

Arnold, J.E., Novick, J.M., Brown-Schmidt, S., & Trueswell, J. C. (2001). Children's on-line use of gender and order-of-mention for pronoun comprehension. In Do, A. H., Domínguez, L., & Johansen, A. (Eds.), *Proceedings from the Boston University conference on language development*, 2000. Somerville, MA: Cascadilla Press, 59-68.

Knowing the Difference Between Girls and Boys: The Use of Gender During On-Line Pronoun Comprehension in Young Children

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1. Introduction

A central aspect of using language involves understanding what the speaker is referring to with names, descriptions, and attenuated referring expressions, like pronouns. This experiment is aimed at understanding the processing mechanism that 5-year-old children use to interpret pronouns on-line. In particular, we examine two cues which are known to influence the earliest processes of adult pronoun interpretation, gender and order of mention. In discourses like (1a) and (1b), which characters do children initially consider as potential referents for the underlined pronoun?

- (1a) Donald is bringing some mail to Mickey, while a big rain storm is beginning. He's carrying an umbrella, and it looks like they're both going to need it.
- (1b) Donald is bringing some mail to Minnie, while a big rain storm is beginning. She's / He's carrying an umbrella, and it looks like they're both going to need it.

Adults rapidly make use of a number of cues to interpret pronouns. When there are two characters in a sentence, they tend to focus more on the first-mentioned character than the second, and represent first-mentioned characters as more accessible in their mental representation of the discourse. This difference in accessibility affects the interpretation of subsequent pronouns, which are easier to interpret when they refer to the focused, first-mentioned character (Arnold, Eisenband, Brown-Schmidt, & Trueswell, 2000; Gordon, Grosz, and Gilliom, 1993).¹ They also can make use of gender cues when available, as in (1b), and easily understand gender-marked pronouns, regardless of whether the referent is focused or not (Arnold et al., 2000; Boland et al., 1998).

The study of these cues in children's on-line language processing is relevant to two larger issues. First, it helps us understand how the adult system develops, which informs our understanding of the kinds of representations and mechanisms that underlie the adult ability to understand referring expressions of all types. Second, the study of pronoun comprehension reveals one component

of the processes involved in on-line language comprehension in young children, in particular how children bring together various sources of information to deal with temporary indeterminacies in the linguistic input. This focus on on-line language processing contrasts with previous research on child language, which has focused mainly on children's knowledge of linguistic structure, meaning, and pragmatics.

Previous research presents conflicting results about whether children use gender to process pronouns. In one of the few previous experiments on on-line processing, Tyler (1983; Tyler and Marslen-Wilson, 1982) used a mispronunciation detection task in Dutch to investigate pronoun processing with children ages 5, 7, and 10. She concluded that children do not consistently use lexical cues like gender and number for on-line pronoun comprehension until age 7. These results contrast with off-line experiments that show the use of gender for pronoun interpretation as young as age 3 (Brenner, 1983; Wykes, 1981).

Research on children's production of referring expressions also sheds light on whether children understand that lexical properties of pronouns can be used to identify a referent. Karmiloff-Smith (1985) reports that when children first start using pronouns anaphorically (around age 6), they use pronouns exclusively for the "thematic subject", or discourse topic, and avoid pronouns for other characters, even when they would have been unambiguous because of their gender. This suggests that children at this age may not know that the pronoun's gender can be helpful to the comprehender for pronoun interpretation. By contrast, Gomme and Johnson (1997) report that children as young as 3 use pronouns when they are disambiguated by gender, although they principally follow a thematic subject strategy.

With respect to the question of whether children use order-of-mention for pronoun comprehension, little is known. In keeping with the production data, there is ample evidence that children tend to focus on characters that are well-established as the discourse topic, and use this for on-line pronoun comprehension. Tyler's (1983) Experiment 3 suggested that 5-year-olds understood pronouns better when they referred to the discourse topic. Song and Fisher (this volume) also show (Experiment 3) that 3-year-olds focus on characters that have been repeated in first-mention position and pronominalized in a previous sentence, both of which are features that can establish a character as the discourse topic. But these studies do not establish whether children, like adults, tend to focus on the first-mentioned of two characters in an utterance. There is some evidence that they do, but this comes from a post-hoc analysis of an offline task (Wykes, 1981). A narrative production study also suggests that when children use pronouns, they tend to use them to refer to the subject of the previous clause (Hickman and Hendricks, 1999).

