	...[than to Jacky]	*!	
	...[than to Jill]	*!	*
(49b) and Jill gave more presents to Mary	...[than to Jane]		*!
	...[than to Jacky]		
	...[than to Jill]	*!	*
(49c) and Jacky gave more presents to Jane	...[than to Jane]	*!	*
	...[than to Jacky]	*!	
	...[than to Jill]		*
(49d) and Jacky gave more presents to Mary	...[than to Jane]		*
	...[than to Jacky]	*!	
	...[than to Jill]		*

Continuation (49a), for example, is interpreted as meaning that Jill gave more presents to Jacky than to Jane. Here, the explicit compared element of the context sentence is not chosen as the implicit compared element of the elliptical comparative, since obeying *Parallelism* would result in a

comparison between two identical elements and hence in a violation of *Principle B*. Because interpreting *Jill* as the compared element would also result in a violation of *Principle B*, the best choice for the compared element in (49a) is *Jane*. From this, it follows that *Principle B* is stronger than *Parallelism*. The non-parallel element *Jane* is chosen as the antecedent of the implicit compared element, because violating *Parallelism* is the only way to avoid a violation of the other, stronger, constraint on interpretation. In (49b), obeying *Parallelism* does not result in a violation of *Principle B*. Therefore, the interpretation that Jill gave more presents to Mary than to Jacky is the preferred interpretation for this sentence. *Parallelism* is obeyed because no stronger constraints have to be violated in order to do this. On the other hand, obeying *Parallelism* in (49c) leads to a violation of *Principle B*, as in (49a). The only possibility for the interpretation of the implicit compared element in (49c) is *Jill*, since this choice does not result in a violation of *Principle B*, whereas choosing *Jane* does. Finally, in (49d) neither the choice of *Jane* nor the choice of *Jill* conflicts with either of the constraints. Hence, this sentence is ambiguous in the context of sentence (49).

Finally, we return to the cases of multiple comparison discussed in Section 1. Consider again example (12), repeated below:

- (12) Less land produces more corn than ever before.

A problem that was pointed out with respect to multiple head comparatives, is why comparatives with a reduced comparative clause or without a comparative clause are acceptable and interpretable, whereas multiple head comparatives with a full comparative clause are unacceptable. As we witnessed above, multiple comparison involves mutually dependent instances of comparison. The quantities of land and the quantities of corn are related by the same predicate in both cases. The interpretation of the two instances of comparison takes place simultaneously. This gives us the correct interpretation for (12). However, if we want to express the two elements denoting the standard value of comparison explicitly (i.e., using a comparative clause), the two instances of comparison are forced into a linear representation (either a syntactic or a semantic representation):

- (51) *Less land produces more corn than land produced corn ever before.

It is this linear representation that causes the infinite regress with respect to the two instances of comparison. In other words, if the input in an OT syntax tableau is the multiple comparison, the optimal syntactic candidate

will be one in which much material is left unparsed in order to avoid infinite regress. The interpretation that is optimal in an OT semantics tableau is a simultaneous interpretation of the two instances of comparison. This cannot be represented linearly, however.

To sum up, comparatives without a comparative clause were shown to be interpreted through the interaction of *Principle B* and *Parallelism*. A parallel interpretation is favored, unless the stronger constraint *Principle B* applies.

5. CONCLUSIONS

Each quantified expression gives rise to an, in principle, infinite set of interpretations. This set of interpretations is evaluated with respect to constraints of varying strengths. This leads to a reduction of the set of interpretations, such that, ideally, a hearer is able to identify one optimal interpretation for a quantified expression within a certain context. We have shown that the use of soft constraints as advocated in the framework of Optimality Theory provides a suitable means for deriving the interpretation of semantic relations, in particular when the argument structure is left implicit.

