

Conflicts in Interpretation

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2. **Abstract for laymen**

Parmenion's assassination was inevitable. Or not? In order to communicate their speculative thoughts, speakers effectively use their implicit knowledge of how hearers arrive at the optimal interpretation of a speaker's utterance in a certain context. Optimization is a major concept in many areas of cognition. The central hypothesis of this project is that optimization plays a crucial role in natural language interpretation, too. The optimal interpretation of an expression is computed by evaluating candidate interpretations against a set of potentially conflicting constraints. The constraints apply simultaneously to syntactic, semantic, prosodic and contextual features of the input-output pairs. Furthermore, the constraints may vary in strength. Hence, if the set of constraints is kept constant cross-linguistically, languages may still differ in the relative

strengths of these constraints. Experimental results are sought that could connect these theoretical insights to the development of comprehension in first language acquisition.

3. Summary of overall aim, key objectives and approach

The overall aim of this project is to explore an innovative view on natural language interpretation, as initiated by recent work of the three project leaders. In this view natural language interpretation is characterized as an optimization process. The research program described below focuses on three subgoals in particular:

- A. developing a *cross-modular* approach to interpretation which integrates various factors into a set of typically conflicting constraints of varying strengths;
- B. elucidating and explaining *cross-linguistic* variation in meaning by investigating how languages vary with respect to their weighting (ranking) of the constraints;
- C. articulating issues of *language learnability* as testable hypotheses on comprehension development by constraint ranking.

Accordingly, the project consists of three parts, Part A (Cross-modularity), Part B (Semantic variation), and Part C (Learnability). Three subprojects are formulated within the program, to be carried out by two PhD-students and one postdoc. The integrated program combines basic theoretical research on language as a major cognitive function, with computational modelling of language processing and experimental research on language learning. Novel methods of constraint interaction derived from connectionist theories are applied to core semantic issues as well as to linguistic issues at the heart of current research in the interfaces of syntax, semantics, pragmatics, and phonology. The hypothesis that optimization is a leading principle in natural language interpretation strengthens the connections between linguistic theory and other cognitive disciplines. Another innovative aspect of the project is the structured investigation of semantic variation among languages and during the course of language acquisition. The aim of this project is to provide support for fundamentally new insights into the way linguistic knowledge is acquired and used. The project will not only strengthen the theoretical basis of linguistics as a cognitive science but also the empirical basis of linguistics with respect to semantic variation among languages and the acquisition of semantic aspects of language. In the project, methods of investigation will be combined from linguistics, artificial intelligence and psychology. The use and acquisition of constraints on natural language comprehension will be subjected to conceptual, computational and experimental analysis. Thematically, the project fits into the area of Organization and Accessibility of Knowledge as described in the report "Fruits of Enlightenment" (in particular with respect to themes such as learnability, the logical dynamics of cognitive processes and computational models of cognition), although there also is a clear link with the area of Communication and Socially Situated Cognition.

4. Participants

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5. Justification of requested personnel

In order to carry out the three subprojects, two PhD-students and one postdoc are necessary. The postdoc will provide the necessary expertise in the area of first language acquisition to complement the expertise of the applicants. As the overall organization of the psycholinguistic research is a time-consuming matter, the postdoc will be hired for three years.

6. Possible interpretations of a historical murder

Whatever its justice, Parmenion's murder seemed inevitable. As Robin Lane Fox puts it: "Parmenion, powerful father to a condemned son, was a threat quite unprecedented since Alexander's accession, and it is not in the least surprising that in self-defense Alexander arranged his assassination" (*Alexander the Great*, Penguin Books 1973). The circumstances under which Parmenion was killed, are well-known. An envoy was sent out to offer Parmenion two letters. The first one was from Alexander the Great himself. The second one was sealed as if from Parmenion's condemned son. *He began to read the letter with pleasure, when they stabbed him (1)*.

