

Registration form (basic details)

1a. Details of applicant

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1b. Title of research proposal

Asymmetries in Grammar

1c. Summary of research proposal

Children from a young age on use the pronoun *him* in an adult-like and systematic way when they speak. Yet they often do not understand this word correctly when it is uttered by someone else. Why would these children use their knowledge of grammar in production, but not in comprehension? In other cases, children understand a form before they use it themselves. Obviously, such asymmetries in acquisition cannot be explained by a traditional rule-based grammar, according to which speakers who obey a rule in production know this rule, and hence should obey this rule in comprehension too (and vice versa for hearers).

This program seeks a unified explanation for these production-comprehension asymmetries. It tests the hypothesis that the grammar is an asymmetrical system of constraints on form and meaning. Hence, production may yield other results than comprehension. Mature language users have learned to integrate the two directions of language use by taking into account their conversational partner's options as well. This results in a symmetrical matching between forms and meanings. The ability to consider other people's options in communication may be limited in children and impaired in autistic individuals.

The proposed program thus explores a novel view on the organization of the grammar. It models the way children produce and comprehend utterances, and the way adults consider their conversational partner's perspective in communication. Psycholinguistic experiments are conducted which test this model by studying production and comprehension in the same subjects. These experiments reveal which part of our mature linguistic competence arises from the grammar, and which part arises from implicit reasoning about our conversational partner's options. The program also applies these new linguistic insights to the field of autism and may improve the diagnosis and treatment of the language deficits within autistic spectrum disorder (ASD), which are still poorly understood.

(300 words; maximum 300 words, plus max. 5 KEYWORDS)

Keywords: Language Acquisition, Optimality Theory, Semantics, Syntax, Autism.

1d. NWO Council area

Geesteswetenschappen

1e. Host institution

CLCG, University of Groningen

Research proposal

2. Description of the proposed research

2.1 Aim: A new model of grammar

In the past three decades, research on language acquisition has identified several asymmetries between comprehension and production in various languages and in various areas of language. Many of these asymmetries came as a surprise to their investigators, because no asymmetries are expected under the traditional view of the grammar as a symmetrical system of linguistic knowledge. The purpose of this project is to construct a model of grammar which accounts for the actual tasks of speakers and hearers and is sufficiently formalized to define patterns of acquisition for different linguistic phenomena. Grounded in linguistic theory as well as in language acquisition and sentence processing, such a model will increase our understanding of the nature of the human language faculty as well as of communication disorders such as in autism.

2.2 Puzzle: Correct production, but incorrect comprehension

When an average 6-year-old child encounters the sentence "Ernie washed him" in a context in which Ernie and Bert are the only two individuals present, about half of the time the child will incorrectly understand the pronoun *him* as referring back to the subject Ernie (see, e.g., the landmark study of Chien and Wexler, 1990). Thus the child concludes that Ernie washed himself. However, children's production of pronouns is adult-like from an early age on, as was found by Bloom, Barss, Nichol, and Conway (1994) in their study of the spontaneous production of first person pronouns by 2 to 5 year olds, and more recently by de Villiers, Cahillane, and Altreuter (in press) in their experimental study of the production and comprehension of third person pronouns by 4 to 7 year olds. Children will almost always use the reflexive *himself* to describe a situation in which Ernie washed Ernie, and the pronoun *him* if Ernie washed Bert. Thus children's language production suggests that they possess the relevant grammatical knowledge. But then why don't they use this knowledge when interpreting the same form? What is so difficult about the word *him* that its meaning is not yet mastered even at age 6? And is *him* somehow special, or do children at this late age experience difficulties understanding other words and sentences as well?

2.3 The research program

To save the traditional view on grammar, this delay in pronoun interpretation, occurring in e.g. English and Dutch, has been attributed to extra-grammatical factors such as problems with real-world knowledge (the 'pragmatic account'; e.g. Thornton and Wexler, 1999) or lack of processing resources (the 'processing account'; e.g. Reinhart, 2004; 2006; in press). In contrast, the proposed program seeks an account for this delay within the grammar (a 'grammatical account'; cf. Hendriks and Spender, 2004; in press), that also explains other asymmetries that may be found in language acquisition, such as with early words, subject-object order, anaphoric subjects and contrastive stress.

The program proceeds from the view that speakers and hearers place different demands on language. As a result, language production may favor certain matchings between form and meaning while language comprehension favors other matchings. Mature hearers can overcome these discrepancies by reasoning about the alternative forms a speaker could have used. If hearers are incapable of doing this (either because considering the speaker's alternatives is cognitively too demanding, or because they have no 'theory of mind' which allows them to consider alternatives entertained by others), comprehension errors occur. If production of the adult form is not dependent on linguistic reasoning, a production-comprehension asymmetry arises.

A linguistic framework supporting such a view of the grammar is Optimality Theory (OT). In OT, production and comprehension are modelled as different directions of use of the same grammar. Because constraints of the grammar may or may not be effective depending on their direction of use, the grammar is asymmetrical. Moreover, OT is not only a theory of language structure, but also of sentence processing and linguistic reasoning about others.

The central hypothesis is that the grammar is an asymmetrical system. Only after hearers have learned to reason implicitly about options available to a speaker, and vice versa, does a symmetrical pattern arise:

Asymmetrical grammar + linguistic reasoning = symmetrical pattern

To test the central hypothesis, the following four subhypotheses must be verified. This will be done in four subprojects discussed below.

- (i) Grammar itself is asymmetrical, and not merely its use (subproject 1, section 2.7).
- (ii) Delays occur both in comprehension and in production, and hence cannot be attributed to comprehension in general being more difficult (subproject 2, section 2.11).
- (iii) The difference between adults' and children's comprehension is qualitative (different operations) rather than quantitative (more processing resources) (subproject 3, section 2.13).
- (iv) A symmetrical pattern does not emerge in individuals unable to consider their conversational partner's alternatives because they lack a 'theory of mind' (subproject 4, section 2.15).