REFERENCES

- Accuosto, Pablo and Dina Wonsever: 1997, 'An Analysis for Spanish Comparatives in Categorical Grammar'. Paper presented at WOLLIC 4, Fortaleza.
- Beaver, David: 1997, 'Presuppositions', in J. van Benthem and A. ter Meulen (eds.), *Handbook of Logic and Language*, Elsevier, Amsterdam, pp. 939–1008.
- Bresnan, Joan: 1975, 'Comparative Deletion and Constraints on Transformations', *Linguistic Analysis* **1.1**, 25–74.
- Chao, Wynn: 1987, *On Ellipsis*, PhD dissertation, University of Massachusetts, Amherst.
- Cinque, Guglielmo: 1993, 'A Null Theory of Phrase and Compound Stress', *Linguistic Inquiry* **24**, 239–297.
- Corver, Norbert: 1990, *The Syntax of Left Branch Extractions*, PhD dissertation, Tilburg University.
- Dalrymple, Mary, Stuart M. Shieber, and Fernando Pereira: 1991, 'Ellipsis and Higher-Order Unification', *Linguistics and Philosophy* **14**, 399–452.
- Eckardt, Regine: 1999, 'Focus and Nominal Quantifiers', in P. Bosch and R. van der Sandt (eds.), *Focus: Linguistic, Cognitive and Computational Perspectives*, Cambridge University Press, Cambridge, pp. 166–186.
- Farmer, A. K. and R. M. Harnish: 1987, 'Communicative Reference with Pronouns', in J. Verschueren and M. Bertucelli-Papi (eds.), *The Pragmatic Perspective*, John Benjamins, Amsterdam.
- Fiengo, Robert and Robert May: 1994, *Indices and Identity*, MIT Press, Cambridge, MA.

- Gawron, Jean Mark: 1995, 'Comparatives, Superlatives, and Resolution', *Linguistics and Philosophy* **18**, 333–380.
- Geilfuß, Joachim: 1995, *Über gewisse Fälle von Assoziation mit Fokus*, PhD dissertation, University of Tübingen.
- Hardt, Dan: 1992, 'VP Ellipsis and Semantic Identity', in S. Berman and A. Hestvik (eds.), *Proceedings of the Stuttgart Ellipsis Workshop*, Stuttgart.
- Hardt, Dan: 1993, *Verb Phrase Ellipsis: Form, Meaning and Processing*, PhD dissertation, University of Pennsylvania.
- Hazout, Ilan: 1995, 'Comparative Ellipsis and Logical Form', *Natural Language and Linguistic Theory* **13**, 1–37.
- Heim, Irene: 1985, 'Notes on Comparatives and Related Matters', Unpublished manuscript, University of Texas.
- Hendriks, Herman: in preparation, 'A Strong Theory of Link and Focus Interpretation', Unpublished manuscript, Utrecht/Amsterdam.
- Hendriks, Herman and Paul Dekker: 1996, 'Links without Locations. Information Packaging and Non-Monotone Anaphora', in P. Dekker and M. Stokhof (eds.), *Proceedings of the Tenth Amsterdam Colloquium*, ILLC, Amsterdam, pp. 339–358.
- Hendriks, Petra: 1994, 'Multiple Head Comparison and Infinite Regress', in J. Ashmore Nevis and V. Samiiian (eds.), *Proceedings of the Western Conference on Linguistics (WECOL 92)*, Vol. 5, California State University, Fresno, pp. 117–131.
- Hendriks, Petra: 1995, *Comparatives and Categorical Grammar*, PhD dissertation, University of Groningen.
- Hendriks, Petra and Helen de Hoop: 1997, 'On the Interpretation of Semantic Relations in the Absence of Syntactic Structure', in P. Dekker, M. Stokhof, and Y. Venema (eds.), *Proceedings of the 11th Amsterdam Colloquium*, ILLC, Amsterdam, pp. 157–162.
- Herburger, Elena: 1997, 'Focus and Weak Noun Phrases', *Natural Language Semantics* **5**, 53–78.
- Hobbs, Jerry R. and Andrew Kehler: 1997, 'A Theory of Parallelism and the Case of VP Ellipsis', in *Proceedings of the 35th Annual Meeting of the Association for Computational Linguistics and the 8th Conference of the European Chapter of the Association for Computational Linguistics*, Madrid, Association for Computational Linguistics, pp. 394–401.
- Hoop, Helen de: 1995, 'Only a Matter of Context?', in M. den Dikken and K. Hengeveld (eds.), *Linguistics in the Netherlands*, Benjamins, Amsterdam.
- Hoop, Helen de and Jaume Solà: 1996, 'Determiners, Context Sets, and Focus', in J. Camacho, L. Choueiri, and M. Watanabe (eds.), *The Proceedings of the Fourteenth West Coast Conference on Formal Linguistics*, CSLI, Stanford.
- Jäger, Gerhard: 1997, 'Anaphora and Ellipsis in Type-Logical Grammar', in P. Dekker, M. Stokhof, and Y. Venema (eds.), *Proceedings of the Eleventh Amsterdam Colloquium*, ILLC, University of Amsterdam, pp. 175–180.
- Johnson, Kyle: 1996, 'When Verb Phrases Go Missing', *Glott International* **2**(5), 3–9.
- Kamp, Hans and Uwe Reyle: 1993, *From Discourse to Logic*, Kluwer Academic Publishers, Dordrecht.
- Kehler, Andrew: 1993, 'The Effect of Establishing Coherence in Ellipsis and Anaphora Resolution', in *Proceedings of the 31st Annual Meeting of the Association for Computational Linguistics*, Columbus, Ohio, Association for Computational Linguistics, pp. 62–69.
- Kennedy, Christopher: 1997, *Projecting the Adjective: The Syntax and Semantics of Gradability and Comparison*, PhD dissertation, University of California, Santa Cruz.

