

# OPTIMAL ACQUISITION: WHY CHILDREN'S LANGUAGE PRODUCTION CAN EXCEED THEIR COMPREHENSION

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## 1. Introduction

This paper discusses a developmental paradox, namely that children's performance in language production sometimes exceeds their performance in language comprehension. This yields a puzzle for most theories of language acquisition. If a child produces a linguistic form correctly, this is considered to be evidence that the child possesses the relevant grammatical knowledge. However, if the child possesses the relevant grammatical knowledge to *produce* a linguistic form correctly, then why is this child unable to *interpret* the same linguistic form correctly? Four potential explanations for such asymmetries between production and comprehension are discussed: task-based explanations, pragmatic explanations, interface explanations and grammatical explanations. In this paper, I will focus on asymmetries occurring with subject-object word order and pronominal reference, but note that many more asymmetries have been attested (Hendriks, 2014).

In Sections 2 and 3, it is argued that task-based and pragmatic explanations of children's errors in their comprehension of word order and pronouns fail to account for children's correct production of word order and pronouns. Although under certain assumptions interface explanations may account for children's correct production of pronouns, these explanations are argued in Section 4 not to be fine-grained enough to account for the full range of patterns observed in child language. This suggests that the cause for the asymmetries must lie in the grammar. This latter possibility is discussed in Section 5. Because this explanation requires a reconsideration of core properties of the grammar, Section 6 discusses the implications of production-comprehension asymmetries for linguistic theory.

## 2. Task-based explanations

In languages such as English and Dutch, the basic word order in main clauses is Subject-Object (SO). If there are no special reasons to place another expression than the subject in first position (such as discourse prominence or contrast), mature users of these languages produce SO word order and place the subject before the object (Cannizzaro, 2012). In normal circumstances, they also *interpret* transitive sentences according to SO word order and interpret the first noun phrase as the agent (and hence the subject) and a later noun phrase as the patient (and hence the object). This seems to confirm the generally accepted assumption in linguistics that, in spite of their superficial differences, sentence comprehension and sentence production are based on the same linguistic competence.

However, children's development of SO word order in these languages appears to proceed at different rates in production and comprehension. For example, Chapman and Miller (1975) tested English-speaking 2-year-olds (age range 1;8–2;8) on their production as well as their comprehension of reversible transitive sentences in an act-out paradigm and found that these children adhered to SO word order more often in production than in comprehension. In comprehension, they assigned an incorrect interpretation to sentences with an inanimate subject and an animate object in on average 50% of the cases.

- (1) The car is pushing the boy.

Instead of interpreting the first noun phrase *the car* in (1) as the subject and the second noun phrase *the boy* as the object, the children interpreted the animate object *the boy* as the subject and the inanimate subject *the car* as the object, thereby ignoring the interpretational cue provided by word order to identify the subject and the object. Sentences in which the subject and object are equal in animacy were interpreted better, at about 65% correct. Sentences with an animate subject and an inanimate object were understood best and were responded to correctly in 90% of the cases. Thus, the observed pattern in comprehension was influenced by animacy, and overall performance was poor. In contrast to these children's comprehension, the same children's production was uniformly adult-like. Across the different animacy conditions, the produced utterances conformed to SO word order in on average 80-90% of the cases. On the basis of these results, Chapman and Miller conclude that children's production of word order is ahead of their comprehension of word order. A similar advantage of production over comprehension in the same children was found in act-out tasks carried out by McClellan, Yewchuk and Holdgrafer (1986) for English and Cannizzaro (2012) for Dutch.

This asymmetry between children's poor comprehension of word order and their adult-like production of word order has been explained as an experimental artifact. According to Bates, Dale and Thal (1995), most researchers agree that children's poor comprehension of sentences they use in their own spontaneous speech must be confounds of the "complex task demands that obscure the child's actual knowledge of grammatical structure". Furthermore, they point out that children's advanced production in some tasks may be merely apparent because the children may have been "using the grammatical forms in question in unanalyzed formulae that have been acquired through rote memory". When these confounds are eliminated, Bates et al. argue, all delays in comprehension disappear from child language. Note that the suggested memorization-and-imitation explanation for children's advanced production skills cannot account for children's adult-like production in Chapman and Miller's study. Because the children in Chapman and Miller's study heard sentences differing in the animacy of subject and object and differing in the order of mention of referents in the comprehension task, adult-like performance in the production task could not have been achieved by simply imitating the sentences heard in the comprehension task.

