Temporal adjunct clauses in Optimality Theory

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The aim of this article is to provide an analysis of the possible interpretations of temporal adjunct clauses inside and outside the scope of adverbial quantifiers. We argue that the framework of Optimality Theory provides a suitable means for constructing the proper set of possible interpretations for inputs that contain either preposed or postponed *when*-clauses. For our analysis, we use three general and simple universal constraints in the temporal domain: (i) establish rhetorical relations; (ii) temporal adjuncts cannot be interpreted as anaphors in a rhetorical relation; (iii) the linear order of two syntactic constituents corresponds with the order antecedent-anaphor in a rhetorical relation which in turn corresponds with the order restrictor-scope in a quantificational structure. The optimal interpretations for quantificational as well as unembedded temporal structures containing *when*-clauses are achieved under one particular ranking of these constraints. [1]

1. Introduction

Quantificational expressions are well-known for the interesting problems they raise for the principle of compositionality (which derives the meaning of a complex expression from the meaning of its parts and syntactic structure), among other things because the interpretation of quantifiers is often dependent on information which is not directly stored in syntactic structure, like intonation (focus) and context (see, a.o., Partee 1995).

Within model-theoretic semantics, quantifiers can be defined in terms of relations between sets. Determiners denote relations between sets of individuals. The determiner *most*, for example, refers to a relation between two sets A and B, such that *most AB* is true if and only if $|A \cap B| > |A - B|$. Consider (1):

(1) Most abstracts are rejected

The sentence in (1) is true if and only if more abstracts are rejected than accepted. In languages like English, Dutch, etc. a determiner forms a syntactic constituent together with a noun and possible modifiers. In accordance with the principle of compositionality the noun always supplies the first argument of the determiner, viz. the

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set that is quantified over, while the predicate (the VP) supplies the second argument. Such a strict compositional function from syntactic structure to semantics, however, does not yield the right interpretation of the following sentence:

(2) Most abstracts are rejected because of their length

In one interpretation, the domain of quantification in (2) is not just supplied by the noun only (*abstracts*), but is further restricted by the predicate (*rejected*), so that the sentence is true if and only if more abstracts are rejected because of their length than for any other reason. This interpretation can be reinforced by stressing *because of their length* (*because of their LENGTH*). This suggests that focus (sometimes at least) plays a role in determining the argument structure of nominal quantification.

Similar observations have been made about adverbial quantification. Adverbs like *sometimes, always, usually, never* do not form an inseparable constituent with another sentence element and are therefore more flexible in selecting their domain of quantification (cf. De Swart 1991). If there is a restrictive clause, it is often taken to be the supplier of the set of situations that forms the domain of quantification (cf. Lewis 1975, Heim 1982):

(3) Martin usually shaves when he is in the bathroom

Sentence (3) will be true if and only if there are more situations when Martin is shaving when he is in the bathroom than when he is not shaving when he is in the bathroom. This interpretation naturally triggers stress on the main clause verb as in (4a). Focus on *bathroom*, however, as in (4b) can yield an interpretation under which it is the main clause that supplies the domain of quantification (cf. Rooth 1985):

(4) a. Martin usually SHAVES when he is in the bathroom
b. Martin usually shaves when he is in the BATHROOM

Unlike (4a), (4b) is true if and only if there are more situations when Martin shaves when he is in the bathroom than when he shaves somewhere else. This, however, seems no longer true if the subordinate clause is in sentence-initial position:

(5) When he is in the bathroom, Martin usually shaves

(5) only has the interpretation corresponding with (4a). These data raise the question what factors determine the argument structure of a quantifier. In this paper we will focus on the contribution of *when*-clauses, and argue that the constraints they impose upon temporal anaphora play a crucial role in quantificational structure. The argument builds on the hypothesis advocated in Hendriks & De Hoop (1999) that the constraints that interact in determining the interpretation of sentences, must be soft in nature, i.e., violable and potentially conflicting. As shown in section 2, this approach yields an insightful analysis of nominal anaphorization. In section 3 we apply the same hypothesis to the interpretation of *when*-clauses, using the insights and analysis developed in De Swart (1999) on the anaphoric character of constructions involving time adverbials. In section 4, we show that the quantificational structure of adverbs of quantification can be determined using the same type of constraints on anaphoric relations. Finally, section 5 establishes a comparison between nominal and adverbial quantification. We argue that our approach is more adequate than an analysis which tries to derive interpretation from syntactic structure only (in particular, within this context, Johnston 1994), and illustrate our claim by presenting an extension of our analysis to *if*-clauses.

2. *Nominal anaphorization*

In Hendriks & De Hoop (1999) it is hypothesized that all possible sets of individuals in a model of the world may serve as the sets between which a relation can be established by a given determiner in a complex expression. This yields an in principle infinite set of possible interpretations for each expression containing a determiner. However, the set of possible interpretations of a natural language expression is reduced by constraints. These constraints can be contextual, intonational or syntactic in nature. Crucially, it is argued that these constraints must be soft, i.e., violable, in an Optimality Theoretic fashion (cf. Prince & Smolensky 1997). This means that the constraints that restrict the set of possible interpretations of a quantified expression can be violated, but only in order to satisfy other, stronger constraints on interpretation.