Consider the last sentence of the previous paragraph again. Note that the sentence consists of a main clause and a subordinate *when*-clause. The interpretation obtained is that there is a temporal overlap between the two events described by these two clauses. Crucially, there is no causal relation between the two events. Reading the letter with pleasure does not cause the stabbing, nor the other way around. When we would prepose the *when*-clause, however, we would get such a causal reading: *When they stabbed him, he began to read the letter with pleasure (2)*. This interpretation (the stabbing causes his reading the letter with pleasure) strikes us as infelicitous in the context of our present world. We can also establish a reversed causal relation by reversing the events in the *when*-clause and the main clause: *When he began to read the letter with pleasure, they stabbed him (3)*. In sentence (3), the reading the letter with pleasure causes the stabbing. Strikingly, when we change the order of the two clauses, we get *two* possible interpretations. Either there is no causal relation, only temporal overlap, just like the reading we got for sentence (1) above, or the causal relation reading as established in sentence (3) is maintained: *They stabbed him, when he began to read the letter with pleasure (4)*. How come?

In order to provide an analysis for the interaction of the semantic (causal relations), syntactic (word order) and pragmatic (world knowledge) factors that come into play in the interpretation of temporal *when*-clauses, we need to develop a cross-modular approach (Part A). The relevant conditions must be violable and hence, we predict that cross-linguistically, different constraint hierarchies may lead to different outcomes (Part B). Learning to assign the optimal interpretation for a particular word order in a certain context involves acquisition of the weighting (ranking) of the different factors in a certain language (Part C).

Part A: Cross-modularity

7. Optimization in linguistics

The historical roots of optimization theories in linguistics lie in neural network modelling. A core concept in the theory of neural computation is optimization. The

harmony of a pattern of activation is a measure of its degree of conformity to the constraints implicit in the connections between the nodes in the network. A pattern of activation that maximizes harmony (or, minimizes energy) is one that optimally balances the typically conflicting demands of all the constraints in the network.

Optimality Theory emerged as a linguistic theory in the early nineties when it was realized that this concept of optimization in neural network modelling could be applied to theories of grammar as well (cf. Legendre, Miyata & Smolensky 1990, Prince & Smolensky 1991, 1997). At the heart of this theory lies the view that a grammar is a set of violable and potentially conflicting constraints that apply to combinations of linguistic elements. These constraints vary in (relative) strength. A grammatical structure is then one that best satisfies the total set of constraints defined by the grammar. Optimality Theory thus provides a way of integrating the subsymbolic level of the brain with the symbolic level that seems necessary for the description and explanation of cognitive processes.

Such a perspective also allows for a clear view on the relation between knowledge of grammar versus the use of this grammar. Rather than assuming that there need not be a direct correspondence between the two, the use of the grammar is assumed to reflect the knowledge of the grammar directly. Differences between production and comprehension result from the different direction of optimization (from meaning to form or from form to meaning). Whereas a speaker optimizes syntactic structure with respect to a semantic input (the speaker's 'thought' or intention), a hearer optimizes the interpretation of a certain utterance in a certain context (cf. Hendriks and De Hoop 1997, 2001).

Optimality Theory does not support a modular view on grammar. Linguistic phenomena and linguistic processes can be the result of the interaction among different linguistic components. Ultimately, they can be explained from the interaction with other cognitive processes as well.

Let us briefly return to the interpretation of the sentences (1)-(4) above. Three constraints appear to play a role in the interpretation of preposed and postponed *when*-clauses (cf. De Hoop and De Swart 2000): (i) a general pragmatic constraint that favors causal (and other anaphoric) interpretations in discourse; (ii) a construction-specific constraint about *when*-clauses that they cannot refer to the result in a causal relation (that is, they cannot be interpreted anaphorically); and (iii) a constraint at the syntax-discourse interface that links syntactic word order to the order of cause and result (antecedent-anaphor) in a causal relation. By ranking the second constraint higher than the other two, we allow for just the right amount of flexibility in the interpretation of the above sentences. Crucially, the constraints are cross-modular, and involve a mix of syntactic, semantic, and pragmatic information.

8. PhD Project: A cross-modular analysis of focus

Focus. In understanding an utterance in relation to the previous discourse, it is important for the hearer to be able to distinguish the part of the utterance that conveys new information from the part of the utterance that expresses information that already is familiar. The part of the utterance that is informative and contributes to the discourse and

to the hearer's mental representation is usually called the *focus*. The already familiar part of the utterance, which has the function of anchoring the sentence to the previous discourse and to the hearer's mental representation of the discourse, is known as the background.