Admittedly, act-out tasks may place heavy demands on the child with respect to their memory and planning skills and hence may not be very well suited to test the comprehension skills of children below age 3 (Goodluck, 1996). For this reason, Cannizzaro (2012) not only used act-out tasks to investigate 2- and 3-year-olds' knowledge of word order, but also carried out picture selection tasks and preferential looking tasks. Comparing the performance of English-speaking and Dutch-speaking children on a picture selection task with animated videos to their performance on a parallel elicitation task based on the same animations, the children were found to more often adhere to SO word order in production than in comprehension. In another task, a preferential looking task, the children only had to watch two animations shown side by side on a computer screen while hearing a sentence, without having to respond in any way. In this preferential looking task, the children's percentage of looks to the correct animation was only around 50% on average and did not reveal any knowledge of word order in comprehension. On the basis of the results across the three different comprehension tasks (act-out, picture selection and preferential looking) compared to two different elicitation tasks (the first one based on actions that were acted out with toys and the second one based on animations), Cannizzaro (2012:148) concludes that there is a real asymmetry with word order in English and Dutch, in favor of children's production.

The pattern of poor comprehension of word order and simultaneous adult-like production of word order found in Chapman and Miller's study and subsequent work investigating the same children's linguistic abilities has been confirmed by other studies that looked at production only or comprehension only. For example, early adult-like production of word order was found in several studies investigating children's use of agent and patient in English, also when the animacy properties of the sentences were manipulated (Angiolillo & Goldin-Meadow, 1982). Furthermore, effects of animacy were found in other child language studies investigating children's comprehension of word order (Chan, Lieven, & Tomasello, 2009 for English, German and Cantonese; Childers & Tomasello, 2001 for English). As all of these studies reveal poor comprehension of word order if word order conflicts with cues such as animacy and find early adult-like word order in production, the asymmetry with word order seems well-established empirically.

However, if asymmetries between production and comprehension in child language are real and are not merely experimental artifacts, how should we account for these asymmetries? The next section presents another attested asymmetry in child language, in this case between the production and comprehension of object pronouns, and discusses several proposed explanations for this asymmetry. Also for this asymmetry, task-based explanations have been proposed (e.g., Conroy, Takahashi, Lidz & Phillips, 2009). These explanations will be discussed below.

### 3. Pragmatic explanations

A well-known delay in English-speaking children's acquisition of their native language is the delay in their comprehension of pronominal objects compared to their comprehension of reflexive objects. Whereas children correctly interpret reflexives such as *herself*, as in (2), in an adult-like manner at age 5, they continue to make errors in their interpretation of pronouns such as *her*, as in (3), beyond the age of 6 (e.g., Chien & Wexler, 1990).

- (2) This is Mama Bear; this is Goldilocks. Is Mama Bear touching herself?
- (3) This is Mama Bear; this is Goldilocks. Is Mama Bear touching her?

In particular, they allow the pronoun *her* to corefer with the local subject *Mama Bear*, in violation of Principle B of Binding Theory (a pronoun must be free in its local domain). In contrast, they interpret reflexives such as *herself* in accordance with Principle A of the same module of grammar (a reflexive must be bound in its local domain). Thus, they correctly interpret *herself* as coreferring with the local subject *Mama Bear*.

Chien and Wexler (1990) found this delay in children's comprehension of pronouns in a study in which they tested an unusually large number of children (at least 120 in each of the first three experiments and 177 in the fourth experiment). In their study, they assessed children's comprehension of reflexives and pronouns in two distinct tasks: an act-out task and a yes-no judgment task in which children had to answer a question about a picture. Other studies have observed this delay using other experimental tasks: for example, Deutsch, Koster and Koster (1986) used a

picture-selection task, Thornton and Wexler (1999) used a truth-value judgment task and Spenader, Smits, and Hendriks (2009) used a picture verification task. This indicates that this so-called Delay of Principle B Effect (DPBE) is not merely an artifact of the experimental task. Furthermore, some studies employed the same task and methods to test children in different languages and found a difference in children's performance in these languages (McKee, 1992; Ruigendijk et al., 2011). For example, McKee (1992) investigated the DPBE in English and Italian and found that, in contrast to English-speaking children, their Italian-speaking peers hardly make any errors. Such cross-linguistic differences support the view that the DPBE is a real effect and is not caused by the task.

The DPBE is explained by Chien and Wexler as resulting from children's lack of pragmatic knowledge. Although pronominal objects are generally not allowed to corefer with the local subject, there are certain exceptions to this generalization (Chien & Wexler, 1990: 256):

- (4) That must be John. At least he looks like him.

In this example, the object pronoun *him* is coreferential with the local subject *he*, as both *him* and *he* refer to John. This is possible because Binding Theory only specifies the interpretation of noun phrases under variable binding, but does not forbid *he* and *him* to accidentally refer to the same referent when they are not bound. For this reason, *he* and *him* in (4) can accidentally corefer. In sentences such as (3), on the other hand, adults do not allow accidental coreference because of a pragmatic principle that forbids accidental coreference in certain contexts (cf. Reinhart, 1983; Grodzinsky & Reinhart, 1993). In contrast to adults, children do not yet know which discourse contexts license accidental coreference and which discourse contexts do not. As a result, they incorrectly allow accidental coreference in (3) and permit the pronoun *her* to corefer with the local subject *Mama Bear*.

