# Tell Me a Story! Children's Capacity for Topic Shift

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Young children often give the impression that they speak or listen from their own perspective, with little or no recognition of the linguistic information that a discourse partner might be using. In relation to discourse reference, children often demonstrate insensitivity to rules that determine the use of discourse pronouns (Karmiloff-Smith 1981). Frequently, discourse development has been explained by such cognitive notions as egocentricity. However, recent eye-tracking studies have shown that very young children are not exclusively egocentrically oriented (Nadig & Sedivy 2002) and that even adults sometimes begin with an egocentric perspective and only later switch to their partner's perspective (Keysar, Barr, Balin & Paek 1998).

The question in the present study is: if children and adults are capable of cognitively taking either perspective, do both children and adults linguistically take into account their partner's perspective in discourse? To explore this question, children and adults participated in a production experiment and a comprehension experiment aimed at investigating their sensitivity to discourse topic and topic shift. In Section 1, we discuss the theoretical framework of bidirectional Optimality Theory, which is shown to make linguistic predictions as to expected differences between adults and children when they deal with topic shift during discourse. Adult speakers and hearers are predicted to optimize bidirectionally and, therefore, to use specific referring expressions to maintain or shift topics during discourse. If children optimize unidirectionally, they will demonstrate a different use or interpretation of referring expressions. Section 2 introduces a production experiment and a comprehension experiment, designed to test for possible discourse topic differences between adults and children. For production, the participants are asked to describe six-page picture books and for comprehension they listen to structured stories about which a question must be answered. The results of these two experiments are presented in Section 3. Section 4 discusses the differences between adults' and children's use and interpretation of pronouns and noun phrases as signaling topic and topic shift in ongoing discourse. Conclusions are summarized in Section 5.

## 1. Bidirectional optimization

In principle, it is possible to refer to the same entity using a variety of referring forms. Adult speakers, however, tend to use specific referring forms depending on the structure of the previous linguistic discourse. For example, they tend to use a pronoun for an entity that is present in the immediate linguistic discourse, an indefinite noun phrase (NP) to introduce a new entity into the linguistic discourse, and a definite NP if the entity has been mentioned before but is not the main focus of attention. Gundel, Hedberg and Zacharski (1993) argue that these different forms can be placed in a hierarchy, or implicational scale, of informativity, according to which pronouns are more given than definite NPs, and definite NPs are more given than indefinite NPs. Speakers will strive for maximal economy by using a form on the scale that is just informative enough to allow the hearer to identify the intended referent.

A linguistic theory that provides a very natural way of capturing the softness of hierarchies such as Gundel et al.'s Givenness Hierarchy is Optimality Theory (OT; Prince & Smolensky, 2004). In OT, the grammar is viewed as a set of soft, or violable, constraints, which are ranked according to strength. If two constraints are in conflict, it is more important to satisfy the stronger constraint than it is to satisfy the weaker one. The optimal output of the grammar is the output that satisfies the total set of constraints best. Gundel et al.'s Givenness Hierarchy can be straightforwardly reformulated as a hierarchy of

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markedness constraints in OT, expressing a preference for pronouns over definite NPs, and of definite NPs over indefinite NPs. Since we focus on the choice between pronouns and definite NPs in this study, we restrict ourselves to the constraint "Avoid full NPs" from this hierarchy and ignore the difference between definite and indefinite NPs. If this constraint were the only force present in the grammar influencing the choice of referring expression, a speaker would never use NPs and would only use pronouns.

To explain why other forms than pronouns are also used, in addition to the constraint Avoid full NPs an opposing force must be present in the grammar that prevents pronouns from appearing under particular conditions. Such an opposing force could be the requirement that pronouns must refer to the most salient entity in the discourse, that is, to the discourse topic. This requirement has been proposed in the literature in several guises, for example as the Pronoun Rule in Centering Theory (Grosz, Weinstein & Joshi 1995). In this paper, we refer to this constraint as ProTop: "Pronouns refer to the discourse topic" (cf. Beaver 2004; Hendriks, Englert, Wubs & Hoeks 2008).