One constraint that plays an important part in interpretation is a pragmatic constraint that favours anaphorization of text. We adopt the formulation of this constraint that is found in Williams (1997):

(6) *Don't Overlook Anaphoric Possibilities (DOAP): Opportunities to anaphorize text must be seized.* [Williams 1997]

This principle accounts for the fact that there is a general preference to interpret linguistic elements as anaphors, related to the discourse. DOAP is easily overruled by other constraints, however. Krahmer & Van Deemter (1997) observe that the definite NP *the doctor* is not readily interpreted as anaphoric to the preceding NP *a doctor* in (7):

(7) Often when I talk to a doctor, the doctor disagrees with him

Krahmer & 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 (8) either, but in fact, in (8) the anaphoric reading is obvious:

(8) Often when I talk to a doctor, the doctor disagrees with himself

What seems to be going on in (7) is a conflict between DOAP and principle B of the binding theory in one formulation or another (see, e.g., Farmer & Harnish 1987, Reinhart & Reuland 1993):

(9) *Principle B: If two arguments of the same semantic relation are not marked as being identical, interpret them as being distinct.* [Hendriks & De Hoop, 1999]

Whereas DOAP and Principle B can both be satisfied in (8), DOAP is violated in (7) but only in order to satisfy Principle B. Hence, Principle B is ranked higher than DOAP in English. Consider the tableau in (10) that determines the optimal interpretation for the input sequence of the three NPs *a doctor*, *the doctor* and *him/himself* in (7) and (8):

(10) *Constraint tableau for (7)*

Input (7)		Output	B >>	DOAP
a doctor	⇒	a doctor$_1$ the doctor$_1$ him$_2$		*
the doctor	⇒	a doctor$_1$ the doctor$_2$ him$_1$		*
him		a doctor$_1$ the doctor$_1$ him$_1$	*!	
		a doctor$_1$ the doctor$_2$ him$_2$	*!	*
		a doctor$_1$ the doctor$_2$ him$_3$		**!

(11) *Constraint tableau for (8)*

Input (8)		Output	B >>	DOAP
a doctor	⇒	a doctor$_1$ the doctor$_1$ himself$_2$		*!
the doctor		a doctor$_1$ the doctor$_2$ himself$_1$		*!
himself		a doctor$_1$ the doctor$_1$ himself$_1$		
		a doctor$_1$ the doctor$_2$ himself$_2$		*!
		a doctor$_1$ the doctor2 himself$_3$		*!*

According to tableau (10), two optimal interpretations are obtained for (7) such that the strong 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 (8), we find only one optimal interpretation in tableau (11). Here Principle B is satisfied and the winning candidate also satisfies DOAP.

Partee (1973) observed that tenses are similar to pronouns in their preference for anaphoric interpretations. This suggests that constraints like Principle B and DOAP have a counterpart in the temporal domain. It turns out that temporal versions of these constraints govern the interpretation of constructions involving preposed and postponed temporal adjunct clauses.

3. Temporal anaphorization

Temporal adjunct clauses introduced by *when, before, after*, etc. come with tense and aspect. In this paper, we will restrict ourselves to the interpretation of *when*-clauses; see de Swart (1999) for an extension of the analysis to other temporal connectives. Heinämäki (1978) observes that the intervals or moments denoted by accomplishments and achievements are included in the intervals referred to by durative sentences (12a), while two durative sentences overlap (12b) and two accomplishments happen in succession (12c):

(12) a. Everybody was away when Jane destroyed the documents
b. It was raining in San Francisco when we were there
c. When Robert wrecked the car, Jane fixed it

Heinämäki's claim that two events related by *when* happen in succes-

sion (12c) has been challenged. Partee (1984) argues that any temporal relation which can be established between two independent clauses can be established between the subordinate and main clause related by the temporal connective *when*. However, the situation is more complicated than that. It is well known that the interpretation of temporal adjuncts is sensitive to clause order. De Swart (1999) observes that neither preposed nor postponed *when*-clauses express a succession of events in which the event described by the subordinate clause follows the main clause event, even if this is strongly suggested by world knowledge. Compare:

(13) a. When the president asked who would support her, Robert raised his hand
b. Robert raised his hand when the president asked who would support her
c. When Robert raised his hand, the president asked who would support her
d. The president asked who would support her when Robert raised his hand
e. The president asked who would support her. Robert raised his hand