Problematic for this pragmatic explanation of the DPBE, however, was the later observation of a production-comprehension asymmetry with object pronouns. In studies testing 4- to 6-year-old children on their comprehension as well as their production of reflexives and pronouns, the same group of children who were found to make errors with pronouns in comprehension showed adult-like performance in production (de Villiers, Cahillane, & Altreuter, 2006; Matthews, Lieven, Theakston, & Tomasello, 2009; Spenader, Smits, & Hendriks, 2009). That is, they produced a reflexive when reference was intended to the local subject and produced a pronoun when reference was intended to another referent. In children's spontaneous speech, correct production of pronouns was established at an even younger age: in their corpus study, Bloom, Barss, Nicol, and Conway (1994) found that 2- and 3-year-old children do not make any binding errors with pronouns. These observations of early correct production are problematic for a pragmatic account of the DPBE. If children have problems distinguishing between contexts that allow accidental coreference and contexts that do not, shouldn't they also make errors in production? In particular, shouldn't they also produce pronouns when reference is intended to the local subject? The fact that children do not make such binding errors suggests that they possess the relevant linguistic knowledge to determine the appropriateness of a pronoun in its discourse context.

Note that a pragmatic explanation of children's errors with object pronouns in binding environments is difficult to reconcile with their early sensitivity to discourse in their use of pronouns in *subject* position. Already around the age of 2.5 years old, English-speaking children are highly sensitive to the structure of the prior linguistic discourse with pronouns in subject position. In their comprehension, they are able to link a subject pronoun to the most prominent referent in the linguistic discourse, based on the same factors that adults use (e.g., Song & Fisher, 2007). In their production of subject pronouns, they use pronouns differently depending on whether the referent has been mentioned before or not in the immediately preceding linguistic discourse (e.g., Campbell, Brooks, & Tomasello, 2000). In fact, when interpreting object pronouns in binding contexts, 4- to 6-year-old children have been found to also be influenced by the linguistic discourse, in particular by whether the correct antecedent of the pronoun is the discourse topic or not (Spenader et al., 2009). This finding of early use of discourse-pragmatic knowledge would be surprising if children have difficulty making referential choices based on discourse information until the age of 6 or even later.

Children's sensitivity to the discourse may further explain why there is so much variation in results among studies investigating the DPBE, as was observed by Conroy et al. (2009) in their survey of experiments testing the DPBE. If children do not use Principle B to narrow down the number of potential antecedents for an object pronoun (as is suggested by the existence of the DPBE), object pronouns could simply be ambiguous for them and equally well refer to the local subject as to some other salient referent. It is then expected that non-grammatical factors such as plausibility of the resulting interpretation or the linguistic or visual prominence of potential antecedents in the discourse will guide the choice of antecedent. In fact, children's sensitivity to discourse prominence may also explain the experimental results of Conroy et al.'s own study, which they argue to show that the DPBE is largely an experimental artifact (see Hendriks, 2014, for discussion).

In sum, children are highly sensitive to the structure of the prior linguistic discourse from an early age on when comprehending and producing pronouns in various positions in the sentence. It is therefore unlikely that they make errors in their interpretation of object pronouns because of the relatively rare occurrence of accidental coreference under special discourse conditions. Moreover, such a pragmatic explanation would not explain children's generally adult-like production of pronouns.

## 4. Interface explanations

Although Conroy et al. (2009) argue that the DPBE is largely an experimental artifact, they conclude that the effects of the task cannot explain all of children's errors. To account for the "residue" of the DPBE in children (Conroy et al., 2009, p. 478), they suggest it has the same source as adults' temporary consideration of ungrammatical antecedents during sentence processing. Various studies using online measures such as eye-tracking and self-paced reading have found that adults, when hearing a sentence with an object pronoun, temporarily access the grammatical antecedent as well as ungrammatical antecedents (e.g., Badecker & Straub, 2002; Kennison, 2003; Runner, Sussman, & Tanenhaus, 2003). Conroy et al. hypothesize that children also access these ungrammatical antecedents, but have more difficulty than adults to subsequently inhibit these ungrammatical antecedents. Thus, they explain the residual DPBE as a kindergarten-path effect.

The term 'kindergarten-path effect' was coined by Trueswell, Sekerina, Hill, and Logrip (1999) in an eye-tracking study, in which they studied children's and adults' online processing of temporarily ambiguous sentences such as (5):

- (5) Put the frog on the napkin in the box.

This sentence is temporarily ambiguous because the prepositional phrase *on the napkin* can be interpreted as a modifier of the preceding noun, indicating which of the frogs is referred to, or as the goal of the putting event, indicating where to put the frog. At the end of the sentence, this ambiguity is resolved due to the presence of a second prepositional phrase, as a result of which only the modifier interpretation remains for *on the napkin*. Comparing the eye-movements of 5-year-old children and adults, Trueswell et al. found that children showed an "inability or reluctance to revise their initial commitment" (p. 121) to the incorrect goal interpretation of the sentence. According to Conroy et al., the residual DPBE with object pronouns has the same source.