The interaction between the constraint Avoid full NPs and the constraint ProTop can be represented in an OT tableau. Consider the situation in which a speaker wishes to refer to an entity that is the discourse topic. The input to optimization is the meaning to be expressed. In principle, the speaker can use several forms to express this meaning, for example a pronoun or a full NP. These two candidate outputs are listed in the first column in Tableau 1a.

| Input: +topic | Avoid full NPs | ProTop |
|---|---|---|
| ☞ <pronoun> | | |
| <full NP> | * | |

Tableau 1a: The optimal form for expressing a +topic meaning

The constraints determining the choice between the candidate outputs are given in the top row from left to right in order of descending strength. Constraint violations are indicated by an asterisk. To express reference to the topic, a pronoun is the optimal form because this form satisfies both constraints, whereas a full NP violates the constraint Avoid full NPs. The optimal output is indicated by the pointing hand.

If a speaker wishes to refer to an entity that is not the discourse topic, using a pronoun would violate the constraint ProTop. This is represented in Tableau 1b. However, since this constraint is weaker than Avoid full NPs, a violation of ProTop is not fatal. Although a pronoun violates one of the constraints of the grammar, it is still a better choice than a full NP, since a full NP violates the stronger constraint Avoid full NPs.

| Input: -topic | Avoid full NPs | ProTop |
|---|---|---|
| ☞ <pronoun> | | * |
| <full NP> | * | |

Tableau 1b: The optimal form for expressing a -topic meaning

Tableaux 1a and 1b illustrate that a highly economical speaker will only produce pronouns when referring to either the topic of discourse or to a non-topic. In both tableaux, an NP violates the strongest constraint, Avoid full NPs. This pattern, however, does not seem to correspond to how adult language users select the appropriate referring form. We will return to this issue below.

Tableaux 2a and 2b represent the hearer's choice of interpretation upon hearing a pronoun or full NP. For the hearer, the second, weaker constraint is decisive, since it is up to the speaker to produce the forms. Tableau 2a represents the situation in which a pronoun is encountered. A hearer will interpret this pronoun as referring to the topic, since the meaning <-topic> violates the constraint ProTop and hence is not optimal.

| Input: pronoun | Avoid full NPs | ProTop |
|---|---|---|
| ☞ <+topic> | | |
| <-topic> | | * |

Tableau 2a: The optimal meaning for interpreting a pronoun

In Tableau 2b, the input is a full NP and the hearer must determine the optimal meaning for this form. In this case, the constraint ProTop is satisfied vacuously, since it applies to pronouns only. As a result, the full NP can be interpreted as referring to either <+topic> or <-topic>. In other words, the full NP is ambiguous between signaling the discourse topic or referring to a non-topic.

| Input: full NP | Avoid full NPs | ProTop |
|---|---|---|
| ☞ <+topic> | | |
| ☞ <-topic> | | |

Tableau 2b: The optimal meaning for interpreting an NP

In our discussion of Tableau 1b, we pointed out that the two constraints discussed here yield incorrect predictions about the production of the optimal form for referring to a non-topic. We hypothesize that this is because the speaker's choice of referring form is necessarily dependent on the hearer's choice of meaning, and vice versa (see also Hendriks, Englert, Wubs & Hoeks 2008). An adult speaker will not use a pronoun to refer to a non-topic because such a pronoun would be unrecoverable as it would be interpreted by a hearer as referring to the topic. In OT, this interdependency of the speaker's choice on the hearer's choice is formally modeled as bidirectional optimization over form-meaning pairs (Blutner, 2000). A bidirectionally optimal form-meaning pair is a pair for which there exists no other bidirectionally optimal pair with a better form or a better meaning. Whereas children optimize unidirectionally (as represented by the tableaux above) and take only their own perspective into account, adults have been argued to optimize bidirectionally by also taking into account the other person's perspective (De Hoop & Krämer, 2005/6; Hendriks & Spenader, 2005/6). This is represented in Tableau 3.

| <form, meaning> | Avoid full NPs | ProTop |
|---|---|---|
| ✌ <pronoun, +topic> | | |
| <pronoun, -topic> | | * |
| <full NP, +topic> | * | |
| ✌ <full NP, -topic> | * | |

Tableau 3: Optimal referring forms and their meanings for adult language users

The constraint violations in Tableau 3 are the same as in the unidirectional OT tableaux. However, the calculation of the optimal output is different. Pronouns are optimal for reference to the discourse topic, and vice versa, because the first pair <pronoun, +topic> satisfies both constraints. However, the second and third pair are blocked because for these pairs there exists a bidirectionally optimal pair with a better form or meaning, namely the first pair. Because the second and third pair are blocked, the fourth pair is also bidirectionally optimal and hence full NPs are optimally paired with non-topics.