The preposed *when*-clause in (13a) allows for only one reading: the main clause event is located shortly after the event described by the adjunct clause. There is a strong causal connection between the two clauses: Robert's raising of his hand is naturally interpreted as a response to the president's request for support. The causal connection is indicative of a rhetorical structure in the sense of Lascarides & Asher (1993). (13c) is similar. World knowledge does not as easily support a causal connection here, but it is not impossible to imagine a scenario in which Robert's raising of his hand is a sign for the president that it is time to ask for support. Again, this interpretation can be taken to reflect a rhetorical relation between the two clauses. Postposition of the temporal clause as in (13b) or (13d) leads to ambiguities. Under one reading of (13b), the sentence is interpreted in the same way as (13a). But there is an alternative interpretation available in which Robert raises his hand just at the moment at which the president asks who would support her. Under this reading there is no causal relation between the two actions; there is just a relation of temporal overlap. Similarly, (13d) shares one reading with (13c), but it has another interpretation in which we do not establish a causal connection or an enablement relation, but just posit a relation of temporal overlap. The puzzle is the lack of a reading for (13d) along the lines of (13a) or the sequence of independent clauses in (13e). If two events related by *when* could describe the two events as happening in succession independently of subordination, then we would predict that we could locate Robert's raising of his hand after the president's request for support. After all, such a causal connection is strongly supported by world knowledge. However, such an interpretation of (13d) is impossible. De Swart (1999) appeals to topic-focus structure and constraints adjunct clauses impose upon temporal anaphora to explain the paradigm in (13). In this section, we will work out that analysis some more in the framework of Optimality Theory.

An important difference between main clauses and temporal adjunct clauses resides in their anaphoric behaviour. Main clauses are anaphoric just like independent clauses. This means that their temporal anchoring is determined by the relation with the preceding discourse. Following Lascarides & Asher's (1993) claim that temporal relations are derived from the rhetorical structure of the discourse, de Swart (1999) argues that main and independent clauses seek to establish a rhetorical relation with an earlier sentence in the discourse. A main or independent clause β thus tries to establish a rhetorical relation R with a clause α which is already part of the discourse representation structure built up so far. Both the nominal and the temporal domain thus have a preference for anaphoric interpretations. Accordingly, we propose a temporal version of DOAP, which we formulate as in (15):

(15) *Don't overlook anaphoric possibilities (DOAP): opportunities to establish a rhetorical relation must be seized.* [2]

The temporal version of DOAP is clearly satisfied in the discourse (13e): the second clause takes the first one as its antecedent in a rhetorical relation. A mixture of linguistic information (aspect) and non-linguistic information (world knowledge about causal connections) decides which rhetorical relation is most appropriate in a given context. Temporal structure is then inferred from rhetorical structure. In the case of (13e), the causal connection leads to temporal succession. DOAP is also satisfied in (13a) and (13c): the *when*-clause provides the antecedent α for the main clause β, and we can establish a rhetorical relation R between α and β. Again, the causal connection leads to temporal succession. The interpretations of (13b) and (13d) which they share with (13a) and (13c) respectively satisfy DOAP for the same reason. But what about the other reading of (13b) and (13d), in

which there is no causal connection, but just a relation of temporal overlap? We claim that these cases show a conflict between DOAP and the non-anaphorical character of *when*-clauses.

According to Heinämäki (1978), time adverbials and temporal clauses are presuppositional. In the framework developed by de Swart (1999), this means that their location in time is taken to be determined independently of the rhetorical structure created by the local context. More precisely, we can formulate this as the claim that time adverbials can never fulfil the role of β in a rhetorical relation R(α, β). We call this constraint TA, and view it as a temporal version of principle B: [3]

(14) *TA:* temporal adjuncts do not function as in a rhetorical relation R(α, β).

In contexts in which the adjunct is not interpreted as the antecedent α, we cannot create a rhetorical structure. Such contexts arise in particular in topic-focus configurations. As argued by de Swart (1999), preposed temporal clauses are topicalized and always provide the rhetorical antecedent of the main clause. Postponed temporal clauses can be either topic or focus. Thus a postponed *when*-clause either provides the rhetorical antecedent of the main clause, or establishes a relation of temporal overlap in the absence of a rhetorical relation. Thus the constraints formulated in (14) and (15), which take care of the anaphoric possibilities of main and adjunct clauses need to be combined with the insights about the topic-focus structure of the construction. We take this to be derived from the general observation that processing takes place from left to right. We find this general pragmatic constraint in all kinds of versions in the literature: topic precedes focus, antecedents precede anaphors, restrictors precede their scope, etc. We will call this constraint $\alpha<\beta$, and give (16) as a first formulation:

(16) $\alpha < \beta$ *(first version)* : $\alpha < \beta$: R(α,β) : topic < focus
The linear order of two syntactic constituents corresponds to the order antecedent-anaphor in a rhetorical relation which corresponds to the order topic-focus in the information structure.

If we combine these constraints in a tableau, we can see that the optimal interpretation for the input sequence of a preposed *when*-clause is the result of the satisfaction of all three constraints. Consider the tableau in (17), which we can take to represent the input of examples like (13a) and (13c) above:

(17)

Input (13a),(13c)		Output	TA	DOAP	α<β
when-clause (e_1) <	⇒	R(e_1,e_2)			
main-clause (e_2)		R(e_2,e_1)	*		*
	⇒	¬R(e_1,e_2)		*	