If Conroy et al. are correct and children make errors with object pronouns due to a similar kindergarten-path effect as with the attachment ambiguity illustrated in (5), sentences with object pronouns must be temporarily ambiguous. Because the same children do not make errors with reflexives in object position, sentences with reflexives must not be temporarily ambiguous. This implies that Principle A must act as an "initial filter" on the processing of reflexives, restricting the interpretation of reflexives from the start. In contrast, Principle B must act as a "late filter" on pronoun processing, allowing for temporary ambiguity. This, however, means that Principle A and Principle B have to operate at different moments during sentence processing, which is left unexplained if Principle A and Principle B are principles of the same module of grammar.

The differences between the way reflexives and pronouns are acquired in childhood and processed during online sentence comprehension motivated linguistic accounts that derive Principle A and Principle B from distinct operations. According to Reinhart (2006, 2011), the grammatical possibilities of reflexives and pronouns differ because the interpretation of reflexives must be obtained through variable binding (governed by Principle A), whereas pronouns can receive their interpretation through variable binding (governed by Principle B) or coreference. She argues that coreference is restricted in its acceptability by the operation of reference-set computation. Reference-set computation is a comparison operation performed at the interface between the grammar and the conceptual system to check whether coreference is necessary or whether the resulting interpretation can be obtained in a more economical way. As the grammatical possibility of variable binding is assumed to be more economical than the pragmatic possibility of coreference, coreference is only allowed if the resulting interpretation is not equivalent to the interpretation achieved by variable binding in the given context. Because the two interpretations are equivalent in sentences such as (3), coreference is blocked in (3). In accidental coreference cases such as (4), on the other hand, coreference gives rise to a slightly different interpretation than variable binding and hence is allowed.

For children, the comparison operation of reference-set computation is cognitively too demanding, according to Reinhart (2004, 2006, 2011). In particular, she argues that children's working memory capacity is too limited to be able to hold all materials needed for reference-set computation active in memory. As a consequence, children fail to complete the operation of reference-set computation and resort to some non-linguistic strategy, such as guessing. This explains children's guessing pattern in their interpretation of pronouns. Children's production is not dependent on the operation of reference-set computation, Reinhart (2004) claims, because in production the speaker already knows what she wishes to say and does not have to compare competing representations. However, knowing what to say does not necessarily imply knowing how to say it. To explain children's correct production of pronouns, Reinhart assumes that speakers also know how to say it (in this case, how to establish a referential dependency by choosing either a pronoun or a reflexive) because the choice of form is fully specified by the grammar.

Reinhart's position differs from that of Ruigendijk, Friedmann, Novogrodsky, and Balaban (2010). Ruigendijk et al. found that German-speaking children, in contrast to English-speaking and Dutch-speaking children, perform well on their production as well as their comprehension of pronouns. Children acquiring Hebrew, on the other hand, make comprehension errors with pronouns and at the same time produce reflexives when they should have produced a pronoun. So German and Hebrew appear to show a symmetric pattern with pronouns, albeit a different type of symmetric pattern in each language. To account for the distinct but symmetric patterns found in German and Hebrew, Ruigendijk et al. argue that Rule I (for Intrasentential Coreference, see Grodzinsky & Reinhart, 1993) must apply in

comprehension as well as production. Rule I states that a noun phrase cannot corefer with another noun phrase if replacing this first noun phrase with a variable bound by the second noun phrase yields an indistinguishable interpretation. Like the interface operation of reference-set computation, the pragmatic Rule I compares the interpretation resulting from variable binding with the interpretation resulting from coreference. In fact, Grodzinsky and Reinhart's Rule I is the predecessor of Reinhart's reference-set computation, which Reinhart argues to only apply in comprehension. Restricting the application of reference-set computation to comprehension allows Reinhart to account for the production-comprehension asymmetry with pronouns as well as several other comprehension delays in child language. In contrast to Reinhart, Ruigendijk et al. hypothesize that Rule I must apply in production too. This allows them to explain the symmetric patterns in German and Hebrew. They argue that Rule I also guides children's choice between a pronoun and a reflexive for establishing a referential dependency in production. Because Hebrew-speaking children make errors across the board, they fail to perform Rule I due to processing limitations. German-speaking children perform adult-like across the board, so Rule I must for some reason not be relevant for them.