If adults optimize bidirectionally but children are not yet able to do so (perhaps because of the extra cognitive load it entails, see Hendriks, van Rijn & Valkenier 2007), we can formulate precise predictions with respect to children's performance on discourse reference. These predictions result from comparing the outcomes of the unidirectional Tableaux 1 and 2 with the outcomes of bidirectional

Tableau 3. The first difference is the form for expressing reference to a non-topic, which is a pronoun according to Tableau 1b (albeit an unrecoverable one) but a full NP according to bidirectional Tableau 3. The other difference is the interpretation of a full NP, which is ambiguous according to Tableau 2b but must refer to another entity than the current discourse topic according to bidirectional Tableau 3. These two differences lead to the following two hypotheses with respect to children's performance regarding referring expressions and discourse topics:

1) As speakers, young children will produce unrecoverable pronouns after a topic shift.
2) As hearers, young children will fail to interpret full NPs as a signal for topic shift.

These two hypotheses about children's linguistic capacity for signalling and interpreting topic shift are tested in parallel production and comprehension experiments presented in the following sections.

## 2. Experimental Design

### *2.1. Participants*

In total, 33 children participated in this study. Of this group, 2 children failed to produce stories in the production task and were excluded. The analyses presented here include the remaining 31 children (15 girls, 16 boys), all of whom were typically developing native speakers of Dutch and attending kindergarten classes in a public school (ages 4;3 – 6;5; mean 5;6 years). The study also included an adult group of 23 native Dutch speakers (11 women, 12 men; ages 20;7 – 30;9; mean 24;7 years).

### *2.2. Materials*

#### *2.2.1. Production task*

While looking at a storybook with one picture per page (six picture-pages per storybook), participants described in a sentence or two what was happening on each page. An example of the six pages of one storybook is given in black-and-white in Figure 1. The pictures presented to the participants were in color.

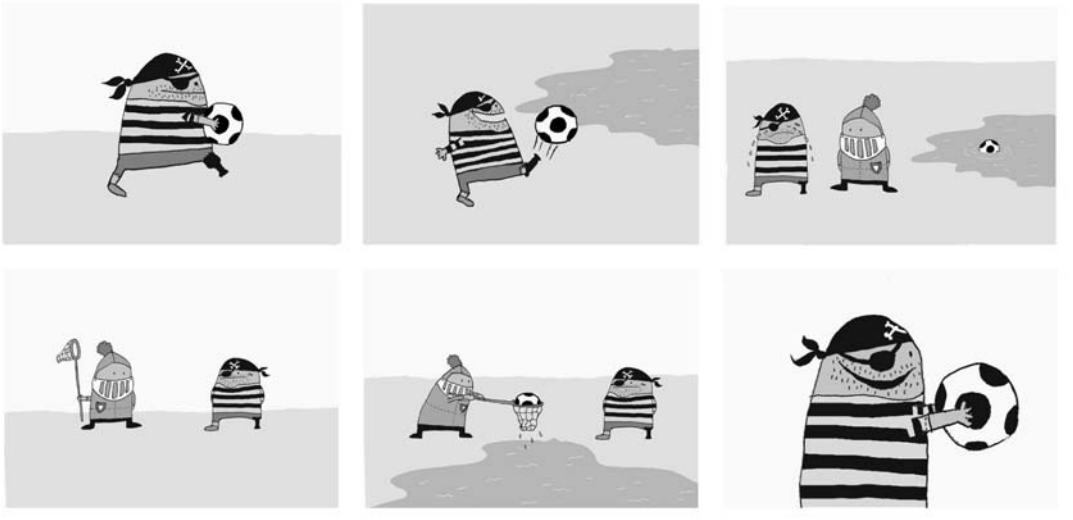

Figure 1: Production task picture storybook, with topic shift (+TS)

There were four storybooks, all with the same internal structure designed to elicit topic shift from the storyteller. Ideally, the speaker should choose to introduce the first character with an indefinite NP when describing the first picture. The speaker could continue to refer to this character in the second and third pictures with a definite NP or a pronoun. A topic shift to the second character should then occur when the speaker describes the fourth picture by introducing the second character with a (in)definite NP and placing this character in subject position. The sixth picture should motivate the speaker to

linguistically clarify for the hearer that there had been a switch back to the original topic, the first character. According to bidirectional Optimality Theory, the speaker should therefore take into account the hearer's perspective by using an unambiguous definite NP to re-introduce the first character. Using a pronoun would lead to an unintended interpretation. If the speaker optimized unidirectionally, however, a pronoun might be used at that moment, since a pronoun form would be the speaker's most economical option.