The applicant will study the formal conditions under which form-meaning asymmetries arise and are resolved, and will integrate the results of the subprojects in a cognitively plausible theoretical model of production and comprehension. The applicant will also coordinate the four subprojects and strengthen the coherence of the program by stimulating collaboration among project members.

2.4 Asymmetries in the use of grammatical knowledge

Suppose you are a native speaker of English and want to express the fact that Ernie hit Bert. You would put the subject *Ernie* first in the sentence, and the object *Bert* after the verb, because English encodes the grammatical function of words by means of word order. When hearing the sentence "Ernie hit Bert", because of the order of the words you would know that Ernie is the one who did the hitting, and Bert is the one being hit. Once you know how English encodes grammatical function, according to the traditional view this knowledge is available to you in production as well as in comprehension.

However, Chapman and Miller (1975) found that young children perform much better on the production of word order than on its comprehension. In a production experiment with 15 children between the ages of 1;8 (i.e., 1 year and 8 months) and 2;8, they found that these children tended to preserve subject-object order with respect to the verb. For example, they would say "car hit boy", "hit boy", or "car hit" when having watched the experimenter perform the action of a toy car hitting a boy doll, but rarely "boy hit car" or "hit car". This strongly suggests that these children have linguistic knowledge of English word order. However, the same children, when tested on the same type of sentences in a comprehension experiment in which they had to act out the meaning of the sentence with toys, significantly less often used cues from word order to

determine the event to be acted out. When hearing the sentence "The car is hitting the boy", the children frequently demonstrated the action with the boy doll hitting the car toy, instead of the other way around. With an inanimate subject and an animate object, the percentage of correct responses was found to be lowest, namely 50.1%. These data strongly suggest that the correct production of basic word order by young English children precedes their comprehension. A later replication of this study by McClellan, Yewchuk, and Holdgrafer (1986) found the same pattern. An explanation for this remarkable but largely ignored pattern in language acquisition is lacking under a traditional symmetrical view on the grammar: if English-speaking children possess knowledge of basic word order, as is evidenced in production, why don't they use this knowledge in comprehension? Since basic word order is generally assumed to be determined by the grammar, neither pragmatic factors nor processing factors can be held responsible for this asymmetry.

2.5 Asymmetrical grammar

If production and comprehension yield different matchings between form and meaning, and if this cannot be attributed to pragmatics or processing, then the grammar itself must be asymmetrical. A linguistic framework allowing for such an asymmetrical grammar is Optimality Theory (Prince and Smolensky, 1993/2004).

Optimality Theory (OT) proceeds from the view that language users select the best output for a given input by optimizing over a set of constraints. The grammar consists of these constraints, which are potentially conflicting and arranged in a hierarchy of strength. Conflicts among constraints are resolved by tolerating violations of weaker constraints, but only insofar as they contribute to the success of a stronger constraint. The optimal output is the output that best satisfies the total set of constraints and their ranking. The input to the OT grammar can be either a form or a meaning. Taking a speaker's perspective, as in OT syntax (e.g., Bresnan, 2000; Grimshaw, 1997; Legendre, 2001), the input to optimization is a meaning. From this input meaning, a set of candidate output forms is generated. These are evaluated on the basis of the ranked constraints. By selecting the optimal form, a mapping is established from the input meaning to this optimal output form. The same constraints can be used to establish a mapping from an input form to an output meaning, thereby taking a hearer's perspective (see Hendriks and de Hoop, 1997; 2001, for the initial idea of applying OT in the domain of interpretation).

Crucially, constraints in OT come in two types: faithfulness constraints and markedness constraints. These two types of constraints can be seen as embodying the competing forces shaping language: the force of communication, and the force of speaker and hearer economy, respectively. Faithfulness constraints state that the relation between input and output must be as straightforward as possible. In OT phonology, where the input is an underlying form and the output a surface form, this amounts to identity. In OT syntax and OT semantics, input and output cannot be identical, and faithfulness constraints must establish a relation of association (between a form and a meaning). Contrasting to faithfulness constraints, markedness constraints have the effect that the relation between input and output is *not* as straightforward as possible. Markedness constraints penalize certain candidates irrespective of their input.

Faithfulness constraints, whether formulated as implications or as bias constraints prohibiting particular form-meaning pairs (cf. Mattausch, 2004), promote a one-to-one mapping between forms and meanings. Consequently, they may have a similar effect when used in the opposite direction. Markedness constraints, on the other hand, pertain to form or meaning only and hence fail to have any effects when used in the opposite direction. Faithfulness constraints thus promote symmetry, whereas markedness constraints promote asymmetry. As a result, an OT grammar is partly asymmetrical and can yield different form-meaning pairs depending on the direction of optimization. Some examples are given in the next section. This property of OT is known but has never been

pursued to its full consequences. Under what constraint combinations and which rankings does an asymmetrical grammar actually produce form-meaning asymmetries, and are these empirically attested? The applicant will investigate the formal conditions under which asymmetries arise and are resolved, thus allowing for a generalization of the model to other languages and other phenomena than the ones studied in this program.

2.6 Production and comprehension yield different results

The fundamental asymmetry of OT explains the well-known observation that children’s ability to produce word forms such as *cat* generally lags behind their ability to comprehend the same forms. Young children may say *ta* when referring to a cat, while being perfectly capable of understanding the word *cat*.

Asymmetry type 1: Children’s language use is characterized by early production delays.

Smolensky (1996) argues that such early delays in production follow from a non-adult constraint ranking where one or more markedness constraints on surface form are ranked too high. Consider the following two simplified unidirectional OT tableaux. In each tableau, the input to optimization is presented in the first column. Because the input is always given, it is kept constant across all possible outputs. A selection of relevant candidate outputs for this input is presented in the second column. If a particular input or output violates a constraint, this is marked by an asterisk in the corresponding cell.