The above discussion illustrates that different positions are possible with respect to the scope of interface operations. The interface accounts of the DPBE agree that reflexives are processed differently from pronouns. These differences in processing follow from the different computations required to determine the interpretation of reflexives and pronouns: pronouns have the option of coreference, whereas reflexives do not. Therefore, pronouns require an additional and cognitively demanding operation at the interface (Rule I or reference-set computation) to determine whether the pronoun is licensed by the linguistic discourse. Symmetry or asymmetry arises from the assumption of whether this additional operation applies in comprehension only (resulting in asymmetry for some expressions in some languages) or whether the additional operation applies in comprehension as well as in production (resulting in symmetry across the board). According to Reinhart (2004, 2006), reference-set computation only applies in comprehension. According to Ruigendijk et al. (2010), in contrast, Rule I applies in comprehension as well as production. The first option makes it possible to explain why pronoun comprehension can be delayed in comparison to pronoun production (English, Dutch), but fails to explain why in some languages pronoun production is also delayed (Hebrew). The latter option explains why pronoun comprehension often is as good as pronoun production (German, Hebrew), but cannot explain why in some languages pronoun comprehension appears to be delayed in comparison to pronoun production (English, Dutch). So neither of these options is able to explain the full range of patterns of pronoun production and comprehension across languages.

Focusing on the explanation for children's patterns of pronoun production and comprehension, I see four further weaknesses of interface accounts, in particular Reinhart's reference-set computation account. First, Reinhart argues that when children fail to complete the cognitively demanding operation of reference-set computation, they resort to some non-linguistic strategy to bypass this operation. However, no motivation is given for why this strategy is guessing in the case of pronoun interpretation, but could be selecting a semantic default in the case of stress shift (Reinhart, 2004). It would be preferable to have some linguistic explanation for why children allow object pronouns to refer to the local subject. Second, the reason Reinhart offers for children's failure to carry out reference-set computation is that their working memory resources are too limited. Reference-set computation is argued to depend on working memory because the derivation of the sentence must be completed while at the same time alternative derivations have to be constructed and compared to the initial derivation (Reinhart, 2004). This is assumed to severely tax working memory. However, in a study investigating pronoun interpretation in ca. 120 Dutch-speaking children with autism, ADHD or typical development, Kuijper, Hartman and Hendriks (submitted) found that performance on pronoun interpretation was associated with Theory of Mind and inhibition skills, but not with working memory. This suggests that whatever causes children to make errors in pronoun interpretation, it is not their limited working memory capacity. Third, interface accounts can only explain asymmetries occurring with linguistic forms that rely on interface operations for their interpretation or use. Other attested asymmetries, such as the asymmetry with word order discussed earlier, must receive a different explanation. Hence, interface accounts do not offer a unified explanation of asymmetries between production and comprehension in child language. Finally, Reinhart's interface account is only able to explain asymmetries that arise as a result of a delay in comprehension. Asymmetries arising as a result of a delay in production, such as 4- to 6-year-old's production of unrecoverable pronouns (Hendriks, Koster, & Hoeks, 2014) or young children's production of reduced words (see the next section), fail to receive an explanation.

These weaknesses suggest that the interface between the grammar and the conceptual system may not be the right linguistic level to look for the cause of asymmetries between production and comprehension. Instead, we seem to need a more fine-grained account of the occurrence of asymmetries between production and comprehension that is formulated in terms of the properties of the grammar. In the next section, such a grammatical explanation is discussed. This grammatical explanation, which is couched in the linguistic framework of Optimality Theory, differs from Reinhart's interface account in that it (i) provides a grammatical account of children's errors in pronoun interpretation, instead of an account in terms of some non-linguistic strategy, (ii) explains mature pronoun interpretation as a grammaticalized process of perspective taking, thus accounting for the association between pronoun interpretation and Theory of Mind in children, (iii) uses the same properties of the grammar to explain asymmetries between production and comprehension in the area of semantics/pragmatics as in the areas of morphosyntax and phonology, and (iv) not only predicts and explains delays in comprehension, but also in production.

## 5. Grammatical explanations

Bloom et al. (1994) found that 2- and 3-year-old English-speaking children already use object pronouns correctly in their spontaneous speech. Trying to explain the discrepancy between their own production results and the general finding in English of a delay in pronoun comprehension, they discuss (and immediately reject) the possibility that comprehension and production are driven by two separate grammars. They point out that this explanation is highly implausible because of the unrealistic prediction that the development of production and comprehension proceeds completely independently and no relation whatsoever is expected between what children are able to produce and what they are able to understand. Also, Bloom et al. wonder how mature production is ever obtained in such a model.

Although the possibility of two independent grammars for production and comprehension indeed seems unlikely, some have argued that the grammar may have different effects in production than in comprehension and that this could explain asymmetries between production and comprehension in child language. Adopting a constraint-based Optimality Theoretic approach to grammar (Prince & Smolensky, 1993/2004), Smolensky (1996) argues that constraints of the grammar may yield a different mapping between form and meaning when applied in comprehension than when applied in production. Smolensky uses this direction-sensitivity of Optimality Theory to explain mismatches between young children's production of reduced forms (such as *ta* for *cat*) and their simultaneous adult-like perception of the target forms. Constraints that apply in production to select the optimal surface form from among a set of potential surface forms do not necessarily also apply in comprehension. This is because in comprehension the optimal meaning is selected from among a set of potential meanings, and not from among a set of potential forms. For this reason, constraints that pertain to forms only and do not pertain to meanings are not relevant in comprehension. For example, the constraint NOCODA that demands syllables without a final consonant specifically pertains to forms and hence will not have any effect on children's comprehension of the word *cat*. To comprehend the word *cat*, a child must select the meaning of this word from among other potential meanings. Therefore, although constraints like NOCODA are part of the grammar, they are only relevant in production and not in comprehension. Similarly, other constraints are only relevant in comprehension and not in production.