### *2.2.2. Comprehension task*

In the comprehension task, the participants listened to pre-recorded stories about two characters of the same gender. At the end of each story, they were asked a question about which of the two characters did something. In total, there were eight stories composed of six sentences each. The structure of the stories differed: four stories included a topic shift (+TS) and the other four stories did not (-TS). All the stories were pre-tested with a different group of adults to ascertain the plausibility of the characters as being actors in these stories.

Story:
1 Een schoonmaakster wil de eendjes gaan voeren.
*A cleaning-lady wants to go feed the ducks.*
2 Ze haalt het oude brood uit de broodtrommel.
*She gets the old bread out of the breadbox.*
3 Ze vraagt aan een juf om mee te gaan.
*She asks a teacher (fem.) to go along.*
4 De juf scheurt de broodjes van de schoonmaakster in stukjes.
*The teacher tears the cleaning-lady's bread into pieces.*
5 En dan geeft de juf het brood van de schoonmaakster aan de eendjes.
*And then the teacher (fem.) gives the cleaning-lady's bread to the ducks.*
6 Ze vindt eendjes hele lieve diertjes.
*She thinks ducks are very sweet animals.*
Question:
Wie vindt eendjes hele lieve diertjes?
*Who thinks ducks are very sweet animals?*

Figure 2: Comprehension task recorded story, with topic shift (+TS)

In the recording of the topic shift stories, the first character was introduced with an indefinite subject NP in the first sentence and referred to with a subject pronoun in the second and third sentences. The second character appeared in the third, fourth and fifth sentences and also was the actor in the fourth and fifth sentences. This character was introduced with an indefinite (prepositional) object NP and appeared thereafter as a definite subject NP. The sixth sentence contained a potentially ambiguous subject pronoun. This pronoun must be resolved in order to answer the concluding comprehension question. If participants assume pronouns to refer to the discourse topic, the pronoun in the question should be referring to the second character who became the topic halfway through the story (fourth sentence). The hearer's answer to the comprehension question should clarify who the hearer thinks the topic is at the end of the story.

Four stories without topic shift were also included in the study to contrast with the topic shift stories. An example of one of these -TS stories is given in Figure 3.

Story:
1 Een clown heeft net zijn eigen gezicht geschminkt.
*A clown has just painted his own face.*
2 Hij wil wel eens iemand anders schminken.
*He wants to paint someone else.*

3 Hij komt in de keuken een kok tegen.
*He comes across a cook (masc.) in the kitchen.*
4 De clown besluit de kok te schminken.
*The clown decides to paint the cook (masc.).*
5 En dan schminkt de clown een heel stoer gezicht bij de kok.
*And then the clown paints a real tough face on the cook (masc.).*
6 Hij vindt dat het prachtig is geworden.
*He thinks it turned out great.*
Question:
Wie vindt het prachtig geworden?
*Who thinks it turned out great?*

Figure 3: Comprehension task recorded story, without topic shift (-TS)

In the no-topic shift condition, the first character was the actor throughout the first five sentences. This character was introduced by an indefinite subject NP in the first sentence and referred to by a subject pronoun in the second and third sentences. In order to keep these stories similar to the stories with topic shift, the first character was mentioned as a definite NP in the fourth and fifth sentences, although as subject rather than object. The second character was present in the third, fourth and fifth sentences. In the third sentence, this character was expressed by an indefinite (prepositional) object NP and, in the fourth and fifth sentences, a definite (prepositional) object NP was used.

In these recorded stories, there was no topic shift: the second character was never the actor and was also never in subject position in the sentences. In the sixth sentence, the pronoun was potentially ambiguous since both characters were in the story and did have the same gender. To answer the concluding comprehension question, the hearer must use the structure of the preceding discourse to determine the referent of the pronoun that appeared in the sixth sentence. Since a pronoun should be referring to the topic, the hearer should give the first character as the answer to the comprehension question.