Different strategies of focus marking. There is an increasing awareness of the fact that different languages have different means to mark the informative part of the utterance, i.e., the focus (e.g., Lambrecht 1994, Vallduví & Engdahl 1996). Languages such as English and many Germanic languages mark the focused material primarily by means of intonation (i.e., sentence accent). For example, in the English sentences below the focused phrase is the phrase carrying sentence accent (accent is indicated by capital letters):

- (5) Jane ate RICE.
- (6) JANE ate rice.

Whereas (5) and (6) are syntactically and semantically identical, they have a different information structure. In Romance languages like Spanish and Italian, focus is marked by word order. The following Italian examples, taken from Lambrecht (1994), show that in Italian the focus of the sentence is generally located at the end of the sentence.

- (7) La mia macchina si è ROTTA.
the my car it is broken
"My car BROKE DOWN."
- (8) Si è rotta la mia MACCHINA.
it is broken the my car
"My CAR broke down."

In (7), *rotta* is the focus of the sentence, whereas in (8) the focus is *macchina*. Note that in these examples the focus is marked by intonation as well. Yet another strategy for focus marking is morphological marking through the use of specific morphemes. Navajo, for example, uses this latter strategy. In this language, a focus morpheme *ga'* is attached to the focused phrase.

However, the picture is more complex than this list of strategies suggests. Although German and Dutch mark focus primarily by means of intonation, word order also plays a role in these languages. In the absence of intonation and further context, *het boek* in (9) can be the focus of the sentence. In (10), however, where the order of the adverb *gisteren* and the direct object *het boek* is switched, *het boek* is preferably interpreted as part of the background and either the adverb or the verb will be the focus.

- (9) Ik heb gisteren het boek gelezen.
I have yesterday the book read
"I read the BOOK yesterday."
- (10) Ik heb het boek gisteren gelezen.
I have the book yesterday read
"I READ the book yesterday."

This indicates that different strategies for focus marking can also be used in combination. But if this is the case, the question arises how these different strategies interact.

This question is especially crucial since the strategies mentioned above apply in different domains of the grammar (e.g., in the phonological component, in the syntactic component and in the lexicon). Because Optimality Theory allows for a formalization of multidimensional constraint interaction, it seems particularly suited to deal with the complex interaction among constraints on word order, intonation, morphology and interpretation.

Focus marking versus focus identification. The major motivation for investigating focus from the perspective of optimization is that focus marking and focus identification appear to involve interaction between different types of constraints. Furthermore, languages differ in the way they mark focus and hence in the way focus is identified. Optimality Theory makes very precise predictions about the ways languages can differ. Differences between languages arise as the result of a reranking of the constraints (see Part B of this program).

An additional advantage of using this theoretical framework is that the development of bidirectional Optimality Theory (cf. Blutner 2000, Zeevat 2000) allows for a distinction between focus marking and focus identification. Previous accounts of focus within an optimization perspective have only been concerned with the speaker oriented question of how the structure of the discourse influences the structure of the utterance. Choi (1996) and Costa (1998), for example, have studied the effects of focus on word order in different languages, using focus as already given. Looking at the hearer oriented process of focus identification, on the other hand, the question can be asked what conclusions a hearer can draw about the structure of the discourse and the information structure of the utterance on the basis of the phonological, syntactic and morphological properties of the utterance. Here, marked word order and other properties of the sentence can be used as an indication of the placement of focus. Obviously, in languages in which word order is a strong marker of focus, word order is expected to also be a strong indicator of focus. A complicating factor is that intonation can be used for other purposes than for marking new information, for example for marking contrast.

This can be illustrated as follows. It was pointed out above that a postponed *when*-clause such as (4) is ambiguous between a temporal overlap reading and a causal relation reading. Note that the two readings are brought out by different intonation patterns. The temporal overlap reading is obtained if we focus the *when*-clause (as in *They stabbed him, when he began to READ the letter with PLEASURE*), whereas the causal relation reading is obtained if we focus the main clause (compare *They STABBED him, when he began to read the letter with pleasure*). However, when the *when*-clause is in preposed position, only one interpretation is possible (the causal relation reading) and focusing the *when*-clause will not help us to get the other, temporal overlap, reading (*When he began to READ the letter with PLEASURE, they stabbed him.*). The reading which results from the latter stress pattern has a pragmatic meaning effect (evoking contrast) but it does not affect the semantics (the causal relation reading) of the sentence.