A second property of Optimality Theoretic grammars that is relevant for explaining asymmetries between production and comprehension is that constraints can be overruled by other constraints. If two constraints are in conflict and cannot be satisfied at the same time, it is more important to satisfy the stronger constraint than the weaker constraint. So if one constraint requires the speaker to pronounce a word the way it is stored in the mental lexicon (e.g., the faithfulness constraint MAX), and another constraint requires final consonants to be omitted (such as the markedness constraint NOCODA), children will reduce the word *cat* in their productions and say *ka* or *ta* if the latter constraint is strongest. If the former constraint is strongest, on the other hand, they will say *cat*. Because adults produce non-reduced forms, for adults the former constraint must be strongest. Children eventually acquire the mature constraint ranking of their language by reranking the constraints of their own child grammar on the basis of the linguistic input they receive.

The direction-sensitivity of an Optimality Theoretic grammar and the non-adult ranking of constraints in children's grammar can be used to provide a grammar-based account of English- and Dutch-speaking children's asymmetry with word order. In production, SO word order emerges if the grammar includes a constraint such as PRECEDENCE (de Hoop & Lamers, 2006), which requires the semantic subject (agent) to precede the semantic object (patient). Application of this constraint results in the expression of a transitive action such as a car pushing a boy by means of SO word order: the semantic subject 'car' thus precedes the semantic object 'boy' in the surface word order of the sentence. In comprehension, this same constraint applies to meanings and helps to select the best meaning from among a set of potential meanings. It promotes the interpretation of sentences such as (1) as SO sentences: according to the constraint PRECEDENCE, the first noun phrase in the sentence must be interpreted as the semantic subject, and the second noun phrase as the semantic object.

The reason that children do not interpret all sentences as SO sentences, according to Hendriks, de Hoop, and Lamers (2005), is because the faithfulness constraint PRECEDENCE is in conflict with the markedness constraint PROMINENCE (de Hoop & Lamers, 2006), which demands that the semantic subject is more prominent than the semantic object and, for example, is more animate than the semantic object. These two constraints are independently motivated, as they were introduced by de Hoop and Lamers to account for adults' online processing of transitive sentences. A too high ranking of PROMINENCE in children's grammar explains the observed pattern of interpretation in child language. If the subject outranks the object in animacy, as in sentence (1), there is no way to satisfy PROMINENCE (the 'animacy constraint') and PRECEDENCE (the 'word order constraint') at the same time. The animacy constraint is satisfied by the OS interpretation according to which the animate noun phrase *the boy* is the subject and the inanimate noun phrase *the car* is the object. On the other hand, this OS interpretation violates the word order constraint, as the first noun phrase *the car* is interpreted as the object and the second noun phrase *the boy* as the subject. In contrast, the SO interpretation according to which the first noun phrase *the car* is the subject and the second noun phrase *the boy* is the object satisfies the word order constraint, but violates the animacy constraint. If the animacy constraint is stronger than the word order constraint in children's grammar, the optimal interpretation generated by the child's grammar is the incorrect interpretation that the boy is pushing the car. This assumption about children's initial constraint ranking is consistent with the hypothesis in Optimality Theory that, initially, markedness constraints outrank faithfulness

constraints, which is based on learnability arguments as well as empirical evidence in the area of child phonology (Davidson, Jusczyk, & Smolensky, 2006; Fikkert & de Hoop, 2009). As the animacy constraint is a markedness constraint and the word order constraint is a faithfulness constraint, their hypothesized initial ranking conforms to this pattern. Acquisition of the mature ranking is assumed to be error-driven and to proceed through the gradual or stepwise reranking of constraints on the basis of mismatches between observed forms or meanings and optimal outputs of the own grammar (e.g., Boersma & Hayes, 2001; Tesar & Smolensky, 1998).

A non-adult-like ranking in which the animacy constraint is stronger than the word order constraint explains children's incorrect interpretation of sentences such as (1), and also explains why sentences like (6) tend to be interpreted correctly by children.

(6) The boy is pushing the car.

Here, the animacy constraint and the word order constraint do not conflict. They are both satisfied by interpreting *the boy* as the subject and *the car* as the object. Therefore, interpreting the sentence as an SO sentence is the optimal interpretation for adults as well as children.