### *2.3. Procedure*

Each child was tested individually in a quiet room at school. The session took roughly 20 minutes, with the production task preceding the comprehension task. Adults were also tested individually in a quiet room and their session lasted roughly 10 minutes. One tester was present for the adults. For the children, two testers were present. One person sat near the child and turned the storybook pages (production) or listened along with the child to the story recordings (comprehension). The other tester kept busy with administrative duties, such as noting answers to test questions. This person sat further away, in front of a computer screen. It was made clear to the child that the second tester wanted to know what was going on, but could not see the production storybook. The child's task was to tell this second person what was happening.

In the sessions with children, the tester began the production task by showing the child an introductory page including all the storybook characters and asking the child to name them. This naming task was included in the introduction to check if the child was able to identify all the characters. Then the tester told a story based on a two-page storybook, using one sentence per page, and asked the child to also tell a story, based on another short storybook. After the practice session, the child was once again reminded that the second tester could not see the storybook. The child was then asked to describe four six-page storybooks, each containing a topic shift. The comprehension test included eight pre-recorded stories, four with topic shift and four without topic shift. Each pre-recorded story included a final question.

The production and comprehension sessions for the adults were equivalent to the children's sessions except the adults did not see the introductory production page containing all the storybook characters. An additional instruction to the adults was the request that they produce only one or two sentences per storybook page, since previous testing showed that some adults tell long and detailed stories.

*2.4. Transcription and coding*

The production stories and comprehension answers were recorded and later transcribed. Random transcriptions were controlled for accuracy.

In the production task, the focus was on the final pictures and how the speakers referred back to a previous topic after they had established a new topic. In order to carry out the final analysis, the structure of each discourse first had to be determined Two other researchers independently inspected each transcript for topics and topic shifts. First, they determined the topic of each utterance. Then they determined the first topic shift halfway through the description of the pictures. Finally, at the end of the descriptions, they noted which referring expression was used and to whom it referred. There were only minimal differences between the two researchers' inspections. These differences were easily resolved in a discussion afterwards. The production score used in the final statistical analyses was based on whether the speakers used a full NP or a pronoun when they referred back to the first character in the last picture.

For the comprehension task, the hearer's answers to the final questions were recorded and transcribed. Since the goal of the comprehension task was to investigate whether the participants were sensitive to the difference between stories with and without topic shift, their answers were scored as to whether they referred to the first character or the second character when answering the final question.

For both the production and comprehension tasks, a third category, "other", included any answers that did not fit into the first two response categories. For example in the comprehension task, a child would occasionally mention a character from a previous story or say "I don't know".

## 3. Results

*3.1. Production task results*

The productions were first analyzed as to whether speakers switched from talking about the first character to the second character when they described the third or fourth picture in the storybooks. In that respect, the structure of the storybooks was quite successful. Both the children and the adults usually switched to the second character at that point (children 89%, 108 out of 124 stories; adults 99%, 91 out of 92 stories). The analyses will include only those productions since the character switch halfway through the story is necessary to insure correct assessment of the topic shift from the second character back to the first character in the last picture.

The production score was based on whether the speakers used a full NP or a pronoun to express a topic shift, when they referred back to the first character in the final picture. Figure 4 gives the percentages of pronoun, full NP or "other" responses produced by children and adults when referring to this character in picture 6.

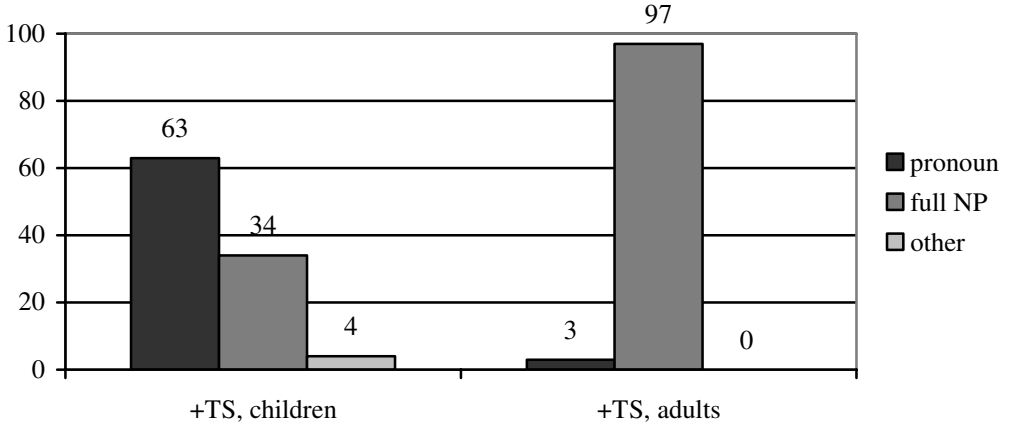


Figure 4: Production task: Percentage of forms used to describe the first character (+TS storybook, picture 6)