Input = underlying form	Output = surface form	Markedness constraints on surface form	Faithfulness constraints
/kæt/ →	[kæt]	*	
	[ta]		*

Tableau 1: Children’s production (from underlying form to surface form)

Candidate output [kæt] violates markedness constraints encoding a dispreference for syllables ending with a consonant and for pronouncing sounds like [k]. Candidate output [ta] is unfaithful to the input /kæt/ because sound segments are replaced (k→t) or omitted (the final t). If in the child’s grammar the markedness constraints are ranked higher than the faithfulness constraints, it is better to violate the faithfulness constraints than the markedness constraints. Consequently, the child will produce the unfaithful surface form [ta] to express the underlying form /kæt/.

Input = surface form	Output = underlying form	Markedness constraints on surface form	Faithfulness constraints
[kæt] →	/kæt/	*	
	/ta/	*	*

Tableau 2: Children’s comprehension (from surface form to underlying form)

In children’s comprehension, in contrast, the pronounced form [kæt] violates the markedness constraints regardless of the hypothesized underlying form. This is indicated by asterisks in each row in the third column in tableau 2. As a result, the lower-ranked faithfulness constraints are decisive and hence [kæt] is interpreted by these children as the faithful underlying form /kæt/.

The same type of explanation can be given for comprehension delays in the acquisition of the grammar, as is argued by Hendriks, de Hoop, and Lamers (2005). Chapman and Miller (1975) observed that young children take animacy as a determining factor for subject-object status in comprehension, but not in production (see section 2.4). Importantly, such animacy effects are present in all languages. Even in German, where the effects of animacy are usually suppressed by the effects of overt case, animacy effects show up in adults’ online processing (Schlesewsky and Bornkessel, 2004). This suggests that the animacy effects observed by Chapman and Miller are the result of the grammar rather than of some non-linguistic heuristic.

Now suppose that these animacy effects are due to an “animacy constraint” saying that subjects should outrank objects in animacy, and word order is due to a “word order constraint” saying that subjects should precede objects. Suppose further that the children in Chapman and Miller’s experiment incorrectly assume that the animacy constraint, which is a markedness constraint on meaning, is ranked higher than the word order constraint, which is a faithfulness constraint establishing an association between a particular form (word order) and a particular meaning (subject-object status of the noun phrases). We now obtain exactly the opposite pattern as in tableaux 1 and 2: correct production is predicted to precede correct comprehension.

Input = meaning	Output = form	Markedness constraints on meaning	Faithfulness constraints
'the car is hitting the boy'	The car is hitting the boy.	*	
	The boy is hitting the car.	*	*

Tableau 3: Children’s production (from meaning to form)

Input = form	Output = meaning	Markedness constraints on meaning	Faithfulness constraints
The car is hitting the boy.	'the car is hitting the boy'	*	
	'the boy is hitting the car'		*

Tableau 4: Children’s comprehension (from form to meaning)

Production is predicted to be adult-like, because the animacy properties of the actors involved in the event are already given as part of the input meaning. Therefore, all possible forms violate the animacy constraint, and the weaker word order constraint becomes decisive. As a result, the subject will be put before the object. In contrast, when hearing a sentence with an inanimate subject and an animate object, such as “The car is hitting the boy”, children will take animacy to be the determining factor because the animacy constraint is stronger than the word order constraint. Hence, they incorrectly

interpret the animate noun phrase *the boy* as the subject. If the animacy constraint and the word order constraint are universal across languages, as is commonly assumed in OT, we expect the same asymmetry to emerge in other languages.

Asymmetry type 2: Is children's language use characterized by early comprehension delays?

If comprehension delays are found with respect to early grammatical knowledge, a unified explanation of early delays in terms of an asymmetrical grammar is preferable to an explanation in terms of lack of psychomotoric skills (as suggested by Zeevat, to appear), which would only account for early delays in production.

2.7 Subproject 1 (PhD): Word order in early child language

Subproject 1 investigates whether the grammar itself is asymmetrical, focusing on the production and comprehension of subject-object order in Dutch. The experiments by Chapman and Miller (1975) and McClellan et al. (1986) were with English-speaking children. However, Koster (1993) notes similar 'inversion errors' with Dutch children in experiments on anaphora comprehension. When presented with the sentence "The brother of John washes him" in a context where there are two individuals, John and John's brother Pete, many children select the picture in which John washes Pete. These inversion errors do not usually surface in picture selection tasks, because in standard tasks the child is forced to choose between only two or three pictures. However, some of the tasks Koster discusses have more varied error possibilities, and here the inversion error turns out to be a significant error type, accounting for up to 44% of the incorrect responses.

Unfortunately, Koster has no matching production data for these Dutch children. This subproject, as well as the other subprojects within this program, will collect both comprehension data and production data from one and the same group of children, a novel approach that will generate new empirical results. Since possessive constructions such as *the brother of John* may independently introduce all kinds of difficulties, this study will focus on reversible transitive sentences with non-complex subjects and objects. McClellan et al. (1986), in their discussion of their results with English-speaking children, suggest that a probable event strategy may interfere with other cues in comprehension. In addition, visual cues available during the production task may facilitate correct production. This study will therefore carefully control for these potentially interfering factors.

Research goal

1. Determine whether young Dutch children show a comprehension delay with respect to subject-object order, and analyze the new data in the light of the central hypothesis.

Methodology and data

Production data as well as comprehension data are collected from unimpaired Dutch-speaking pre-school children (ages 1;6-4). Comprehension is studied using act-out tasks and picture selection tasks. Production is studied in the same children using elicitation tasks. Elicitation tasks make it possible to use the same type of sentences in the comprehension study and the production study, and to determine the intended meaning for each produced sentence (which is impossible with corpus research).