Therefore, if sentence accent indeed is a constraint on the identification of focus, it must be a soft, i.e., violable constraint. The observations above suggest that the identification of the focus of an utterance is not a process that takes place in isolation, but is highly dependent on the alternative solutions that are available. As such, focus identification is a complex interplay between constraints from different components of the grammar. The observations furthermore suggest that there might be interesting differences in focus identification between languages, which could receive an explanation in the framework of Optimality Theory.

In addition, a pilot study will be carried out to investigate whether a computer model can be developed for focus identification in which the proposed constraints and their interaction are implemented. This pilot study will be based on the Alpino grammar which has been developed at the department of Computational Linguistics in Groningen. The results of this pilot project will be compared with the judgements of native speakers.

Central research question. The central research question of this project is what (potentially conflicting) constraints can be argued to play a role within a cross-modular analysis of the marking and identification of focus and whether it is possible to characterize cross-linguistic variation by means of the reranking of these constraints.

Part B: Semantic Variation

9. Cross-linguistic semantics

Linguistics is the study of language (as a cognitive faculty) and the study of languages (as particular realizations of the language faculty). Within the field of linguistics, there is always a tension between the search for unification ('universal grammar') and the empirical diversity of language phenomena. There is one sub-field of linguistics where this tension is very low, if not almost absent, and that is semantics, the study of meaning.

Nowadays, we generally accept the insight that all languages are equally suitable for communication. From there, it is only one step to the view that semantics is part of universal grammar: if languages can all get a certain message across, they must share a universal set of 'meanings'. If we mean by this that languages typically have words for concepts like 'man', 'child', 'water', and ways to express predication and quantification, this is probably true. But that does not go much beyond the claim that languages generally have vowels and consonants, or a distinction between nouns and verbs. The true challenge for phonologists and syntacticians resides in the formulation of theories that account for a wide variety of phonemes, stress patterns, word orders, and sentence constructions across the languages of the world in the light of the assumption that all humans share the same cognitive faculty of language. And in fact the challenge is the same for semanticists. For example, even though all languages may have systematic ways to express quantification or spatio-temporal information, as typologists have documented and semanticists have explored (e.g., Bach *et al.* 1995, Levinson and Wilkins, in prep.), they do not necessarily have the same array of meanings and they vary with respect to the degree to which these meanings are expressed in the language. But the study of language-specific semantic phenomena does not lead to a theory of cross-linguistic semantics unless there is a framework in which this theory can be couched.

For a long time, typologists formulated language universals to reconcile language variation with the idea of a universal language faculty. The developments of generative grammar in the second half of the 20th century led to the formulation of principles and parameters, where the setting of a parameter fixes a whole series of grammatical features. In the late 20th century, connectionist views spread to linguistics, and led to the development of optimality theoretic analyses of linguistic variation (see also Part A). Neither typological formulations of linguistic universals, nor principles and parameters lend themselves that well for the study of semantic variation. Optimality Theory opens new perspectives for cross-linguistic semantics.d

In our view then, the time is ripe to apply the framework of optimality theory not only to general questions of interpretation, but also to the more specific question of variation in meaning across languages. The empirical application of this general approach we choose in this part of the program is the study of bare nominals.

10. PhD Project: A cross-linguistic study of bare nominals

Bare nominals. ‘Bare’ nominals are nominal phrases without a(n overt) determiner, such as the bare plural and bare mass noun in English: *children were playing in the garden*, *Ann ate cookies*, *cats like milk*, etc. In languages like English, bare nominals fill regular argument positions of the predicate, just like ‘full’ nominal expressions with a determiner (*a child*, *two cookies*, *no milk*). Their interpretation is flexible, though: they can have an existential meaning (‘some children were playing’) or a generic meaning (‘cats in general like milk’). The interpretation is determined by the interplay of the syntactic position (subject/object asymmetry) and the kind of predicate (stage-level/individual level contrast).