The interaction between the stronger animacy constraint and the weaker word order constraint thus explains children's non-adult-like performance in comprehension. In comprehension, the input form is fixed and listeners determine the optimal interpretation of this form. As the animacy constraint is strongest, this constraint is decisive. In production, in contrast, the input meaning is fixed and speakers determine the optimal form for expressing that meaning. Crucially, the animacy constraint does not help in selecting a particular word order from a set of alternatives that includes SO word order and OS word order. To see this, consider an input meaning with an inanimate semantic subject and an animate semantic object. This input meaning violates the animacy constraint. As all output forms by definition express this input meaning, the animacy constraint does not help the speaker in choosing between the possible word orders for expressing this input meaning. Only the word order constraint does. This constraint prefers an SO word order over an OS word order. For this reason, all sentences produced by English- and Dutch-speaking children tend to satisfy the word order constraint and conform to SO word order. This illustrates that in Optimality Theory the same constraints under the same ranking can give rise to a different mapping of form and meaning in production than in comprehension. With marked forms such as the word *cat*, this results in comprehension being ahead of production, and with marked meanings such as inanimate subjects and animate objects, this results in production being ahead of comprehension.

Similarly, in the area of pronominal binding the interacting constraints PRINCIPLE A and AVOID PRONOUNS give rise to a different mapping of form and meaning in children's comprehension of object pronouns than in their production of object pronouns (Hendriks & Spenader, 2006). According to this Optimality Theoretic account of pronominal binding, children's production of reflexives and pronouns is influenced by the constraint PRINCIPLE A, which requires reflexives to be syntactically bound by the local subject. Furthermore, it is influenced by the weaker constraint AVOID PRONOUNS, which prefers the use of reflexives over the use of pronouns. These two constraints result in a symmetric pattern with reflexives, as PRINCIPLE A is the strongest of the two constraints: the constraints select a reflexive for expressing a coreferential meaning in production and select a coreferential meaning for interpreting a reflexive in comprehension. With pronouns, on the other hand, an asymmetric pattern emerges, as AVOID PRONOUNS is a constraint that is only relevant in production. In production, pronouns are selected as the optimal form when reflexives are not optimal. This happens when a non-coreferential meaning is expressed. In this case, using a reflexive would violate PRINCIPLE A. Using a pronoun violates AVOID PRONOUNS. However, as this is the weaker constraint, a violation of this constraint (by using a pronoun) is tolerated to avoid a violation of PRINCIPLE A. Thus, pronoun production is in accordance with the adult pattern. In comprehension, on the other hand, neither of the two constraints restricts the interpretation of pronouns: PRINCIPLE A only pertains to reflexives and hence does not restrict the interpretation of pronouns, and AVOID PRONOUNS is not relevant in production, as it does not help to distinguish between potential meanings for a pronoun. Consequently, both a coreferential and a non-coreferential interpretation are possible for object pronouns, resulting in non-adult-like ambiguity.

Note that this yields a grammatical explanation for children's guessing pattern in pronoun comprehension. According to the Optimality Theoretic account of the DPBE, children guess because for them pronouns are ambiguous. If they have to select an interpretation, they will select the correct interpretation about half of the time and the incorrect interpretation the other half of the time, provided that the correct antecedent and an incorrect antecedent are equally salient in the discourse. This grammatical explanation of children's guessing pattern contrasts with Reinhart's (2006, 2011) explanation of children's guessing pattern with object pronouns: Reinhart argues that children resort to some non-linguistic strategy, which she assumes to be guessing in the case of pronouns, because the cognitive demands of reference-set computation exceed children's working memory capacity (but see the discussion in Section 4).

According to Hendriks and Spenader's (2006) Optimality Theoretic account of the DPBE, pronouns are not ambiguous for adults because adults do not only consider their own perspective as a listener, but also consider the opposite perspective of the speaker. A mature listener is able to block the coreferential meaning for an object pronoun because, if the speaker would have wanted to express a coreferential meaning, the speaker would have used the

optimal form for expressing that meaning, namely a reflexive. As the speaker did not use a reflexive, but instead used a pronoun, a mature listener will be able to conclude that the speaker did not intend to express a coreferential meaning. This Theory-of-Mind-like process is formally modeled in Optimality Theory as bidirectional optimization (Blutner, 2000). Whereas Reinhart's reference-set computation is an operation that takes place outside the grammar but rather at the interface with the conceptual system, bidirectional optimization can be seen as part of the grammar.

Bidirectional optimization was defined by Blutner (2000) as a *representational* restriction on form-meaning pairs. In their computational account of pronoun processing, van Rij, van Rijn and Hendriks (2010) implemented bidirectional optimization as a *procedural* restriction on the interpretation and generation of linguistic forms. In their computational models, comprehension is modeled as a first step of optimization from the listener's perspective (from input form to optimal meaning), followed by a second step of optimization from the speaker's perspective (from input meaning to optimal form). In production, the order of the two steps is reversed, thus modeling how mature speakers check whether the intended meaning is recoverable for the listener from the form the speaker wishes to use.