2.8 Linguistic reasoning

If the grammar is asymmetrical, as hypothesized in this program, then why don't adults display asymmetries? According to the central hypothesis, this is because mature hearers take into account the speaker's perspective, and vice versa. This can be modelled by combining the two directions of optimization: the speaker's direction from meaning to form, and the hearer's direction from form to meaning. The resulting formal model of linguistic reasoning is known as bidirectional OT (Blutner, 2000). In bidirectional OT, a given form only has a certain meaning if this meaning yields the same form back again, and vice versa. Other forms and meanings are blocked. Bidirectional optimization can be defined non-recursively as follows:

- (1) A form-meaning pair $\langle f, m \rangle$ is bidirectionally optimal if and only if there is no pair $\langle f', m \rangle$ such that $\langle f', m \rangle$ is more harmonic than $\langle f, m \rangle$, and there is no pair $\langle f, m' \rangle$ such that $\langle f, m' \rangle$ is more harmonic than $\langle f, m \rangle$.

The term "harmonic" refers to the notion of harmony, which is taken from neural network theory and is a numerical measure of how well the pairs conform to the constraints of the grammar (Smolensky, 1986).

Under this type of bidirectional optimization (so-called 'strong' bidirectional optimization), many instances of ambiguity and optionality that are still present under an adult constraint ranking now disappear, because one of the potential meanings or forms is blocked. The presence of blocking in the adult grammar (and its absence in the child's) may provide a straightforward explanation for the pronoun interpretation delay. Children merely try to find the best form (as a speaker) or the best meaning (as a hearer), without taking into account the opposite perspective as well. Consequently, a form that can give rise to multiple meanings will be ambiguous for children.

This can be illustrated by the example of pronoun interpretation discussed earlier. Consider again the utterance "Ernie washed ..." in a context in which Ernie and Bert are the only two individuals present. In this context, object pronouns and reflexives are produced correctly from an early age on (Figure 1).

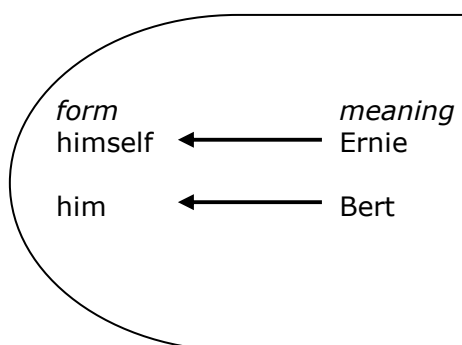


Figure 1: Children's production (speaker's perspective)

So the child will say "Ernie washed himself" if Ernie is washed, and "Ernie washed him" if Bert is washed.

Hendriks and Spenser (2004; in press) argue that for children until at least the age of 6 object pronouns such as *him* are ambiguous, and can be coreferential with the subject *Ernie*, or be disjoint to the subject and refer to Bert (Figure 2).

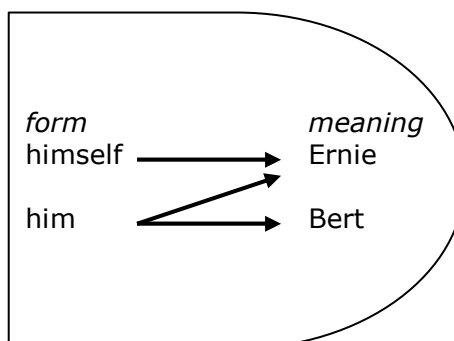


Figure 2: Children's comprehension (hearer's perspective)

In contrast to children, adults not only adopt the hearer's perspective when comprehending an utterance, but simultaneously consider the speaker's alternatives. If the speaker would have wanted to express a coreferential meaning, the speaker would have used a reflexive, because this is the optimal form for this meaning. If the speaker uses a pronoun instead, an adult hearer may conclude that the speaker did not intend to express a coreferential meaning. As a result, the pronoun is interpreted as disjoint to the subject. So because there is a better way to express coreferentiality, the coreferential meaning is blocked for the pronoun (the dashed arrow in Figure 3 is pruned).

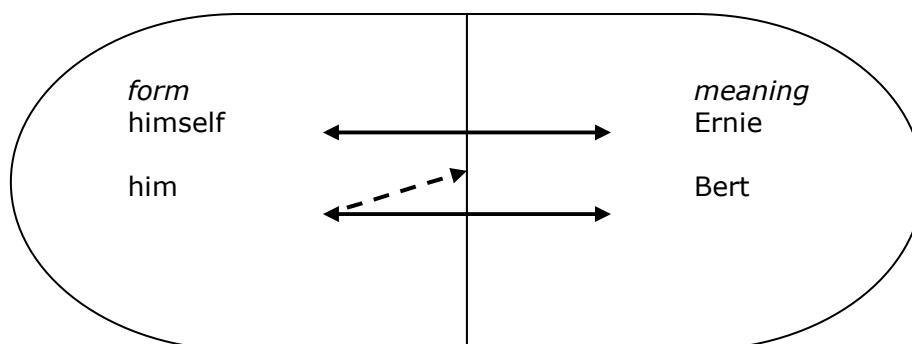


Figure 3: Combining speaker's perspective and hearer's perspective

So the speaker direction of the grammar and the hearer direction of the grammar do not yield a symmetrical adult grammar when combined. To arrive at a symmetrical grammar, adults discard communicatively suboptimal pairs that do not return the same form or meaning back again. Definition (1) describes this procedure. Because children until at least the age of 6 are hypothesized to optimize in one direction only, their grammar is partly inconsistent and gives rise to mismatches between form and meaning, which result in the observed delays in comprehension. The inconsistencies can only be repaired if the child recognizes that speakers and hearers place different demands on language and is able to effectively use this knowledge in communication.