Distribution and interpretation. Languages vary in whether they do or do not have bare nominals: English and Germanic languages do, for Romance languages this is a very restricted option. Languages vary in which nominals can be bare: in English we have bare plurals and bare mass nouns, but not bare singular count nouns, whereas in Slavic languages we have all three options. Languages vary in the interpretation bare nominals can take up: existential only in Hungarian, existential and generic in English, existential, generic and definite in Slavic languages and Hindi. Some attempts have been made to account for these observations in terms of parametric variation (cf. Chierchia 1998). The results of these studies indicate that there are conflicting constraints at play: tendencies towards minimal syntactic structure, and maximal freedom of interpretation conflict with opposite tendencies. Languages also vary in the relative effects of focus and word order on the interpretation of a bare nominal in a certain context (cf. Dayal, to appear).

An optimality-theoretic approach could shed more light on this, by assuming that the same constraints apply cross-linguistically, but are ranked in a different order. Furthermore, bi-directional OT can help to account for opposite tendencies in the process from meaning to structure (‘speaker’s point of view’), and from structure to meaning (‘interpreter’s point of view’).

A further complexity arises when we consider the possibility of noun incorporation. In English and Germanic languages, this process is restricted to

compounding (*baby sitting, berry picking*), but in many American-Indian languages, in Inuit and other languages, this is a regular syntactic process (cf. Van Geenhoven 1996). Incorporated bare nominals are always interpreted existentially, even if the language also allows bare nominals in free argument position, and allows generic and/or definite interpretations for those (Hindi). If we want to account for this in Optimality Theory, we need to show that different constraint rankings do not affect the interpretation of incorporated bare nominals.

Finally, incorporation languages vary in which bare nominals can incorporate: bare singulars are always possible, but sometimes bare plurals can incorporate as well. This triggers differences in anaphoric structure: incorporated bare singulars can be the antecedent of a discourse anaphoric pronoun in some languages (Greenlandic Eskimo), but not in others (Hindi, Hungarian). In languages in which bare plurals incorporate, they can always be the antecedent of a discourse anaphoric pronoun (Hindi, Hungarian).

The fact that the contrast between bare singulars and bare plurals plays a role in incorporating and non-incorporating structures alike supports a theory in which the same family of constraints play a role in different languages, even though their ranking and their interaction with the rest of the system is different.

In sum, the empirical domain of bare nominals is an ideal ‘playground’ for an optimality-theoretic approach to semantics, because quite a few of the data have been uncovered, while an account that does justice to the cross-linguistic variation is not available in the existing literature, but seems well within the range of the Optimality Theoretic framework.

Central research question. The central research question of this project is whether we can develop a bi-directional Optimality Theoretic account of bare nominals that takes into account their distribution and interpretation in a wide variety of languages.

Part C: Learnability

11. Language acquisition

The character of the restrictions imposed by Optimality Theory have demonstrable and significant consequences for central questions of learnability (cf. Tesar and Smolensky 2000). Optimality Theory is inherently comparative: the well-formedness of an output candidate is determined not in isolation, but with respect to competing candidates. Thus, each piece of positive evidence brings with it a body of implicit negative evidence in the form of the competing (suboptimal) representations. Such pairs are what feed the learning algorithm of Tesar and Smolensky. They claim to have constructed a learning algorithm to exploit the structure provided by the optimization theory of cross-linguistic variation. This algorithm has the property that it finds the correct ranking, when supplied with the correct input-output pairs for a language. Furthermore, the number of well-formed outputs required by the algorithm is quite modest, especially when compared with the number of distinct rankings.

Optimality Theory provides an attractive framework for the study of the acquisition of language comprehension as it can incorporate different factors (syntactic, prosodic, contextual), whose development is normally considered separately, enabling us to bring together findings from different areas of language development.

Thus, we may account for the broad patterns of comprehension development which become manifest through language acquisition phenomena. Another advantage of such an optimization view to language acquisition is its transparency. Since each constraint applies in principle to all input-output pairs, a change in the ranking or weight value of a constraint may affect the outputs for a range of different input structures. Hence, an analysis of a particular deviation of language learner outputs (interpretations) as compared to adult outputs generates clear predictions about the outputs for other input structures.