What we see in tableau (17) is that there is one interpretation which satisfies all three constraints. In this optimal interpretation, we establish a rhetorical relation (satisfaction of DOAP), but we do not make the *when*-clause the rhetorical anaphor (satisfaction of TA), and we reflect the clause order in the antecedent-anaphor order in the rhetorical relation (satisfaction of $\alpha<\beta$). As a result, the optimal interpretation makes the *when*-clause the rhetorical antecedent for the main clause. Thus in (13a) for example, the president's request triggers Robert's raising of his hand as a natural response. An interpretation in which Robert raising his hand triggers the president's request or a simple relation of temporal overlap in the absence of any rhetorical relation are not felicitous interpretations for this sentence, because they violate one or more of the constraints in (17). This suggests that the combination of TA, DOAP and $\alpha<\beta$ yields a set of constraints which appropriately constrains the interpretation of *when*-clause constructions. Note however that preposed *when*-clauses do not give us any clue as to the ranking of the three constraints. They occur in a certain order in the tableau in (17), but we did not indicate a ranking between them. Obviously, cases in which the optimal candidate does not violate any constraints at all do not allow us to determine the ranking within a set of constraints. Quite generally, we need to look at cases in which there is a conflict between constraints in order to decide the ranking. As already suggested above, postponed *when*-clauses provide such a case. Consider the tableau in (18) for examples like (13b) and (13d).

(18)

Input (13b),(13d)		Output	TA >>	DOAP<>	α < β
main-clause (e_2) <	⇒	R(e_1,e_2)			*
when-clause (e_1)		R(e_2,e_1)	*!		
	⇒	¬R(e_1,e_2)		*	

Postponed *when*-clauses generally allow two interpretations. One is the same interpretation as the construction with the preposed *when*-clause. But unlike in (17) with the preposed *when*-clause as input, this interpretation violates $\alpha<\beta$. That is, the linear order of the main clause and the *when*-clause does not correspond to the order antecedent-anaphor in the rhetorical relation. The constraint $\alpha<\beta$ is satisfied by the second candidate, but this candidate violates TA, which is obviously a more serious violation as the concomitant interpretation does not exist. In the other possible interpretation, there is no rhetorical relation, but just a relation of temporal overlap between the two events. In an Optimality Theoretical approach, the fact that there are two interpretations suggests that there are two optimal candidates. Such a situation typically arises when each output violates some condition, but the two conditions are ranked equally high. This is indeed the situation we find in tableau (18). We have three constraints, and we observe that a violation of TA never leads to an optimal interpretation. Just like in the case of nominal anaphorization we can thus rank this constraint higher than DOAP. The two other interpretations each violate one constraint. If we give the sentence the same interpretation as its counterpart with a preposed *when*-clause, we respect DOAP, but we violate $\alpha<\beta$. If we do not establish a rhetorical relation but interpret *when* as temporal overlap, we respect $\alpha<\beta$, but we violate DOAP. If we rank these constraints equally high, but rank TA higher, we end up with the two desired interpretations as the optimal candidates. Note that the interpretation of the third candidate only arises if the *when*-clause is in focus. There is no rhetorical relation, but the correspondence constraint $\alpha<\beta$ would be violated if the *when*-clause would be interpreted as the topic. That is, in the absence of $R(\alpha,\beta)$, the correspondence between syntactic structure and information structure can still be satisfied ($\alpha<\beta$: *topic* < *focus*). For the interpretation of the first candidate, topic-focus structure does not correspond to the syntactic structure, but in this case it does not have to, as it corresponds to the order of the antecedent and the anaphor in the rhetorical relation. So, we claim that in the latter interpretation, if the *when*-clause is interpreted as the topic, $\alpha<\beta$ is violated only once (that is, $\alpha<\beta : R(\alpha,\beta)$ is violated, but $R(\alpha,\beta)$: *topic*<*focus* is satisfied). If, however, in this case the topic-focus structure would correspond to the syntactic structure, we would obtain two violations of $\alpha<\beta$. Thus, we account for the fact that the interpretation of sentences like (13b) and (13d) correlates with topic-focus structure. One of the optimal interpretations is obtained when the *when*-clause is interpreted as the topic, whereas

the other optimal interpretation arises when the *when*-clause is in focus.

In sum, we see that DOAP is a general constraint, which works in the temporal domain pretty much like in the domain of individuals. $\alpha<\beta$ reflects a general processing strategy, which we find in all kinds of contexts. Thus none of these constraints are specific to the *when*-clause construction. Just like in the nominal domain, we find that not all expressions have the same anaphoric possibilities. This leads to the formulation of a construction-specific constraint TA, which can be looked upon as the temporal version of principle B. Both DOAP and $\alpha<\beta$ are soft constraints which can easily be overruled by other, stronger constraints. In particular, we find that DOAP and $\alpha<\beta$ can be overruled by TA. Hence, TA is ranked higher than either DOAP or $\alpha<\beta$. The resulting picture shows a high degree of similarity between nominal and temporal anaphorization.