Similar explanations have been given for delays in comprehension involving indefinite subjects and objects in Dutch (de Hoop and Krämer, in press), scalar implicatures (see e.g. Papafragou and Musolino, 2003, for acquisition data, and Blutner, 2006, for a bidirectional OT account), and tense and aspect in Dutch (van Hout, 2006).

Asymmetry type 3: Children's language use is characterized by various late comprehension delays.

Under the proposed 'grammatical account', children learning the grammar have two tasks. First, they have to learn the adult constraint ranking. Several learning algorithms have been proposed within OT to account for this task (e.g., Tesar and Smolensky, 1998; Boersma and Hayes, 2001; see Legendre, Vainikka, Hagstrom, and Todorova, 2002, for evidence for constraint re-ranking in the acquisition of syntax). If the adult ranking is not yet obtained, we may find 'early' delays in language acquisition (see table 1, section 2.10). Second, children have to start to optimize bidirectionally, that is, to reason about alternative forms and meanings. If the child is not yet able to optimize bidirectionally, we may find 'late' delays in language acquisition. Based on a cognitively motivated computational model of the acquisition of pronoun comprehension, Hendriks, van Rijn, and Valkenier (submitted) suggest that bidirectional optimization may not have to be learned but simply emerges as unidirectional constraint application becomes faster.

2.9 Comparison to other approaches

In this section the proposed grammatical account will be briefly compared to two other accounts of the comprehension delays observed in language acquisition: the pragmatic account and the processing account.

Accounting for the pronoun interpretation delay, Thornton and Wexler (1999) argue that children possess the relevant grammatical knowledge but simply fail to apply certain discourse principles. According to their pragmatic account, sentences such as "Ernie washed him" are not subject to the grammatical principle B which governs variable binding such as in "Every bear washed him", but rather to conditions on accidental coreference between the pronoun and the subject. For adults, accidental coreference is only allowed in a restricted range of discourse contexts. According to Thornton and Wexler, children and adults differ in their application of real world knowledge and their knowledge of the pragmatics of guise creation that restricts accidental coreference readings. However, Thornton and Wexler do not give an explicit description of the real world knowledge that the child lacks. Moreover, their account does not explain why children's production of object pronouns is essentially adult-like, and cannot be generalized to other attested comprehension delays.

Reinhart's processing account (Reinhart, 2004; 2006; in press) also argues that children possess the relevant grammatical knowledge. However, for the comprehension of pronouns the parser has to perform the extra operation of reference-set computation. Reference-set computation involves constructing, for a given derivation, a reference set consisting of pairs of derivations and interpretations, and determining whether the given derivation is appropriate, or whether the pair of derivation and interpretation could be obtained more economically. If the latter is true, the given derivation is blocked. Reinhart shows that reference-set computation not only accounts for the adult interpretation of pronouns (and children's comprehension problems), but also for the adult interpretation of contrastive stress (and children's comprehension problems), thus offering important insights into the parallels between these phenomena. Because children have insufficient working memory capacity to perform reference-set computation, Reinhart claims, they resort to a guessing strategy when reference-set computation is needed. In adults, the demanding process of reference-set computation is only required for the comprehension of marked forms such as pronouns, and not for the comprehension of unmarked forms such as reflexives, or for the production of marked or unmarked forms. Because children have the relevant grammatical knowledge, Reinhart's account predicts no delays in

production (but see the next section for suggestive evidence that this may not be correct). Although Reinhart's processing account can be generalized to other late comprehension delays, her account does not explain the early delays in the acquisition of purely grammatical knowledge (section 2.6), nor does it explain why language acquisition seems to proceed in two stages (displaying early and late delays).

In contrast to the pragmatic account and the processing account, the grammatical account provides a *unified explanation* for all early and late delays observed in language acquisition. The pragmatic account and the processing account suffer from the additional conceptual problem that they shift the explanatory burden for the acquisition delays to the extra-grammatical areas of discourse pragmatics and working memory capacity, respectively, without providing an explicit description of the required concepts in these areas and their interaction with the grammar. In contrast, the grammatical account seeks a formalized explanation for all attested acquisition delays *within the grammar*. Such an explanation is feasible because of the novel view of the grammar as an asymmetrical system of constraints on forms and meanings.

2.10 Do speakers also take into account the hearer's perspective?

As a consequence of the proposed two-stage view on language acquisition (see section 2.8), four types of acquisition asymmetries are predicted:

	Early delays (< ±4 years of age)	Late delays (> ±4 years of age)
Production	Type 1	Type 4
Comprehension	Type 2	Type 3

Table 1: Predicted types of acquisition asymmetries

Asymmetries of type 1 and 2 follow from a non-adult constraint ranking (section 2.6). Asymmetries of type 3 can be explained via the assumption that mature hearers optimize bidirectionally and take into account the speaker's perspective, but children fail to do so (section 2.8). Asymmetries of type 4 would follow from the assumption that mature speakers also optimize bidirectionally and take into account the hearer's perspective (cf. Buchwald, Schwartz, Seidl, and Smolensky, 2003; Jäger, 2004; Wilson, 2001), whereas children are unable to do so. But is there any evidence for this assumption?

Although many linguists agree that hearers somehow take into account the alternative forms a speaker could have used (albeit not as part of the grammar, but usually as an extra layer of pragmatic interpretation enriching the underspecified meaning provided by the sentence), there does not seem to be such a general consensus with respect to speakers. Zeevat (2000), for example, claims that speakers do not take into account the perspective of the (hypothetical) hearer, and illustrates this with ambiguous wh-questions in Dutch:

- (2) Wie ziet Jan?
 (i) 'Who sees Jan?'
 (ii) 'Whom does Jan see?'