In sum, there is mixed evidence about whether young children do or do not use gender information for on-line pronoun processing. This, together with evidence that they can use the discourse history to infer referent accessibility when it's strongly manipulated, suggests that perhaps children use order-of-mention more than gender for on-line pronoun comprehension.

At the same time, there is reason to believe that children may use gender more than order-of-mention. Gender is a categorical cue to the pronoun's referent, but order-of-mention is probabilistic indicator of referent accessibility, which in and of itself is a probabilistic indicator of the pronoun's referent. This has implications for both the acquisition and use of these cues. If the acquisition process is sensitive to statistical patterns in the linguistic input, then it should be relatively easy to learn that "she" refers to female entities and "he" refers to male entities, since this pattern occurs nearly categorically.

By contrast, children may have to learn the link between order-of-mention and accessibility by observing that first-mentioned entities tend to be more important to the upcoming discourse than other entities. This observation would require the accumulation of a fairly large database of linguistic input, and therefore should take time. (For further discussion of this view of order-of-mention as a statistical cue, see Arnold, 1998). The probabilistic vs. categorical nature of these two cues also makes gender a more reliable cue to the pronoun's referent than order-of-mention, which may also lead children to use it before order-of-mention.

In the current study, we employ a head-mounted eyetracking technique to study how gender and order-of-mention influence children's moment-by-moment hypotheses about pronoun interpretation. This method was originally developed for use with adults (Cooper, 1974; Tanenhaus et al., 1996), but has recently been shown to be effective with children as young as 4.5 years of age (Sedivy et al., 2000; Nadig and Sedivy, 2000; Trueswell, Sekerina, Hill, and Logrip 2000).

2. Methods / Participants / Materials

Sixteen children ages 4;0-5;9 (mean 5;2) participated in a modified truth-value judgment task (e.g. Crain and Thornton, 1998; Musolino et al., 2000) while their eye-movements were recorded by a head-mounted eye-tracking system. Children were given a small toy in exchange for participation. 13 participants had to be replaced because a) we had difficulty calibrating the eyetracker (n=1), b) the child refused to wear the eye tracker (n=5), c) the child had difficulty doing the truth-value-judgement task (n=5), or d) the child stopped in the middle of the task (n=2). All children were native speakers of English with at least one native English-speaking parent.

Children were first introduced to a puppet that was described as 'not very smart', and they were asked to help the puppet identify when he made a mistake. In the familiarization routine, children were introduced to the idea that the puppet might say wrong things (e.g., 'Your shirt is blue' (when it's red)), and were encouraged to punish the puppet for mistakes (e.g., by making him do push-ups), or reward him for correct statements (e.g., with candy). This method was employed to engage the child in the truth-value judgment task, and to encourage the child to pay close attention to the puppet's statements.

The experimental task was to view scenes including familiar cartoon characters,² and listen to the puppet tell a story about the picture. During the

story the puppet hid from the child's view, and the child was told that the puppet's voice would be coming out of the computer. As in the familiarization routine, the child's task was to say if the puppet 'made a mistake', and if so, to say what the mistake was. The child was introduced to this procedure in at least two warm-up trials (both 'incorrect'). Following the warm-up trials there were 2 practice trials (1 'correct', 1 'incorrect'), followed by 8 experimental items (all 'correct') intermixed with 8 fillers (3 'correct', 5 'incorrect'). Children were only included in the analysis if they correctly answered 2/5 of the 'no' fillers (i.e., if they said that the puppet had made a mistake on at least 2 'incorrect' trials).