Two Repeated Measures ANOVAs were performed, one on the basis of mean percentages per participant (F1, or analysis by participants) and one on the basis of mean percentages per item (F2, or analysis by items). All percentages were normalized using an arcsine transformation. Type of Response (pronoun vs. full NP vs. "other") was treated as a within-participants and within-items factor, Age Group (children vs. adults) was treated as a between-participants factor in the analysis by participants, and as a within-items factor in the analysis by items. To guard against possible violations of the assumption of sphericity, the Huyn-Feldt correction was applied whenever the factor Type of Response was involved (Stevens 1992). Original degrees of freedom are reported.

There was a significant main effect of Response Type ($F1(2,104)=72.4$; $p<.001$; $F2(2,6)=90.6$; $p<.005$), with full NPs being produced 65% of the time (SE=4%), pronouns 33% of the time (SE=4%), and "other" responses only 2% of the time (SE=1%). This main effect was qualified by a significant interaction between Response Type and Age Group ($F1(1,104)=62.6$; $p<.001$; $F2(2,6)=100.8$; $p<.005$).

Follow-up analyses showed that the main effect of Response Type was significant in each age group (Children: $F1(2,60)=21.2$; $p<.001$; $F2(2,6)=24.6$; $p<.05$; Adults: $F1(2,44)=456.3$; $p<.001$; $F2(2,6)=217.5$; $p<.005$). Posthoc analyses by participants (p1) and by items (p2) showed that for children, there was no significant difference (both p-values >.12) between the percentage of pronouns (63%; SE=5%) and the percentage of full NPs (34%; SE=5%), while both were produced significantly more often than the "other" responses (4%; SE=1%) (all p-values <.05). For adults, a qualitatively different pattern emerged, since the adult participants almost exclusively used full NPs (97%; SE=6%) instead of pronouns (3%; SE=6%) or "other" responses (0%; SE=2%). The percentage of full NPs was significantly different from the other types of response (all p-values <.001); pronouns and "other" responses did not differ significantly (both p-values >.17). Note that for all sets of pairwise comparisons Bonferroni correction was applied.

### *3.2. Comprehension task results*

The children and adults were also compared as to how they answered the final question at the end of the two types of comprehension stories. The results are given in Figure 5, for stories with a topic shift (+TS) and for stories without a topic shift (-TS).

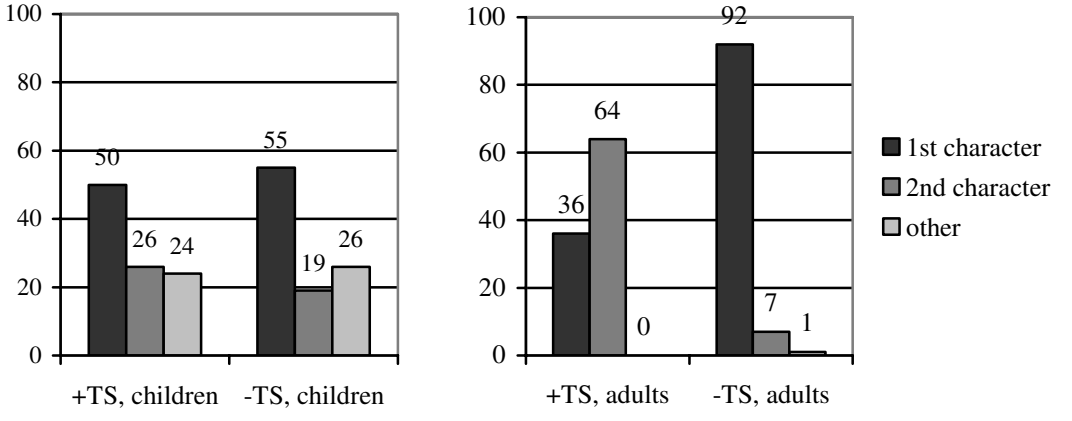


Figure 5: Comprehension task: Percentage of meanings assigned to final question (+TS and –TS recorded stories)

Repeated measures ANOVAs were applied on the response percentages per participant (F1, averaged over items) and on percentages per item (F2, averaged over participants). These analyses included three factors: Response Type (first character, second character, "other" response), Story Type (with topic shift (+TS) and without topic shift (-TS)) and Age Group (children and adults). Response Type was considered a within-participants and within-items factor, Story Type was treated as within-participants and between-items, and Age Group as between-participants but within-items. As in the previous

analyses, we used an arcsine transformation for all percentages and we report the Huyn-Feldt correction where appropriate.