- Kennedy, Christopher and Jason Merchant: 1997, *Attributive Comparatives and Bound Ellipsis*, Unpublished manuscript, University of California, Santa Cruz.
- Krahmer, Emiel and Kees van Deemter: 1997, 'Presuppositions as Anaphors: Towards a Full Understanding of Partial Matches', in P. Dekker, J. van der Does, and H. de Hoop (eds.), *De Dag. Proceedings of the Workshop on Definites*, Utrecht Institute of Linguistics OTS, Utrecht.
- Krifka, Manfred: 1995, 'A Compositional Semantics for Multiple Focus Constructions', in *Proceedings of SALT 1*, Cornell University, Ithaca, New York, pp. 159–185.
- Kuppevelt, Jan van: 1996, 'Directionality in Discourse: Prominence Differences in Subordination Relations', *Journal of Semantics* **13**, 363–395.
- Leusen, Noor van: 1994, 'The Interpretation of Corrections', in P. Bosch and R. van der Sandt (eds.), *Focus and Natural Language Processing*, Vol. 3, IBM, Heidelberg.
- Lobeck, Anne C.: 1995, *Ellipsis: Functional Heads, Licensing and Identification*, Oxford University Press, New York.
- May, Robert: 1985, *Logical Form: Its Structure and Derivation*, MIT Press, Cambridge MA.
- McCawley, James D.: 1998, *The Syntactic Phenomena of English*, 2nd edn, The University of Chicago Press, Chicago.
- Morrill, Glyn: 1994, *Type Logical Grammar. Categorical Logic of Signs*, Kluwer, Dordrecht.
- Morrill, Glyn and Teresa Solias: 1993, 'Tuples, Discontinuity and Gapping', in *Proceedings of the 6th Conference of the European Chapter of the Association for Computational Linguistics*, Utrecht, pp. 287–297.
- Murphy, Gregory L.: 1985, 'Processes of Understanding Anaphora', *Journal of Memory and Language* **24**, 290–303.
- Nerbonne, John, Masayo Iida, and William Ladusaw: 1990, 'Semantics of Common Noun Phrase Anaphora', in A. L. Halpern (ed.), *The Proceedings of the Ninth West Coast Conference on Formal Linguistics*, CSLI, Stanford.
- Partee, Barbara: 1995, 'Quantificational Structures and Compositionality', in E. Bach, E. Jelinek, A. Kratzer, and B. H. Partee (eds.), *Quantification in Natural Languages*, Kluwer, Dordrecht.
- Pinkham, Jessie: 1982, *The Formation of Comparative Clauses in French and English*, Indiana University Linguistics Club, Bloomington, Indiana.
- Prince, Alan and Paul Smolensky: 1997, 'Optimality: From Neural Networks to Universal Grammar', *Science* **275**, 1604–1610.
- Prüst, Hub: 1992, *On Discourse Structuring, VP Anaphora and Gapping*, PhD dissertation, University of Amsterdam.
- Rayner, Manny and Amelie Banks: 1990, 'An Implementable Semantics for Comparative Constructions', *Computational Linguistics* **16**(2), 86–112.
- Reinhart, Tanya: 1995, 'Interface Economy: Focus and Markedness', Manuscript, Utrecht/Tel Aviv.
- Reinhart, Tanya and Eric Reuland: 1993, 'Reflexivity', *Linguistic Inquiry* **24**(4), 657–720.
- Rooth, Mats: 1985, *Association with Focus*, PhD dissertation, University of Massachusetts, Amherst.
- Rooth, Mats: 1992, 'A Theory of Focus Interpretation', *Natural Language Semantics* **1**, 75–116.
- Rumelhart, David E., James J. McClelland, and the PDP Research Group: 1986, *Parallel Distributed Processing: Explorations in the Microstructure of Cognition*, MIT Press, Cambridge, MA.