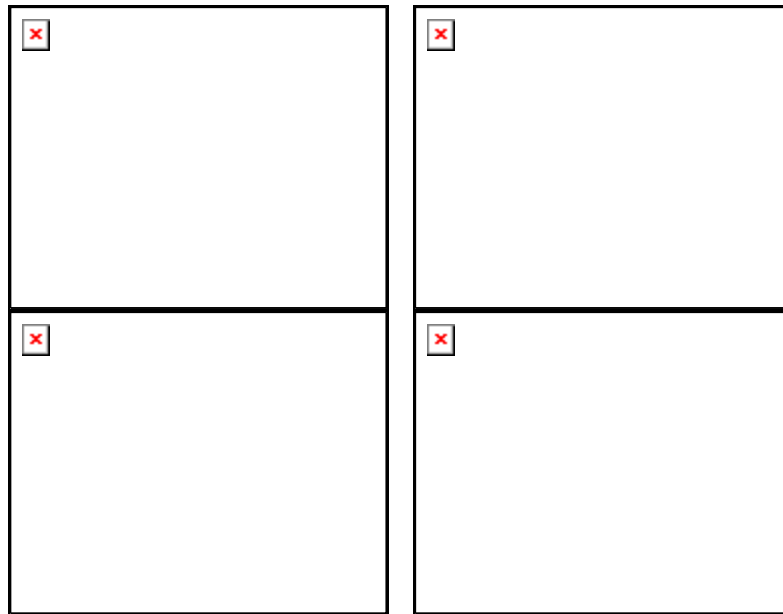


Figure 1. Sample visual stimuli in four conditions: different-gender/1st-mention (upper left), different-gender/2nd-mention (upper right), same-gender/1st-mention (lower left), same-gender/2nd-mention (lower right).

An ISCAN eyetracking visor was used to record eye-movements while the child listened to the stories (for eyetracking details see Trueswell et al., 1999 and Arnold et al., 2000). The scene image and the superimposed eye position, along with all auditory stimuli, were recorded once for each 33-ms frame of video tape, using a frame-accurate digital video recorder (a SONY DSR-30).

A 2x2 design yielded four variants of each item, manipulating a) gender (same vs. different) between subjects, and b) order-of-mention (first vs. second) within subjects. One version of each item was assigned to each of 4 lists, each having forward and reverse orders.

Each text had four clauses, broken into two sentences, as in (1a and b). The first clause mentioned the two characters; the second mentioned some other object in the picture. The third clause began with a pronoun referring to one character or the other, and the final clause provided concluding information without mentioning either character individually. In all cases the picture disambiguated the pronoun, but not until after the verb (e.g. in this picture both characters are holding something, but only one is holding an umbrella). In half the items the first-mentioned character was on the right of the picture, in half it was on the left. Sample visual stimuli are shown in Fig. 1.

Texts were digitally recorded to a computer by a female speaker. The same recording was used for all conditions of a give item, with the differing names and pronouns spliced in using SoundEdit 16. The pictures and texts were controlled by PsyScope 1.0.2 running on a G3 PowerBook.

3. Results

Children's offline responses (i.e., whether the puppet had made a mistake or not) showed a relatively high rate of acceptance for the utterances (mean=86%) and no difference among conditions ($p>.1$), indicating that they ultimately understood the pronoun in most cases.

In order to examine the time-course of pronoun interpretation, we coded the video record of children's eye movements, beginning at the onset of the pronoun. For each video frame, we identified where the child was looking: the target (the referent of the pronoun), competitor (the other character), other (something else in the picture), or track loss.³

Differences in the time spent looking at the target (e.g., Donald) and the competitor (e.g., Mickey) provide some indication of what the child thought the pronoun (e.g., 'he') referred to over time. To measure this, we computed the proportion of time spent looking at the target minus the proportion of time spent looking at the competitor for four separate 400-ms segments immediately following the pronoun (Fig. 2). The first difference among the conditions emerged in the second segment, at 400 ms after the pronoun onset, where children started looking at the target more than the competitor in the different-gender conditions. This corresponds to about 169 ms after the offset of the pronoun, which lasted an average of 231 ms. It takes 150-200 ms to program and launch an eye movement (Matin, Shao and Boff, 1993), which means that children in the different-gender conditions had sometimes begun to program an eye movement to the target before the offset of the pronoun.