4. Adverbial quantification

In the previous section, we accounted for the meaning effects of preposed and postponed temporal *when*-clauses. At this point, let us determine the interaction of these clauses with the quantificational structure of quantifying adverbs. Reconsider the crucial sentences (4) and (5), which were borrowed from Rooth (1985) and which are repeated here as (19):

(19) a. Martin usually SHAVES when he is in the bathroom
b. Martin usually shaves when he is in the BATHROOM
c. When he is in the bathroom, Martin usually SHAVES
d. When he is in the BATHROOM, Martin usually shaves

The generalization is as follows: preposed *when*-clauses always restrict the domain of quantification, independently of the role of focus (19c,d). Postponed *when*-clauses are ambiguous. If focus is on the main clause, the subordinate clause restricts the domain of quantification (19a). If focus is on the *when*-clause, the main clause restricts the domain of quantification (19b). The fact that preposed *when*-clauses are unambiguous, whereas postponed *when*-clauses are sensitive to topic/focus structure suggests that the same considerations which played a role in the determination of temporal anaphorization determine the argument structure of adverbial quantification. Crucially, the rhetorical structure of the *when*-clause construction is

embedded under quantification. Consequently, we expect both TA and DOAP to be relevant constraints. However, the situation is slightly more complex, because we have to establish a connection between the quantificational and the rhetorical structure. What we see is that the argument structure of the quantificational relation reflects the antecedent-anaphor relation of the rhetorical relation. This suggests a generalization of the $\alpha<\beta$ constraint. The new formulation of this constraint is spelled out in (20):

(20) $\alpha < \beta$ *(final version)*: $\alpha<\beta$: R(α,β) : Q(A,B) : topic < focus
The linear order of two syntactic constituents corresponds to the order antecedent-anaphor in a rhetorical relation which corresponds to the order restrictor-scope in a quantificational structure which corresponds to the order topic-focus in the information structure.

The combination of TA, DOAP and the generalized version of $\alpha<\beta$ leads to the tableau in (21) for preposed *when*-clauses embedded under an adverbial quantifier (e.g. 19c,d). A quantificational adverb denotes a relation between two sets of events. The first set of events can be given by either the *when*-clause or the main clause. The second argument is the set of these events further restricted by the events introduced by the other clause via a rhetorical relation between the two types of events. This embedding of a rhetorical relation in a quantificational structure results in six possible interpretations for a *when*-clause and main clause embedded under a quantificational adverb.

(21)

Input (19c,d)		Output	TA >>	DOAP < >	$\alpha<\beta$
Adverb	⇒	$Q(E_1,\{e_1{:}\exists e_2\ R(e_1,e_2)\})$			
[*when*-clause (e_1),		$Q(E_1,\{e_1{:}\exists e_2\ R(e_2,e_1)\})$	*!		**
main clause (e_2)]		$Q(E_1,\{e_1{:}\exists e_2\ \neg R(e_1,e_2)\})$		*!	
		$Q(E_2,\{e_2{:}\exists e_1\ R(e_1,e_2)\})$			*!
		$Q(E_2,\{e_2{:}\exists e_1\ R(e_2,e_1)\})$	*!		*
		$Q(E_2,\{e_2{:}\exists e_1\ \neg R(e_1,e_2)\})$		*!	*

Just like in the case of a preposed *when*-clause in a non-quantified sentence, we find one optimal candidate here which does not violate any constraints. As a result, only one interpretation is possible.

For (19c,d), this correctly yields the interpretation in which all situations in which Martin is in the bathroom provide the background for, and thus temporally include a situation of him shaving.

As in the cases of unembedded temporal anaphorization, we observe that the combination of the three constraints yields the desired interpretation. That means that the ranking we proposed for the unembedded order is unproblematic so far. In order to explore the explanatory power of these constraints further, we need to find a case in which two or more constraints are in conflict. Again, postponed *when*-clauses provide such a case. Consider tableau (22) for postponed *when*-clauses under quantification (e.g. 19a,b).

(22)

Input (19a,b)		Output	TA >>	DOAP <>	$\alpha<\beta$
Adverb	⇒	$Q(E_1,\{e_1{:}\exists e_2\ R(e_1,e_2)\})$			*
[main clause (e_2),		$Q(E_1,\{e_1{:}\exists e_2\ R(e_2,e_1)\})$	*!		*
when-clause (e_1)]		$Q(E_1,\{e_1{:}\exists e_2\ \neg R(e_1,e_2)\})$		*	*!
		$Q(E_2,\{e_2{:}\exists e_1\ R(e_1,e_2)\})$			**!
		$Q(E_2,\{e_2{:}\exists e_1\ R(e_2,e_1)\})$	*!		
	⇒	$Q(E_2,\{e_2{:}\exists e_1\ \neg R(e_1,e_2)\})$		*	

As pointed out above, constructions such as (19a,b) allow two interpretations, depending on the topic-focus articulation of the sentence. Two candidates emerge as optimal interpretations. The first one violates $\alpha<\beta$, and treats the postponed *when*-clause as the temporal antecedent of the rhetorical structure (19a). The generalized version of $\alpha<\beta$ requires the quantificational structure to reflect the rhetorical structure. Corresponding to the syntactic order but not to the rhetorical structure thus leads to two violations of this constraint (as in the fourth line of the tableau). The second possible interpretation respects $\alpha<\beta$, but it violates DOAP. In the absence of a rhetorical relation between the two clauses, the quantificational structure corresponds to syntactic structure directly. That is, the quantifier takes the first clause as its first argument, and the second clause as its second argument. This leads to quantification over the set of events provided by the main clause (19b).