Meaning (i), where the wh-word *wie* is interpreted as the subject of the verb, reflects the canonical word order in main clauses in Dutch, which is SVO. Meaning (ii), on the other hand, where *wie* is interpreted as the direct object of the verb, reflects a non-canonical OVS word order. According to all known syntactic analyses, meaning (i) violates fewer constraints than (ii) and hence is the optimal meaning. Nevertheless, as Zeevat points out, sentence (2) allows for meaning (ii), although not as the preferred reading. However, a bidirectional OT model would predict meaning (i) to be the only meaning

available for sentence (2). Accordingly, Zeevat argues that hearers take into account speakers, but speakers do not take into account hearers.

However, a drawback of Zeevat's model is that it fails to explain recoverability effects and word order freezing. Word order freezing is the phenomenon that in certain circumstances the options for word order variation disappear. For example, in principle both SVO and OVS word order are possible in Dutch main clauses, although SVO is the unmarked word order. In the absence of further cues from context or intonation (3) can only mean that Marie sees Jan, not that Jan sees Marie.

- (3) Marie ziet Jan.
(i) 'Marie sees Jan'

Although the syntax of Dutch allows speakers to use both word order variants, only (3) is used for expressing the meaning that Marie sees Jan, reflecting the canonical word order SVO. In these cases we say that word order is 'frozen'. This seems to be related to the fact that Dutch hearers will interpret (3) as expressing only the canonical word order. So speakers must be aware of the hearer's options, otherwise they would freely use both word order variants for expressing meaning (3i). Word order freezing therefore yields an argument for the speaker's sensitivity to the hearer (Bouma, 2006; Kuhn, 2003; Lee, 2001; Vogel, 2004).

If we adopt a bidirectional OT model, we are able to explain the word order freezing in (3) but as a result cannot account for the ambiguity of (2). In this case, we will have to loosen our optimization model to be able to account for ambiguity (see Bouma, 2006, for the proposal that the model should be loosened by allowing a partial rather than total ranking of the constraints). Alternatively, if we adopt Zeevat's model, we can account for the ambiguity of (2) but fail to explain the word order freezing in (3). In this case, we may have to search for explanations for word order freezing outside the grammar. So which model of the adult grammar is the correct one? The key to the solution lies in language acquisition: If adults take into account the hearer's perspective in production, but children do not, we should be able to find production delays in child language. This issue will be investigated in subproject 2. We focus on recoverability of anaphoric expressions (for which the same argument can be presented) rather than word order freezing because elicitation is easier in the former case.

2.11 Subproject 2 (postdoc): Anaphoric subjects in child language

The pragmatic account and the processing account both predict that production should be adult-like already in 4-year-olds, because speakers know what they intend to say. The same prediction follows from a model such as Zeevat's. A bidirectional OT model on the contrary predicts that mature speakers take into account the hearer's options when deciding which form to use. If children are unable to do this, they will sometimes produce forms which are not recoverable for a hearer (Blutner, de Hoop, and Hendriks, 2006). As a result, delays in production are predicted. This issue is investigated with respect to the selection of anaphorically used subjects.

There is some suggestive evidence from English and French that 4- and 5-year-olds more frequently produce ambiguous anaphoric subjects than older children. Karmiloff-Smith (1985), in a production experiment with 240 English and French children, found that children between the ages of 4 and 6 used pronouns instead of full noun phrases much more often than older children, even in situations where the pronoun could be interpreted in a non-intended way. These children would typically produce strings of subject pronouns referring at times to the main protagonist in the story and at other times to a subsidiary protagonist, as *he* in the following fragment:

- (4) The little boy's walking along. The man's giving him a balloon. He asks for some money so he gives him some money and then he gives him the balloon.

This pattern can be explained under the assumption that older children and adults take into account the hearer's perspective, whereas younger children are not yet able to do so. Because hearers tend to interpret subject pronouns as referring to the discourse topic, a bidirectionally optimizing speaker will only use pronouns when intending to refer to the discourse topic. For non-topical referents, a full noun phrase such as *the man* is used. Thus the adult pattern of subject pronoun production emerges. Until the age of 6, children will regularly produce non-recoverable subject pronouns (which are from a speaker's perspective more economical than full noun phrases) because they are not able to block the non-adult use.

Asymmetry type 4: Is children's language use characterized by late production delays?

For the comprehension tasks, this project will use stories in which the topic structure is manipulated. All stories will feature two protagonists of the same sex. Half of the stories involve a topic shift, the other half a continuing topic. Similar stories will be used for the production tasks, but with series of pictures rather than text. As a starting point for constructing and analyzing the stories, we will use Beaver's Optimality Theory/Centering Theory model of discourse anaphora (Beaver, 2004).

Research goal

2. Determine whether Dutch children show a production delay with respect to anaphoric subjects, and analyze the new data in the light of the central hypothesis.

The expertise of this postdoc researcher will be complementary to that of the applicant in the area of language acquisition. This postdoc researcher will co-supervise subproject 1 (PhD).

Methodology and data

Production data as well as comprehension data are collected from unimpaired Dutch-speaking children (ages 4-8). Production is studied using elicited production on the basis of picture stories. Comprehension is studied using truth-value judgment tasks (Crain and Thornton, 1998) in a story context. Children's responses will be compared to those of adult controls.

2.12 Constraints in sentence processing

Several recent studies have explored whether a single OT grammar can account for both linguistic competence and linguistic performance (Fanselow, Cavar, Kliegl, and Schlesewsky, 1999; Gibson and Broihier, 1998; Hoeks and Hendriks, 2005; de Hoop and Lamers, 2006; Lamers and de Hoop, 2005; Stevenson and Smolensky, 2006). According to the OT model of incremental optimization of interpretation, hearers use the set of ranked OT constraints on comprehension on a word-by-word basis during sentence comprehension. If the optimal interpretation changes from one word to the next, processing difficulties are expected. Thus, patterns of constraint violations can be mapped onto the online effects found in processing studies.