In the same-gender conditions, by contrast, there was no evidence of children looking at the target more than the competitor until the 4th segment, a full 1200 ms after the onset of the pronoun. This is also well after the point where the pronoun became disambiguated (e.g., the onset of the word 'umbrella' in (1)), which occurred on average 640 ms after the pronoun onset. The increased looks to the target at this point are likely to be the result of post-verbal disambiguating information. Children may look at the target because they have

finally succeeded at interpreting the pronoun, or simply because they hear reference to something associated with the character, e.g. the umbrella.

For each segment, we compared the four conditions with analyses of variance on the subject and item means. In segment 1 there were no differences among conditions (p 's $> .1$). In segment 2 there was a main effect of gender (p 's $< .005$). In segment 3 there was a main effect of gender (p 's $< .001$), and a marginal interaction between gender and order-of-mention in the participants analysis only ($p = .069$). In segment 4 there was a main effect of gender in the participants analysis only ($p < .02$). There were no other effects or interactions in any segment (p 's $> .1$)

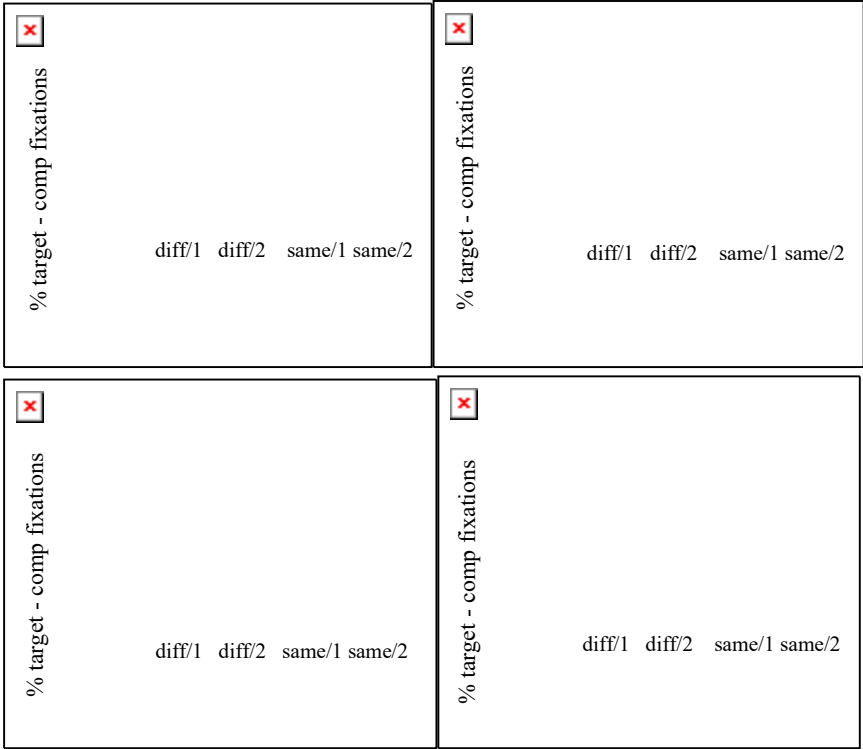


Figure 2. Eye movement results, shown as difference between time looking at target and time looking at competitor. Positive bars indicate more looks to the target in that condition.

We also compared target and competitor looks directly in each segment and condition with paired t-tests. There were more looks to the target than the competitor in the different-gender/2nd-mention condition for segment 1, in both different-gender conditions for segments 2, 3, and 4, and in both same-gender conditions for segment 4 only (p 's $< .05$). There were also marginally more

looks to the target than the competitor in the same-gender/1st-mention condition in segments 2 and 3 (p 's=.08).

This pattern of results suggests that as a group, 5-year-olds rapidly use gender to identify the pronoun referent, but they do not use order-of-mention during on-line pronoun processing. These results contrast with adult behavior on a very similar task, where they used both gender and order-of-mention, and quickly looked at the target in all conditions except the same/2nd-mention condition (Arnold et al., 2000). Importantly, in the conditions where they were successful, both adults and children showed evidence of identifying the pronoun referent equally as quickly, approximately 400 ms after the pronoun onset.