Just like in the case of unembedded temporal anaphorization, we observe that the two optimal candidates for sentences with postponed *when*-clauses correspond with the violation of one constraint

each. Again, the distribution of topic-focus triggers these two possible readings. For the interpretation that violates $\alpha<\beta$, the *when*-clause must be interpreted as the topic (in order to avoid a second violation of this constraint), whereas the interpretation that violates DOAP is only possible if the *when*-clause is in focus (in order to avoid an additional violation of $\alpha<\beta$). This suggests that our hypothesis that DOAP and $\alpha<\beta$ are ranked equally high is confirmed by the quantificational case. Note that an interpretation in which TA is violated remains unavailable. This confirms our claim that TA is ranked higher than the other two. We conclude that the same constraints which play a role in temporal anaphorization govern the interpretation of *when*-clause constructions under quantification. The result is a simple and general set of constraints, which allows just the right amount of flexibility in the interpretation of these sentences.

5. *On the role of syntax*

5.1. *A comparison between nominal and adverbial quantification*

There is much debate in the literature on the similarities and differences between nominal and adverbial quantification (cf. Bach *et al.* 1995 for an overview). The debate centers around the role of syntax in the interpretation. The general idea seems to be that focus and context play a role in interpretation, but syntax wins in the end (Partee 1995). Instead of encoding syntactic information as hard constraints and contextual and pragmatic information as soft constraints, the Optimality Theoretical account of determiner quantification advocated by Hendriks & de Hoop (1999) integrates the different types of information in a ranked set of soft, i.e. violable constraints. They argue that syntax plays an important role in the interpretation of determiner expressions in the sense that if there is lexical material present in combination with a determiner, then this material further reduces the set of possible interpretations. Hence, if there is syntactic structure, it must be used in the determination of the interpretation of a quantified expression. This can be formulated as follows:

(23) *Syntactic structure*: If there is an N' that constitutes an NP together with a determiner, use it to restrict the domain of quantification of that determiner. [Hendriks & De Hoop, 1999]

If we treat determiners as denoting a relation between A and B, we

can thus argue that N' always contributes to a restriction on the set A, and never on the set B. More generally speaking, the domain of quantification is always restricted by the context, which can be formalized by a context set variable (*most* $(A\cap X)B$, cf. Westerståhl 1984). This variable can sometimes be determined with the help of focus. In De Hoop & Solà (1996) X is equated with the generalized union over the set of alternatives à la Rooth (1985, 1992) of the argument that receives stress. This can be used to explain why focus plays a role in the context in (2) above, repeated here as (24a):

(24) a. Most abstracts are rejected because of their LENGTH
b. Most SYNTAX abstracts are rejected because of their length

The focussed material in (24a) goes into the set B, and the non-focussed material of the VP is added to the restrictor set. The constraint formulated under (23) helps to explain why focus within the first argument does not lead to an additional restriction of the domain of quantification. For example, stressing *syntax* in (24b) does not have a truth conditional effect. Focus cannot be used to put part of the common noun denotation into the set B, because the syntactic constraint in (23) is ranked quite high, and will overrule this possibility. Obviously, focus (stress) has other functions besides constraining the domain of quantification. The stress on *syntax* in (24b) can be interpreted as a contrastive topic for instance.

The question arises whether syntax plays a role in adverbial quantification as well. The set of constraints proposed in section 4 above does not contain a syntactic constraint like (23) at all. The question is whether this is a desirable feature or not. We will provide two arguments in favor of a lesser role of syntax in adverbial quantification. One argument consists in showing that syntactic approaches to adverbial quantification create more problems than they solve (section 5.2). The other argument involves an extension of our analysis to *if*-clauses (section 5.3).

5.2. *A comparison with a syntactic approach*

Our analysis of preposed and postponed *when*-clauses under quantification makes use of a tied ranking of DOAP and $\alpha<\beta$ to explain why preposed *when*-clauses always constrain the domain of quantification whereas postponed *when*-clauses lead to ambiguities. This contrasts with a syntactically oriented approach like the one

developed by Johnston (1994). Johnston proposes that the two readings of sentences like (19a,b) can be accounted for in terms of a mapping from syntactic structure into quantificational structure. His proposal is summarized in (25):

(25) *Adjunct Factorization*:
(i) Adjuncts adjoined to IP are mapped into the restriction;
(ii) Adjuncts adjoined to VP are mapped into the nuclear scope. [Johnston 1994]

A postponed *when*-clause can be adjoined to either the VP or the IP. A preposed *when*-clause, however, can only be adjoined to IP. Therefore, a preposed *when*-clause always determines the domain of quantification, whereas only IP-adjoined postponed *when*-clauses do. The main problem with Johnston's proposal concerns the question of the other reading that happens to exist for sentences like (19a,b). The mechanism in (25) does not dictate that the main clause determines the domain of quantification when the *when*-clause is in focus. But even if we assume additional machinery in order to derive the correct interpretation in those cases, there are other problems for this syntactic approach to interpretation. Besides the lack of the VP-adjunction reading for preposed *when*-clauses, Johnston provides one other apparently strong argument to support his analysis.