The first OT models of sentence processing were unidirectional and used purely syntactic constraints (e.g., Fanselow et al., 1999; Stevenson and Smolensky, 2006). Later models combined syntactic and semantic constraints (Hoeks and Hendriks, 2005; de Hoop and Lamers, 2006; Lamers and de Hoop, 2005), but still assumed a

unidirectional perspective. But if bidirectional optimization plays such an important role in the ultimate interpretation of a sentence, shouldn't the effects of bidirectional optimization be visible during online sentence comprehension too? Or is bidirectional optimization a global (as opposed to local) process? This issue will be studied in subproject 3, which focuses on the acquisition of sentence prosody. By investigating word order (subproject 1), discourse reference (subproject 2) and sentence prosody (subproject 3), the entire program covers three distinct areas of language. This will make the overall results, if confirming the hypothesis, even more relevant.

2.13 Subproject 3 (postdoc): Processing of contrastive stress in children and adults

Sentence prosody is another area where children's production precedes their comprehension. Gualmini, Maciukaite, and Crain (2002) investigated English-speaking children between the ages of 4 and 6 with respect to their comprehension of sentence prosody. They used sentences with the focus particle *only*, which can be true or false depending on the position of contrastive sentence stress (e.g., Krifka, 2006). The focus refers to that part of the sentence which specifies what is contrastive.

- (5) Tigger only threw a chair to PIGLET.
(i) 'only to Piglet' (= indirect object focus meaning)
(ii) 'only threw a chair to Piglet' (= VP focus meaning)
- (6) Tigger only threw a CHAIR to Piglet.
(i) 'only a chair' (= direct object focus meaning)
(ii) 'only threw a chair to Piglet' (= VP focus meaning, exclusive to children)

In (5), stress (indicated by capital letters) falls on the default, unmarked, position, whereas in (6) it falls on a special, marked, position. For adults, sentence (5) with default stress is ambiguous. It can mean that Tigger did not throw a chair to anyone but Piglet (the indirect object focus meaning), or that Tigger did not do anything except for throwing a chair to Piglet (the VP focus meaning). Sentence (6) with marked stress, on the other hand, can only mean that Tigger did not throw anything but a chair to Piglet (the direct object focus meaning).

Gualmini et al. (2002) found that children's performance is adult-like on sentences with default stress like (5), but below or around chance on sentences with marked stress like (6) (cf. Gennari, Gualmini, Crain, Meroni, and Maciukaite, 2001; Halbert, Crain, Shankweiler, and Woodams, 1995). Similar results were found for Dutch by Szendrői (2004), who points out that children's mistakes typically consist in a non-adult selection of VP focus for (6). So for children, (6) is ambiguous too and can also mean that Tigger did not do anything else.

Children's inability to correctly comprehend marked stress is *not* reflected in their production of marked stress. In their review of acquisition experiments investigating prosodic competence, Cutler and Swinney (1987) conclude that, with respect to prosody in general, young children's productive skills appear to outstrip their receptive skills. This is true for contrastive stress in general (e.g., Hornby and Hass, 1970) as well as for contrastive stress occurring with focus particles (see Nesterstigt, 2001, for German).

The phenomenon of contrastive stress is extremely well-suited for the investigation of online effects of unidirectional versus bidirectional optimization. First, the difference between the adult pattern of comprehension and production and children's pattern can be explained as resulting from bidirectional versus unidirectional optimization (Hendriks, Hendrickx, Looije, and Pals, 2005). In a bidirectional model, the VP focus meaning for (6) is blocked by the possibility of expressing this same meaning using an unmarked form: sentence (5). As a result, for adults (6) is not ambiguous, whereas for

children it is. Secondly, this phenomenon can be investigated by keeping the story context and the sentence constant, and only manipulating the position of sentence stress. And thirdly, the phenomenon of contrastive stress allows us to make precise predictions with respect to the occurrence of processing difficulties and online preferences. Recall that for adults only (5) is ambiguous, whereas for children both (5) and (6) are. Under the assumption that ambiguity gives rise to extra processing costs, the unmarked form (5) is predicted to be more difficult to process for adults than the marked form (6). In contrast, no differences between the two forms are expected for children. Moreover, if bidirectional optimization is a local process, adults will discard the blocked meaning of (6) as soon as the element carrying marked stress is encountered (the results for English by Gennari, Meroni, and Crain, 2005, indeed suggest such a pattern).

The grammatical account therefore predicts that the comprehension differences between adults and children are also qualitative, rather than merely quantitative. For children, the comprehension of (6) will cause more errors than the comprehension of (5), but will *not* be more difficult to process. Although adults hardly make any errors in comprehension, they will nevertheless find the unmarked but ambiguous form (5) more difficult to process than the marked form (6). Contrasting with these predictions, Reinhart's processing account expects that the same forms that give rise to children's comprehension errors also cause a higher processing load in adults, thus predicting only quantitative differences between adults and children.

Research goals

3. Determine whether Dutch children show a comprehension delay with respect to contrastive stress.
4. Determine whether Dutch children's and adults' online comprehension of contrastive stress differ, and analyze the new data in the light of the central hypothesis.

The expertise of this postdoc researcher will be complementary to that of the applicant in the area of sentence processing.

Methodology and data

Production data as well as comprehension data are collected from unimpaired Dutch-speaking children (age 4–8). Production is studied using the elicited production task introduced by de Villiers et al. (in press) and employed by Spenader, Smits, and Hendriks (in preparation) in their study of pronoun production in 83 Dutch children. Comprehension in children as well as adults is studied with eye-tracking experiments investigating online comprehension, using a visual world paradigm (cf. Gennari et al., 2005).