The following sub-project is aimed at a thorough investigation of the role of constraint learning and ranking in the empirical domain of anaphora comprehension.

12. Postdoc project: Acquiring anaphoric interpretations

Acquisition. The relevance of studying patterns of language acquisition for the theory of optimization is obvious when the process of language acquisition is assumed to consist in the ranking of universal constraints. This requires a principled explanation of why certain interpretations are acquired late relative to others.

Children's interpretation of anaphora. Consider the following Dutch sentences. They are uttered in an experimental situation in which four little jars are standing in front of the hearer. The jars have been mentioned in a previous utterance.

- (11) Wil je een potje twee keer omdraaien?
would you a jar two time over-turn
“Would you turn over a jar twice?” (turn one and the same jar twice)
- (12) Wil je twee keer een potje omdraaien?
would you two time a jar over-turn
“Would you turn over a jar twice?”(turn two jars, each once)

Sentence (12) is interpreted by four-year old children in an adultlike manner. Their response is to turn two different jars. However, most four-year olds and no less than 35% of the seven-year olds interpret sentence (11) the same way. That is, adults will turn one and the same jar as a response to (11), whereas these children will turn two different jars (Krämer 2000). It can be argued that in order for a child to interpret sentence (11) in the adultlike manner, she must be able to interpret ‘a jar’ as a specific jar, thus anaphorically linked to the previous discourse. Indeed, the word order in (11) indicates that the anaphoric reading for the object is the intended reading (compare the example in (10) above). Children seem to neglect this word order clue and interpret the indefinite object in (11) like the (non-specific) non-anaphoric one in (12).

Adopting the insights of Optimality Theory, it has been argued convincingly by several authors that constraints on anaphoric relations must be violable (cf. Burzio 1998,

Menuzzi 1999, Ter Meulen 2000, Wilson 2001, Bresnan, 2001). These authors provide evidence that from the speaker's point of view, anaphoric forms are chosen on the basis of relative best-formedness, rather than absolute well-formedness, with respect to a set of universal constraints. Cross-linguistic variation in the distribution of specific forms is mainly derived from intrinsic lexical properties and economy considerations. The choice of an anaphoric option is relative to the set of competing options, and competition is decided by best satisfaction of the set of constraints. From the hearer's point of view, given the use of a certain anaphoric form, the competition is among the possible interpretations that form can get. For children to learn the anaphoric use of noun phrases in their language, they must learn the lexical properties of those forms first. That is, before a child can learn that a definite can be used anaphorically, she must learn to recognize the form of a definite. But identifying for instance a form like 'definite article + noun' as a definite noun phrase is still relatively complicated considering the variation in interpretation which allows for definite descriptions to refer either anaphorically or non-anaphorically.

This problem may be solved if, initially, only the basic non-anaphoric interpretation is available. This would limit the problem space for the children's task of identifying the basic interpretations of the different forms of noun phrases that their language input contains. A frequency based learning algorithm may then associate different nominal categories with different basic interpretations.

We hypothesize then that, initially, anaphoric interpretations are not available. There is more evidence that points in this direction. Consider (13).

(13) The boy touches a bell. And then the girl touches the bell.

When asked to act out sentences like (13) with a boy and a girl doll, interpretations of 'the bell' on which the girl touches the same bell as the boy, were at chance level. Only at age nine, the definite object is interpreted anaphorically by the majority of the children (Karmiloff-Smith 1979). Similarly, many authors have proposed that children's pronouns are not anaphoric, but rather they refer directly to individuals in the (non-linguistic) context. Finally, strongly quantified noun phrases, such as *all boys*, usually involve taking into consideration anaphoric possibilities in order to determine the domain of quantification (the boys in a particular story, for example). If children do not have anaphoric options available, how do they interpret utterances containing strongly quantified noun phrases? One possibility is that children determine the domain of quantification on the basis of visual clues, evidence for which was found in Brinkmann, Drozd and Krämer (1996). In the present part of the project we will evaluate the basic hypothesis proposed above on the initial non-availability of anaphoric interpretations. Different categories of nominal constituents (definites, indefinites, pronouns, quantifiers) will be tested in a systematic way, using highly similar experimental methods (see also part B of the project about the anaphoric possibilities of bare nominals cross-linguistically).