In van Rij et al.'s procedural version of bidirectional optimization, a meaning is optimal in comprehension if the input form for the listener in the first step is identical to the output form generated by the speaker in the second step. This corresponds to a listener checking whether he or she as a speaker would have used the form for expressing the selected meaning. If this is not the case, this meaning must be blocked. Van Rij et al.'s models proceed from the assumption that children as listeners are aware that they must take into account the perspective of the speaker, but do not have sufficient processing speed yet to carry out the two optimization steps within the available time. Because optimization can be seen as an incremental process that does not require a complete sentence for interpretation, but rather compares potential meanings each time a new word is encountered (see, e.g., de Hoop & Lamers, 2006), van Rij et al.'s account makes different predictions about pronoun processing than do interface accounts. Reinhart argues that reference-set computation must be a global rather than a local operation, because only at the end is it possible to filter out nonconvergent derivations (Reinhart, 2004: p. 113). Hence, Reinhart's interface account predicts processing effects of reference-set computation to only occur at a global level, at the end of the sentence, as do Gricean (utterance-based) accounts. In contrast, van Rij et al.'s account predicts effects of bidirectional optimization to occur at the local level, as soon as the pronoun is encountered. Indeed, local processing effects with object pronouns were found in an experiment in which children were presented with slowed-down speech (van Rij et al., 2010).

## 6. Implications for linguistic theory

In this paper, I argued that asymmetries between production and comprehension in child language are real and cannot be dismissed as experimental artifacts: asymmetries are not limited to particular experimental tasks, are found with some linguistic forms but not with others (e.g., with sentences with an inanimate subject and an animate object, but not with sentences with an animate subject and an inanimate object), and are observed in some languages but not in others (e.g., the asymmetry with object pronouns is found in English, but not in Italian). Children's comprehension delay with object pronouns does not seem to be caused by their immature discourse-pragmatic skills either: this does not explain children's generally adult-like production of object pronouns and also contrasts with their early sensitivity to discourse when using and interpreting anaphoric pronouns outside binding environments. Although interface explanations may explain why children make errors in their comprehension of object pronouns, these explanations do not seem fine-grained enough to provide a complete account of all patterns of pronoun production and comprehension attested in natural language. If the cognitively demanding interface operation is taken to apply only in comprehension, it remains unexplained why pronoun production is also non-adult-like in some languages. On the other hand, if the cognitively demanding interface operation is assumed to apply in comprehension as well as production, it remains a mystery why pronoun production can be ahead of pronoun comprehension. Furthermore, interface explanations fail to account for attested asymmetries that do not require interface operations, such as asymmetries in morphosyntax (as with SO word order) and phonology (as with children's early words). Finally, the proposed interface explanations seem to make incorrect predictions about the role of working memory capacity and online effects during sentence processing. On these grounds I believe a grammatical explanation is to be preferred.

The need to provide a grammatical explanation for asymmetries between comprehension and production places specific demands on the architecture of the grammar. In particular, the grammar must be able to yield different mappings of form and meaning in production than in comprehension. In Section 5, it was shown that an Optimality Theoretic grammar has this property because of the direction-sensitivity of optimization: in production, the meaning is given and a choice is made among alternative forms, whereas in comprehension the form is given and a choice is made among alternative meanings. Because of the different competing alternatives in production and comprehension, the same set of constraints can give rise to an adult-like pattern in production but a non-adult-like pattern in comprehension, or vice versa.

One might object that generative linguistic theories such as the Minimalist Program are not intended to account for the way language is used in comprehension and production, but rather are intended as theories of linguistic knowledge. As such, they cannot be expected to explain specific patterns of use in comprehension or production. An implicit assumption underlying this work is that a particular theory of linguistic knowledge can be operationalized in



several ways, depending on the specific assumptions made about language processing and use. Therefore, what is not explained by the grammar is assumed to be explained by performance factors. However, it remains to be seen whether theories of language processing or language use are able to explain all attested asymmetries between production and comprehension. Also, shifting the responsibility for explaining production-comprehension asymmetries to the domain of linguistic performance would severely weaken the explanatory power of the linguistic theory, as asymmetries have been attested in many areas of language. Moreover, the assumption of an at most indirect relation between linguistic competence and linguistic performance implies that, without an explicit and well-founded theory of how exactly competence and performance are linked, it is impossible to evaluate theories of linguistic knowledge empirically. I consider this a serious drawback for language acquisition research, which tries to explain the empirical patterns of language production and comprehension displayed by children on the basis of theories of linguistic competence.

In this paper, I discussed several explanations of asymmetries between production and comprehension. Although some questions were answered, many other questions still remain open. For example, what grammatical properties cause the DPBE to be absent not only in Romance languages, but also in German, and what are the grammatical properties of Hebrew that result in acquisition errors with pronouns in comprehension as well as production? What are the types of linguistic phenomena that give rise to an asymmetry between production and comprehension in language acquisition? These questions indicate that currently we only have a partial understanding of the intricate relation between comprehension and production in child language.

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