The main effect of Response Type was significant ($F1(2,100)=60.9$; $p<.001$; $F2(2,12)=38.5$; $p<.001$), as were the two-way interactions of Response Type and Age Group ($F1(2,100)=13.7$; $p<.001$; $F2(2,12)=9.3$; $p<.05$) and of Story Type and Response Type ($F1(2,100)=41.8$; $p<.001$; $F2(2,12)=16.6$; $p<.001$). These effects, however, were qualified by a significant three-way interaction of Response Type, Story Type and Age Group ($F1(2,100)=28.7$; $p<.001$; $F2(2,12)=8.2$; $p<.05$).

Follow-up analyses investigating the nature of this three-way interaction showed that, for children, there was no interaction between Story Type and Response Type (both F-values <1): Whether they heard a story with or without topic shift, in either case the children most often answered the final question by naming the first character as the referent to the final question (52%; SE=4%), as opposed to choosing the other options (all p-values <.05). The remaining responses were equally distributed over the second character (23%; SE=3%) and the "other" responses (25%; SE=5%) (both p-values equal 1.00). In contrast, there was a highly significant interaction effect for adults on Response Type and Story Type ($F1(2,42)=83.4$; $p<.001$: $F2(2,12)=14.6$; $p<.005$). Follow-up analyses showed that there was a qualitatively different response pattern for stories with a topic shift as compared to stories without a topic shift. Adults favored answering the question in topic shift stories with the second character (64%; SE=4%) over the first character (36%; SE=5%) ($p1<.05$; $p2=1.00$) or the "other" response (0%; SE=5%) ($p1<.001$; $p2=.14$), and with the first character over the "other" responses ($p1<.001$; $p2<.05$), although these differences were not always significant in the analysis by items. For stories without topic shift the answer pattern was completely reversed: here, adults preferred answering with the first character (92%; SE=5%) over either the second character (7%; SE=3%) ($p1<.001$; $p2<.05$) or the "other" response (1%; SE=5%) ($p1<.001$; $p2<.005$). The difference between the second character versus the "other" response was not significant (p-values >.19). As in the previous analyses, Bonferroni correction was applied for each set of pairwise comparisons.

## 4. Discussion

In this study, children and adults were tested on their production and comprehension of referring expressions in relation to topic shift during ongoing discourse. The results of these experiments differentiate clearly between adults and children, in support of the predictions made by Optimality Theory. In the production task, children optimized unidirectionally. They preferred using unrecoverable pronouns to NPs when they linguistically re-introduced the first character in the final picture. By selecting an optimal form exclusively from the perspective of the speaker, the children were being too economical. In contrast, the adults optimized bidirectionally. The form they used was a full NP, signaling to their hearer that a topic shift back to the first character was intended. In the comprehension task, the children again optimized unidirectionally. They interpreted the final question equivocally in recorded stories with and without an earlier topic shift, that is, they selected the most optimal meaning from the hearer's perspective, ignoring the speaker's intended meaning. In contrast, the adult listeners optimized bidirectionally and successfully recovered the speaker's intended meaning, based on their interpretation of the speaker's discourse structure. In topic-shift stories, the adults interpreted the final question as referring to the newly introduced topic. In stories without topic shift, they interpreted final question as referring to the first character, which had been the topic throughout the story

The acquisition of pronouns has long been a topic of investigation in child language and several other developmental delays have been documented. Many studies have concentrated on the unexpected delay in comprehension of object pronouns in comparison to reflexives (see for Dutch: Deutsch, Koster & Koster 1986; French: Jakubowicz 1984; English: Chien & Wexler 1990). The general consensus is that children have non-adultlike comprehension of the object pronoun *him*, often allowing coreference with the local subject, whereas they seem to correctly comprehend the reflexive *himself* from an early age onward. In relation to the principles of the traditional Binding Theory (Chomsky, 1981), it is difficult to explain how a child seems to master Principle A and reflexives, but not Principle B and pronouns. In the past, various attempts have been made to explain this developmental pattern (Koster 1993; Reinhart to appear; Thornton & Wexler 1999). A recent explanation which can correctly capture this pronoun-reflexive developmental asymmetry in terms of bidirectional optimality theory has been