2.14 Autistic Spectrum Disorders (ASD)

If delays in language acquisition are caused by children's inability to consider the opposite perspective in communication, it is expected that autistic children, who have been argued to lack a 'theory of mind', never develop mature language. Indeed, although individuals with autistic spectrum disorders (ASD) may overcome the initial phonological, lexical and syntactic problems, problems remain with the pragmatic use of language (Baltaxe, 1977; Tager-Flusberg, 2000). Interestingly, these pragmatic deficits are different from the language deficits displayed by children with specific language impairment (Surian, Baron-Cohen, and van der Lely, 1996). A language abnormality which is very common in the speech of autistic individuals is pronoun reversal (Tager-Flusberg, Paul, and Lord, 2005). Pronoun reversal is the usage of *you* or another pronoun where *I* is meant, and vice versa. If speech continues to develop, these pronoun reversals may disappear in some, but not all, autistic individuals. The commonality of pronoun reversals already suggests that perspective-taking is difficult for children with autism.

Consequently, bidirectional optimization, which not only involves perspective taking or a shift in perspective, but rather a synchronisation of one's own perspective as a hearer with the perspective of oneself as a speaker (or vice versa), is expected to be impossible or nearly impossible.

2.15 Subproject 4 (PhD): Comprehension versus production in ASD

The language deficits within ASD are still poorly understood. This subproject investigates whether we can pinpoint the language problems in ASD by studying the production and comprehension of autistic children and adolescents on tasks which are known or hypothesized to give rise to asymmetries in unimpaired children: (i) the comprehension and production of object pronouns, (ii) the comprehension and production of anaphoric subjects, and (iii) the comprehension and production of contrastive stress. This subproject aims at answering one of the main questions of this program, but also at improving the diagnosis and treatment of ASD by revealing clearly identifiable differences in language use between children with ASD and unimpaired children.

Research goals

5. Determine whether Dutch subjects with ASD show a comprehension delay with respect to object pronouns and contrastive stress, and a production delay with respect to anaphoric subjects.
6. Determine whether observed production-comprehension asymmetries disappear with age, and if so, determine the time line of development.

Methodology and data

Production data as well as comprehension data are collected from Dutch-speaking children and adolescents with ASD (ages 6-18). Only subjects diagnosed with ASD with an IQ within the normal range will be included. Comprehension is studied using truth-value judgment tasks. Production is studied using elicited production tasks. In addition, a number of Theory of Mind tests (e.g., Steerneman, Meesters, and Muris, 2000) are conducted. The subjects with ASD are compared to a balanced control group of unimpaired children. This subproject is conducted in collaboration with Accare, the largest organization in the northern part of the Netherlands specialized in child and adolescent psychiatry, and will be co-supervised by dr. Hartman and prof.dr. Minderaa of Accare. Subjects diagnosed with ASD using standardized diagnostic instruments are recruited from their pool of patients.

2.16 Innovation

The program focuses on four potential production-comprehension asymmetries in Dutch: asymmetries in the acquisition of basic word order, anaphoric subjects, contrastive stress, and object pronouns. These asymmetries are by no means exceptions to the general pattern of language acquisition. In recent years, several other production-comprehension asymmetries have been identified (e.g., Håkansson and Hansson, 2000; de Hoop and Krämer, in press; van Hout, 2006; Hurewitz, Brown-Schmidt, Thorpe, Gleitman, and Trueswell, 2000). With respect to these asymmetries, comprehension is delayed by often as much as three or four years. In some cases, children are not yet adult-like even at the age of 11 (see Unsworth, 2005, for scrambled indefinite objects). This stands in stark contrast to the generally expressed claim that children have mastered the most important aspects of the grammar of their language at age 5.

This program is innovative in (1) seeking a unified explanation for these asymmetries by (2) exploring a novel view on the grammar based on (3) new empirical results with respect to production and comprehension in the same children. Asymmetries in language acquisition suggest that the essence of our linguistic competence may very well lie in speaker-hearer interaction, in the same way that the essence of some of our other cognitive abilities lies in multi-agent interaction (cf. van Benthem, in press).

Because of their well-developed reasoning skills, mature unimpaired language users may not be the best source of evidence for identifying the constraints of the grammar. By focusing on various aspects and various stages of language acquisition, this program helps to uncover the impact of communication and linguistic reasoning on the nature and organization of the grammar.

2.17 Plan of work

Timetable

All subprojects will be carried out in the first four years of the program.

Year 1: Constructing and pretesting the first sets of experiments. Formulating hypotheses.

Year 2 & 3: Testing of hypotheses. Interpretation of the data. Further experiments. Further interpretation of the new data. Reinterpretation of the old data. Publication of preliminary results.

Year 4: Integration of the results of the different parts of the project. Final analysis of the data. Postulation of final hypotheses. Publication of final results.

Year 5: Collecting key results in a book on the relation between language production and comprehension.

Local, national and international collaboration

Because of its strong focus on psycholinguistic and neurolinguistic research, on the one hand (key researchers: dr. John Hoeks, dr. Angeliek van Hout, dr. Laurie Stowe), and formal syntax and semantics, on the other (key researchers: prof.dr. Jack Hoeksema, prof.dr. Jan Koster, prof.dr. Alice ter Meulen, dr. Jan-Wouter Zwart), the Center for Language and Cognition Groningen is the ideal place to carry out this research. With respect to subproject 4, this program benefits from the expertise available at Accare (key researchers: dr. Catharina Hartman, prof.dr. Ruud Minderaa). Also, there is close collaboration with the department of Artificial Intelligence at the University of Groningen (key researchers: dr. Hedderik van Rijn, dr. Jennifer Spenader, dr. Rineke Verbrugge) in the areas of pragmatics, cognitive development, cognitive modelling and multi-agent communication.

The program will be closely connected to various research programs carried out in the Netherlands (Nijmegen, Utrecht, Amsterdam), Germany (Humboldt Universität Berlin, Potsdam, Bielefeld) and the U.S.A. (Stanford University, Johns Hopkins University) in terms of a general interest in the relation between production and comprehension and bidirectional approaches to language. Furthermore, several researchers in the area of language acquisition (both nationally and internationally) have already expressed their interest in collaboration.

(7998 words; maximum 8000 words on 16 pages)

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