At the same time, it appears that at least some children are beginning to use order-of-mention for on-line pronoun processing. First, there was a nonsignificant trend for subjects to look at the target more in the same/1st-mention condition in segments 2 and 3. Second, further evidence comes from the children's off-line responses. Recall that the task was to tell the puppet if he had made any mistakes, and if so, what the mistake was. 3 of the 8 children in the same-gender condition showed evidence of a first-mention bias in their response. In at least one item in the 2nd-mention condition, they said the puppet made a mistake, because e.g. 'Donald wasn't carrying an umbrella'. This suggests that they had a bias to initially interpret the pronoun as referring to the first-mentioned character, and they weren't able to revise this interpretation when later disambiguating information suggested otherwise. However, even these three children only responded this way in one or two of the four 2nd-mention items. Their eye movements showed somewhat more looks to the target than the other children, but still did not look completely adult-like. This suggests that these children were on their way to learning to use order-of-mention, but had not yet achieved an adult-like use of it.

4. Discussion

The eye movement results showed that 5-year-old children used gender during on-line pronoun comprehension as rapidly as adults do, but they had difficulty using order-of-mention.

The finding that 5-year-olds use gender as quickly as adults is in conflict with Tyler's findings that 5-year-olds did not consistently use lexical cues during on-line processing. We suspect, however, that the differences arise because of methodological differences between the studies. Tyler's mispronunciation task requires disruption of the on-going interpretation process to make a judgement about a surface property of the stimulus. This disruption, combined with the a need to focus on mispronunciations, may have focused children's attention on the utterance itself, rather than the meaning, thus interfering with the normal processes of pronoun comprehension. In contrast, the eye movement technique used in the present study does not disrupt processing and provides a visual scene to reduce the memory load needed to remember the story and the gender of characters. Furthermore, it is worth

noting that Tyler's own findings suggested that 5-year-olds may have begun using gender, while the use of number was clearly delayed until age 7.

The finding that 5-year-olds don't use order-of-mention initially seems to be in conflict with Song and Fisher's results (this volume) that children successfully interpreted ambiguous pronouns on-line, on the basis of the preceding discourse context. The reason for this difference, we propose, stems from the fact that Song and Fisher's materials manipulated the accessibility of the two characters even more strongly than ours. The first-mentioned character was mentioned twice before the target sentence occurred, and was pronominalized in one of the two context sentences. This contrast is consistent with our findings for adults (Arnold et al., 2000, Experiment 2), where we found that mentioning to the first-mentioned character twice before encountering the target sentence (once as a pronoun) made the pronominalized character even more accessible, and the non-pronominalized character even less accessible as the referent of a subsequent pronoun. This finding is also consistent with earlier research that found a sensitivity to the "thematic subject" in children's production and comprehension of pronouns (Karmiloff-Smith, 1985; Tyler, 1983)

So with a subtler manipulation of referent accessibility, we have uncovered a child deficiency relative to adults in their use of such cues for pronoun processing. Why might such a child-adult difference exist? The question has to do with three issues: a) Do children use their knowledge about referent accessibility for the interpretation of pronouns? b) How do they infer the accessibility of discourse characters? c) What is the time course over which they can use accessibility during pronoun interpretation? It seems likely that children use accessibility for pronoun interpretation to some extent, given findings that children tend to focus on well-established discourse topics (Karmiloff-Smith, 1985; Song and Fisher, this volume; Tyler, 1983). With respect to the two remaining issues, we offer some speculations.

These data are consistent with the idea that children have to learn the first-mention bias, and probably other indicators of referent accessibility, from the data. They might learn, for example, that first-mentioned characters have a higher likelihood of being important to the upcoming story, and thereby learn that if two characters are mentioned in a sentence, the first-mentioned one should be represented as more accessible than the second (Arnold, 1998).