- Sag, Ivan and Jorge Hankamer: 1984, 'Towards a Theory of Anaphoric Processing', *Linguistics and Philosophy* 7, 325–345.
- Sandt, Rob van der: 1992, 'Presupposition Projection as Anaphora Resolution', *Journal of Semantics* 9, 333–377.
- Sanford, Anthony, Linda Moxey, and Kevin Paterson: 1994, 'Psychological Studies of Quantifiers', *Journal of Semantics* 10, 153–170.
- Snyder, William, Kenneth Wexler, and Dolon Das: 1995, 'The Syntactic Representation of Degree and Quantity: Perspectives from Japanese and Child English', in *Proceedings of the West Coast Conference on Formal Linguistics XIII*, Center for the Study of Language and Information (CSLI), Stanford, CA.
- Smyth, Ron: 1994, 'Grammatical Determinants of Ambiguous Pronoun Resolution', *Journal of Psycholinguistic Research* 23(3), 197–229.
- Stechow, Arnim von: 1984, 'Comparing Semantic Theories of Comparison', *Journal of Semantics* 3, 1–79.
- Tanenhaus, Michael and Greg Carlson: 1990, 'Comprehension of Deep and Surface Verbphrase Anaphors', *Language and Cognitive Processes* 5(4), 257–280.
- Vallduví, Enric: 1990, *The Informational Component*, PhD dissertation, University of Pennsylvania, Philadelphia.
- Westerståhl, Dag: 1985, 'Determiners and Context Sets', in J. van Benthem and A. ter Meulen (eds.), *Generalized Quantifiers in Natural Language*, Foris, Dordrecht.
- Williams, Edwin: 1997, 'Blocking and Anaphora', *Linguistic Inquiry* 28, 577–628.

Petra Hendriks

Department of Dutch Cognitive Science & Engineering (TCW)

University of Groningen

Grote Kruisstraat 2/1

9712 TS Groningen

The Netherlands

E-mail: petra@tcw2.ppsw.rug.nl

Helen de Hoop

Utrecht Institute of Linguistics OTS

Utrecht University

Trans 10

3512 JK Utrecht

The Netherlands

E-mail: helen.dehoop@let.uu.nl