Johnston (1994) discusses the following VP-deletion example:

(26) Lions always attack a human when they are hungry

(27) Lions always attack a human when they are hungry and tigers always do - when they are scared

Sentence (26) has two readings, just like sentence (4). In one reading, the set of events in which lions are hungry is a subset of the set of events in which they attack a human. In that reading, one event in which a lion would be hungry but not attack a human would make the sentence false. In the other reading, the set of events in which lions attack a human is a subset of the set of events in which they are hungry. That is, one event of a lion attacking a human without being hungry would make the sentence on this reading false. The first reading would be the result of an IP-adjoined *when*-clause, according to Johnston, the second one to a VP-adjoined *when*-clause.

Crucially in Johnston's approach, VP-deletion only applies to maximal VPs; hence, the remaining *when*-clause in the VP-deletion

structure in (27) must be an IP-adjoined *when*-clause. Therefore, Johnston claims that we only get the corresponding reading (where the *when*-clause provides the domain of quantification). This would mean that one event in which a tiger is scared yet does not attack a human would make (27) false. In our view, the other reading still seems to be more natural. That is, one event in which a tiger attacks a human although it is not scared, would make (27) false. This reading corresponds with Johnston's VP-adjunction reading, however, and should not be possible in (27) at all.

Moreover, note that if we do not delete the VP in (27), we expect Johnston's effect to disappear. That is, both readings should be possible in (28) again, versus only one reading in (27), but in our view no such difference between (27) and (28) arises:

(28) Lions always attack a human when they are hungry and tigers always attack a human when they are scared

Similarly, (29) gets the VP-adjunction reading without any problems (Martin does not shave unless he is in the bathroom and Peter does not shave unless he is in the kitchen), whereas the IP-adjunction reading (the only one that should be possible according to Johnston) is pretty awkward (whenever Martin is in the bathroom, he is shaving, while Peter cannot be in the kitchen without shaving).

(29) Martin always shaves when he is in the bathroom and Peter always does when he is in the kitchen

Let us consider now a VP-deletion example where the *when*-clause is deleted as well. Evidently, Johnston (1994) would predict that in such a case, only the VP-adjunction reading would be available (in which the main clause eventually provides the domain of quantification). For example:

(30) Lions never attack a human when they are hungry, but tigers always do -

In (30), we get the reading that hungry lions never attack a human, whereas hungry tigers do. That is, one event in which a hungry tiger would not attack a human, would make (30) false. Clearly, what we get naturally here, is the IP-adjunction reading instead of the predicted VP-adjunction reading. In fact, the VP-adjunction reading does not seem to be possible at all (under this reading, the sentence

should become false in case a tiger that happens to be not hungry would attack a human).

To sum up, Johnston's syntactic approach to different readings for preposed and postponed arguments does not get any further support from VP-deletion contexts (rather, on the contrary, since his analysis appears to make exactly the wrong predictions here). Our approach does take into consideration syntactic structure as well (compare in particular the constraint $\alpha<\beta$), but the different readings are claimed to arise as the result of the interaction between several soft constraints from different modules (syntax, semantics and pragmatics).

5.3. *About* when *and* if

In section 1 above, we mentioned that *when*-clauses are often quoted as preferred restrictors, but that we need to leave room for an interpretation in which they contribute to the scope rather than the restrictor of an adverbial quantifier. This proved to be an important argument in favor of our analysis, because the restrictions on quantificational interpretations could be derived in a straightforward way from the restrictions on temporal anaphorization. However, it has also been pointed out in the literature that not all constructions involving adverbial quantification are dependent on temporal structure in this way. In particular, there is a sharp contrast between the behavior of *if*- and *when*-clauses. Postponed *when*-clauses display ambiguities, but it turns out that postponed *if*-clauses do not. Thus, the ambiguity of (19a,b) contrasts with a lack of ambiguity in (31):

(31) Martin usually shaves if he is in the bathroom

The behavior of *if*-clauses rather than *when*-clauses could thus be taken to provide the main motivation for Lewis (1975) and Heim (1982) to consider adjunct clauses to be typical restrictors. Von Fintel (1994: p. 87 and further) defends a slightly different analysis, and compares *if*-clauses to correlative clauses. It is well known that relative clauses which restrict common noun denotations intersect with the A-set to provide a further restriction on the domain of quantification of a determiner. Von Fintel treats *if*-clauses in a similar way, so that they always intersect with the domain of quantification of an adverbial quantifier. The distinction between *if*-clauses as providing the domain of quantification of the adverb (the Lewis/Heim approach) or as restricting this domain (the Von Fintel approach) is irrelevant for our purposes. In both cases, the authors seem to suggest a syntactic constraint along the lines of the one formulated for determiner quantification in (23) above. In our approach, such a separate syntactic constraint turned out to be superfluous. In order to account for the difference between *if*- and *when*-clauses, we suggest that a generalization of TA to *if*-clauses can do the job. The crucial property of temporal adjunct clauses was that they did not want to be the second argument (the anaphor) in a rhetorical relation. *If*-clauses do not participate in temporal structure the way *when*-clauses do, but we claim they are subject to a very similar constraint: *if*-clauses do not want to be interpreted in the second argument (the set B or the scope) of a quantificational relation. If *if*-clauses cannot contribute to the set B, they will have to be interpreted in the first argument (the set A, or the restrictor) of the quantificational relation. We think that a generalization of the TA constraint is more appropriate than the introduction of a separate syntactic condition, because it preserves the similarities with the *when*-clause constructions, without reducing one to the other.