given by Hendriks and Spenader (2005/6). Another acquisitional asymmetry which has recently come to researchers' attention is the difference between children's poor comprehension versus their good production of the same object pronouns (De Villiers, Cahillane & Altreuter 2006). This asymmetrical development is also difficult to explain via a traditional grammatical view, since after a particular linguistic parameter is set, it should be equally applicable to production and comprehension. Hendriks and Spenader (2005/6) have shown that such acquisitional asymmetries can be explained within the grammar of bidirectional Optimality Theory.

In relation to pronoun acquisition, how do children achieve the production-comprehension symmetry that typifies the adult language user? From an Optimality Theory standpoint, an early step in language acquisition is presumed to be the proper ranking of the necessary constraints. To achieve the adult symmetry of production and comprehension, however, bidirectional optimization is also necessary. Hendriks, van Rijn and Valkenier (2007) have developed a computational model of object pronoun and reflexive acquisition, based on bidirectional Optimality Theory, involving a first step of optimization from form to meaning followed by a second step of optimization from meaning to form. The computational simulation suggests that a lack of sufficient processing speed may cause the model to perform unidirectionally, that is, to produce an output before both processing steps have been completed, which confirms the prediction of comprehension errors with pronouns and not with reflexives.

The lack of sufficient processing speed has also been demonstrated in real-life manipulation of speech presented to children. In an experimental study (Van Rij, Hendriks, Spenader & van Rijn 2008), children who showed the Delay of Principle B effect were also exposed to the same type of object pronoun sentences, but presented in slowed-speech. In the slowed speech condition, the children had a much higher percentage of correct pronoun interpretations. The implication is that the extra processing time during comprehension of slowed speech made it possible for these children to complete the bidirectional optimization required to achieve adult-like pronoun interpretation.

Another factor possibly limiting bidirectional optimization, besides amount of processing time, is the size of working memory. It is presumed that young children who have smaller working memories may have more difficulties completing bidirectional optimalization. The children in the present study were also tested for working memory and first results confirm a relationship between the size of their working memory and more or less adultlike performance on the topic shift tasks.

In this paper, we argued that children's and adults' patterns of production and comprehension can be explained by (lack of) bidirectional optimization. Our account is highly similar to the bidirectional optimization account of Hendriks and Spenader (2005/6) for object pronouns. The present study and Van Rij et al. give evidence that bidirectional optimization requires sufficient processing resources. As children's processing and memory capacities increase, they will be able to complete bidirectional optimalization and their language will become adultlike. Note that, in our account, processing difficulties are predicted to be fully determined by the output of the grammar. In general, children do not seem to have problems with pronouns. Only if they wish to refer to a non-salient entity in production do the pronoun problems occur. Also, children's problems can emerge either in production, as with subject pronouns, or in comprehension, as with object pronouns. In this respect, our grammatical account, which includes bidirectional optimization as part of the grammar, differs from processing explanations that attribute children's errors to general processing difficulties. Under a bidirectional optimization account, all late delays in child language result from a difference between the output of adults' bidirectional optimization and the output of children's unidirectional optimization.

## 5. Conclusion

The original question in the present study was: if children and adults are both capable of cognitively taking another person's perspective, do they also both linguistically take their partner's perspective into account? Children and adults participated in a production task in which, as speakers, they had to repress using a subject pronoun to re-introduce a previous topic in their description of a set of pictures. They also participated in a comprehension task in which, as hearers, they had to interpret a subject pronoun based on the structure of earlier recorded discourse. Both production and comprehension by children were not yet adult-like: they did not take their conversational partner's linguistic situation into

consideration and did not select optimal form-meaning pairs in discourses involving topic shift. Since, at the average age of 5;6 years, it can be presumed that these children are cognitively capable of taking someone else's perspective, the source of their linguistic inability to take another person into consideration is attributed to their developing grammar. In terms of bidirectional Optimality Theory, the children in this study can be expected to have already acquired the correct adult ranking of the constraints involved in pronoun use. Their difficulty lies in an inability to optimize bidirectionally and to select the best ensuing form-meaning pairs. It is this aspect of the children's developing grammar which leads to a delay in the appropriate production of pronouns as well as the comprehension of topic shift.

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