This pattern indeed does exist in written children's stories and adult speech, in that it's more likely that the first-mentioned / subject entity will be referred to again in the following utterance. However, this pattern is probabilistic. In an analysis of children's stories, it was found that 73% of all references to something in the previous clause (n=336) referred to the subject entity, and 27% referred to some other entity. Pronouns were also used more often for references to the subject entity (88%) than other entities (70%) (Arnold, 1998). Because neither probability of re-mention or probability of pronominalization is categorical, children may require a large database of material to develop a robust connection between either order-of-mention or grammatical function and the accessibility of the first-mentioned character.

Even once children have developed the knowledge that first-mentioned entities are more likely to be continued in the story than other entities, they may

still have trouble using this cue during on-line pronoun processing. For instance, if children have limited processing resources, they may be more likely to focus their attention on those cues that are highly reliable, like gender, and pay less attention to less reliable sources of information like order of mention. This may be especially true as they bring multiple sources of information together on the fly when trying to interpret spoken language.

Indeed, the very fact that other studies find that children in similar age groups produce pronouns in a pattern respecting order-of-mention or parallel structure (e.g., Hickman & Hendriks, 1999) suggests that although such probabilistic knowledge about appropriate pronoun use is available to children, it is not easily employed during the “quick-and-dirty” guessing-game known as language interpretation: Children instead rely on the highly reliable cue of gender. (See also Hurewitz, Brown-Schmidt, Thorpe, Gleitman & Trueswell, 2000, for discussion of a similar cue reliability phenomenon in syntactic ambiguity resolution.)

Thus, the limited use of order-of-mention by five year olds could stem from one or both of two things: a) children’s association of order-of-mention with accessibility may be only partially formed, in which case they would be less likely to rely upon it, or b) even once this association is fully formed, they may use it less, simply because it’s a probabilistic and hence less reliable cue, so instead they devote their limited processing resources during on-line processing to more reliable cues like gender. Both of these ideas are consistent with the findings discussed above that children perform better when a number of cues point to a single entity as the more accessible one in the discourse, e.g. the discourse topic.

Finally, another factor that might affect children’s ability to use order-of-mention is the discourse genre. In this experiment our “stories” could have been seen as descriptions of the picture. This may have encouraged children to interpret the pronouns deictically (c.f. Karmiloff-Smith, 1985), perhaps spending less energy building a mental representation of the discourse. This would inhibit any effect of order-of-mention, which can only have an effect through the comprehender’s representation of the preceding discourse, and lead children instead to use cues that are readily apparent from the picture, like gender. By contrast, listening to a spoken narrative that is less tightly linked to the picture may encourage children to build a richer mental representation of the discourse, and thus increase the likelihood that order-of-mention will influence subsequent pronoun comprehension.

In sum, this experiment points out striking similarities and differences between the processing mechanisms used by adults and young children to comprehend pronouns online. 5-year-olds use gender as rapidly as adults do, but they do not consistently use one of the most robust cues that adults use, order-of-mention. Such an effect might be expected by a system that is gradually bringing to bear additional informative, but less reliable, cues to the ambiguity resolution process.

Endnotes

- * This research was partially funded by National Institute for Health grant 1-RO1-37507-01 to the final author, and by a Science and Technology Center grant to the Institute for Research in Cognitive Science at the University of Pennsylvania (NSF-STC Cooperative Agreement number SBR-89-20230). We thank the following schools in the Philadelphia area for the use of their facilities and for participating in these studies: Mulberry Child Care and Preschool and the Penn Infant Center. Many thanks to Felicia Hurewitz, Julien Musolino, and Jesse Snedecker for their invaluable advice.
1. Order-of-mention in these sentences is confounded with two other features that have been claimed to be relevant: a) Grammatical Function, where entities that are referred to with a subject NP are considered more accessible than other entities (Gordon et al., 1993; Brennan et al., 1987), and b) Parallel Function, or the tendency for entities in the same grammatical position as the pronoun to be more accessible as antecedents (Chambers and Smyth, 1998; Sheldon, 1974). I will discuss this bias here as a first-mention bias, but this terminology is for ease of presentation only and does not exclude the possibility that grammatical function and parallel function also play a role.
 2. Before the experiment we reviewed and practiced the names of the characters until we were sure the child knew the names.
 3. Track loss accounted for 8% of the data. The primary cause for track loss was the child blinking.

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