6. Conclusion

In this paper, we developed an analysis of temporal anaphorization and adverbial quantification in the framework of Optimality Theory. Our account was based on the proposals for nominal anaphorization and determiner quantification developed by Hendriks & De Hoop (1999), and provides a natural extension of their general approach. An important argument in favor of our approach is that the integration of pragmatic and syntactic/semantic information in a system of ranked constraints achieves better results than a purely syntactical account of *when*-clauses, and opens up new ways to think about the similarities and differences between *if*- and *when*-clauses.

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Notes

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[2] This constraint is similar to a constraint that was proposed by Asher & Lascarides (1998), called "Maximize Discourse Coherence".
[3] Obviously, the content of this constraint does not have anything to do with the locality restrictions imposed upon nominal anaphora. The similarity between (9) and (14) resides in the observation that construction-specific constraints relevant for particular subclasses of anaphoric expressions exist besides general constraints such as DOAP.

Bibliographical References

ASHER, Nicholas & Alex LASCARIDES (1998), "Bridging", *Journal of Semantics* 15:83-113

BACH, Emmon *et al.* (eds.) (1995), *Quantification in Natural Languages*, Kluwer Academic Publishers, Dordrecht/Boston/London

FARMER, ANN K. & Robert M. HARNISH (1987), "Communicative reference with pronouns", in Jef VERSCHUEREN & Marcella BERTUCCELLI-PAPI (eds.), *The pragmatic perspective*, John Benjamins, Amsterdam

FINTEL, Karl VON (1994), *Restrictions on Quantifier Domains*, Ph.D. Dissertation, University of Massachusetts, Amherst

HEIM, Irene (1982), *The Semantics of Definite and Indefinite Noun Phrases*, Ph.D. Dissertation, University of Massachusetts, Amherst

HEINÄMÄKI, Orvokki (1978), *Semantics of English temporal connectives*, Ph.D. Dissertation, University of Texas, Austin

HENDRIKS, Petra & H. DE HOOP (1999). "Optimality Theoretic semantics", Ms. University of Groningen Cognitive Science and Engineering prepublications 1998-3

HOOP, Helen DE & Jaume SOLÀ (1996), "Determiners, context sets, and focus", in J. CAMACHO *et al.* (eds.), *The proceedings of the fourteenth West Coast Conference on Formal Linguistics*, Stanford, CSLI publications

JOHNSTON, Michael (1994), "*When*-Clauses, Adverbs of quantification, and Focus", *Proceedings of WCCFL* 13.

KRAHMER, Emiel & Kees VAN DEEMTER (1997), "Presuppositions as anaphors: Towards a full understanding of partial matches", in P. DEKKER, J. VAN DER DOES, & H. DE HOOP (eds.), *De Dag. Proceedings of the Workshop on Definites*, Utrecht Institute of Linguistics OTS, Utrecht

LASCARIDES, Alex & Nicholas ASHER (1993), "Temporal interpretation, discourse relations and commonsense entailment", *Linguistics and philosophy* 16:437-493

LEWIS, David (1975), "Adverbs of Quantification", in E. KEENAN (ed.), *Formal Semantics of Natural Language*, Cambridge University Press, Cambridge

PARTEE, Barbara H. (1973), "Some structural analogies between tenses and pronouns in English", *Journal of Philosophy* 70:601-609

PARTEE, Barbara H. (1984), "Nominal and temporal anaphora", *Linguistics and philosophy* 7:243-286

PARTEE, Barbara H. (1995), "Quantificational structures and compositionality", in Emmon BACH *et al.* (eds.) *Quantification in Natural Languages*, Dordrecht/Boston/London, Kluwer, 541-601

PRINCE, Alan & Paul SMOLENSKY (1997), "Optimality: From Neural Networks to Universal Grammar", *Science* 275:1604-1610

REINHART, Tania & Eric REULAND (1993), "Reflexivity", *Linguistic Inquiry* 24:657-720

ROOTH, Mats (1985), *Association with Focus*, Ph.D. Dissertation, University of Massachusetts, Amherst

ROOTH, Mats (1992), "A theory of focus interpretation", *Natural language semantics*, 1:75-116

SWART, Henriette DE (1991), *Adverbs of quantification: a Generalized Quantifier Approach*, Ph.D. Dissertation, University of Groningen [published by Garland, New York, 1993]

SWART, Henriette DE (1999), "Position and meaning: time adverbials in context", in P. BOSCH & R. VAN DER SANDT (eds.), *Focus: linguistic, cognitive and computational perspectives*, Cambridge University Press, Cambridge, 336-361

WESTERSTÅHL, Dag (1984). "Determiners and context sets", in J. VAN BENTHEM & A. TER MEULEN (eds.), *Quantifiers in natural language*, Dordrecht: Foris, 45-71

WILLIAMS, Edwin (1997), "Blocking and Anaphora", *Linguistic Inquiry* 28:577-628.