There are a number of reasons why anaphoric options might not be available until a certain age: processing limitations or lack of automatization of anaphoric processes,

limited attention span, or a less than fully developed ability to identify the relevant linguistic context (Brown 1998). If children initially cannot apply a notion of anaphora, constraints that deal with anaphora are vacuous, rather than just ranked low. For example, it must be assumed then that the constraint that favors anaphoric interpretations whenever possible that was argued to play a role in the interpretation of temporal *when*-clauses, initially cannot guide children's interpretations of these clauses.

It is an interesting question what happens when the role of anaphora increases. Are the constraints acquired gradually or with sudden jumps? What are the constraints relevant to anaphora interpretation and how do they interact with each other? As we have seen in project A, prosody is known to overrule certain word order constraints for adults, but is this also the case for children? There are some indications that prosodic clues have a smaller effect on children's interpretations than on adults (cf. Cutler and Swinney 1987). Questions like these may be tested by manipulating the context of an utterance in such a way that a particular constraint is promoted.

Central research question. The central research question of this project is what the constraints relevant to anaphora interpretation are and whether we can explain the acquisition process of anaphora comprehension in terms of learning (the weight values or ranking of) these constraints.

13. On the optimal interpretation of a historical murder

At first sight, it does not make sense to assume that there was a causal relation between Parmenion's reading the letter with pleasure and him being stabbed. However, not all historians agree on that. We have seen that when the sequence of events is described as in sentence (1) above, the relation between the reading the letter with pleasure and the stabbing can only be a coincidental, temporal overlap relation. Accordingly, this is usually how the historical event is described, for example: "He began to read it with an expression of evident pleasure, when his generals drew their daggers and stabbed him repeatedly" (Fox 1973, p. 286); "He was reading the second joyfully, as could be seen from his countenance, when they struck him down" (Mary Renault 1975, *The nature of Alexander*, New York, p.165).

Yet, suppose an author wishes to speculate on a possible causal connection between reading a letter with pleasure and getting killed, in the sense that the former causes the latter. This can be done by reformulating the sentence along the lines pointed out above. In the following fragment, Parmenion's reading the letter with pleasure is interpreted as a sign that caused the stabbing as it conveyed Parmenion's knowledge of the conspiracy against Alexander the Great. "It was when Parmenion showed evident pleasure at its contents, and not before, that he was killed. If he had shown puzzlement, irritation, vague disapproval, anger, fear, would the daggers have been drawn?" (Renault 1975, p. 165). This speculative interpretation of history is simply achieved by using a particular linguistic construction: a preposed *when*-clause. The author uses her implicit knowledge about the constraint ranking that governs interpretation to express the sequence of events in such a way the warranted interpretation emerges as the optimal one. It seems to us that this can only be properly accounted for within a bidirectional optimization approach to natural language interpretation.

14. International position and collaboration

Optimality Theory (OT) was developed in the 1990s by Alan Prince and Paul Smolensky as a general theory of language and grammar. Only recently OT was applied to semantic and pragmatic analysis for the first time and the last few years have shown a remarkable growth in the use of conflicting constraints to characterize natural language interpretation. This project will be closely connected to research programs carried out in Berlin (Prof.dr. Manfred Krifka, Dr. Reinhard Blutner), Stanford (Prof.dr. Joan Bresnan, Prof.dr. David Beaver), Amsterdam (Dr. Henk Zeevat, Dr. Paul Dekker, Dr. Robert van Rooy) and Johns Hopkins (Prof.dr. Paul Smolensky, Prof.dr. Géraldine Legendre, Dr. Anne Vainikka).

15. Selected publications by the applicants

- Hendriks, P. (1999), 'The problem with logic in the logical problem of language acquisition'. In: L.R. Gleitman & A.K. Joshi (eds), *Proceedings of the Twenty-Second Annual Conference of the Cognitive Science Society*, Lawrence Erlbaum, Mahwah, NJ.
- Hendriks, P. & H. de Hoop (1997), 'On the interpretation of semantic relations in the absence of syntactic structure' In: *Proceedings of the 11th Amsterdam Colloquium*. Amsterdam: ILLC.
- Hendriks, P. & H. de Hoop (2001), 'Optimality Theoretic Semantics' *Linguistics and Philosophy* 24, 1-32.
- Hendriks, P., H. de Hoop & H. de Swart (eds) (2000), Special issue on the optimization of interpretation, *Journal of Semantics* 17.3, 17.4.
- Hoop, H. de & H. de Swart (2000), 'Temporal adjunct clauses in Optimality Theory' *Rivista di Linguistica* 12.1, 107-127.
- Swart, H. de (1996), '(In)definites and genericity.' In: M. Kanazawa, C. Piñon & H. de Swart (eds), *Quantifiers, deduction and context*. Stanford: CSLI.
- Swart, H. de & H. de Hoop (2000), 'Topic and focus.' In: L. Cheng & R. Sybesma (eds), *The First Glot International State-of-the-Article Book*, Berlin: Mouton de Gruyter.

16. Key references

- Blutner, R. (2000), 'Some Aspects of Optimality in Natural Language Interpretation' *Journal of Semantics* 17.3, 189-216.
- Hendriks, P. & H. de Hoop (2001), 'Optimality Theoretic Semantics' *Linguistics and Philosophy* 24, 1-32.
- Prince, A. & P. Smolensky (1991), *Notes on Connectionism and Harmony Theory in Linguistics*. Technical Report, Department of Computer Science, University of Colorado, Boulder.
- Prince, A. & P. Smolensky (1993), *Optimality Theory. Constraint Interaction in Generative Grammar*. To appear MIT Press, Cambridge.
- Prince, A. & P. Smolensky (1997), 'Optimality Theory: From Neural Networks to Universal Grammar' *Science* 275, 1604-1610.
- Tesar, B. & P. Smolensky (2000), *Learnability in Optimality Theory*. Cambridge, MA: The MIT Press.

Wilson, C. (2001), 'Bidirectional Optimization and the Theory of Anaphora', In: G. Legendre, J. Grimshaw, and S. Vikner (eds) *Optimality-Theoretic Syntax*. Cambridge, MA: MIT Press.

Zeevat, H. (2000), 'The Asymmetry of Optimality Theoretic Syntax and Semantics' *Journal of Semantics* 17.3, 243-262.

17. Previous research related to this proposal

The first application of Optimality Theory to the field of semantics was Hendriks & De Hoop (1997). This paper, a more elaborate version of it which appeared in *Linguistics and Philosophy*, and De Hoop & De Swart (2000) aroused a lot of interest from semanticists as well as pragmaticians in the possibility of explaining natural language interpretation by using conflicting constraints. The new field of Optimality Theoretic Semantics was brought to the attention of a broad linguistic community by two conferences in Utrecht in 2000 organized by the applicants. This resulted in a special issue of *Journal of Semantics*, edited by the applicants.

18. Main lines of experimental approach

The research of the first PhD project (Part A) and the second one (Part B) will be carried out by applying the standard methodology of theoretical linguistics, namely collecting linguistic data, formulating hypotheses and testing hypotheses against new data. The linguistic data will be taken from a wide range of languages, including Germanic and Romance languages and possibly also other language families. Wherever possible, the data will be collected by consulting native speakers. In addition, grammatical descriptions of the relevant languages will be used and the recently constituted LOT typological data base will be consulted. The pilot study on computational modelling (Part A) will be carried out in collaboration with the department of Computational Linguistics in Groningen. The research of the postdoc project (Part C) will be carried out by applying the standard methodology of psycholinguistics, namely constructing, testing and running psycholinguistic experiments in first language learning environments.

19. Practical investigation scheme

Year 1 (4 months): Collecting data. Design of acquisition experiment. Formulating hypotheses.

Year 2 and 3: Constructing, pretesting and running four acquisition experiments.

Interpretation of cross-linguistic data. Integration of the results of the different parts of the project. Analyses of the data. Postulation of hypotheses. Pilot study on computational modelling. Presentations of ongoing research at conferences and workshops. Publication of results in international journals.

Year 4: Publication of final results of postdoc project. Final analyses of the data.

Postulation of final hypotheses. Presentations at conferences and workshops. Publication of results in international journals.

Year 5 (8 months): Final report on the key results in two dissertations.