

Who's "she"? Discourse prominence influences preschoolers' comprehension of pronouns[☆]

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Abstract

Four experiments examined whether 3-year-olds' comprehension of pronouns was affected by the discourse prominence of the possible antecedents. In each experiment, children listened to short stories. The final (test) sentence of each story differed in whether it continued the grammatical subject (and first-mentioned character) established in prior sentences or shifted to a new one, and whether it had a pronoun or a lexical noun phrase subject. We assessed comprehension by measuring accuracy in an elicited imitation task (Experiment 1), and responses in a looking-preference comprehension task (Experiments 2–4). Both measures revealed a continued-subject bias in the interpretation of pronouns: Children tended to interpret a pronoun as coreferential with the subject (and first-mentioned character) in the preceding context. Thus young children's comprehension of a sentence is affected not only by knowledge of its words and syntactic structure, but also by the prominence of each referent in a representation of the discourse; referent prominence is affected by some of the same factors that affect coreference processing in adulthood. These findings suggest considerable continuity in the basic architecture of the sentence processing system throughout development.

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Introduction

Language is full of ambiguity. Example (1) illustrates the use of ambiguous referring expressions so wide-

spread in conversation and text. This passage contains a number of pronouns used to refer to multiple characters, and a verb phrase with an omitted subject (*and at once set to work...*).

- (1) ... Alice... thought it would be as well to introduce some other subject of conversation. *While she was trying to fix on one, the cook took the cauldron of soup off the fire* [italics added], and at once set to work throwing everything within her reach at the Duchess and the baby—the fire-irons came first...

(Carroll, 1872)

If the italicized phrases in (1) were encountered in isolation, *she* would be interpreted as *the cook*; in (1), however, it is clear *she* is *Alice*. The ubiquity of

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pronouns and noun phrase omission guarantees that most sentences are difficult to understand without integrating information across sentences. How do children learning their first language cope with all this ambiguity? In this paper we focus on 3-year-old children's interpretation of pronouns, exploring the possibility that young children's pronoun interpretation is influenced not only by the syntax and meaning of the sentence containing the pronoun, but also by the prominence of candidate referents in the discourse context.

Reference resolution within sentences

Most studies of the development of pronoun interpretation have examined sensitivity to the syntactic constraints that limit coreference within rather than across sentences (e.g., Avrutin, 1999; Grimshaw & Rosen, 1990; Lust, 1981; Manzini & Wexler, 1987; Solan, 1983). Languages typically have two classes of anaphoric elements: pronouns (e.g., *she*, *her*) and reflexives (e.g., *herself*). These are linked with different sets of antecedents, as shown in (2).

- (2) Alice_i looked at herself_i in the mirror.
 *Alice_i looked at her_j in the mirror.

The coreference patterns of pronouns and reflexives are described by the principles of Chomsky's Binding Theory, which depend on the hierarchical syntactic relation *c-command* (Chomsky, 1981; Reinhart, 1983). In essence, these principles state that pronouns cannot be bound to an antecedent that is structurally more prominent (higher in the syntactic structure) or equally prominent within a structurally defined local domain, while reflexives require a local antecedent that is more or equally prominent. These principles accurately predict naïve adults' judgments of coreference for pronouns and reflexives (e.g., Gordon & Hendrick, 1997).

Many experiments have found that children as young as 3 years of age are sensitive to these syntactic constraints on the possible antecedents of pronouns and reflexives (e.g., Avrutin, 1999; Grimshaw & Rosen, 1990; Lust, 1981; Manzini & Wexler, 1987). Though the origin of this sensitivity remains controversial, such findings imply that the representation of sentences as hierarchically structured, and the use of that structure to guide sentence interpretation, are natural and early features of language comprehension (see also Lidz & Musolino, 2002).

Reference resolution across sentences

Syntactic restrictions on within-sentence coreference are not sufficient to solve the difficulties in example

(1). The binding principles demand disjoint reference for pronouns in (2), but say nothing about where to seek an antecedent outside the sentence. Adults use many sources of information to determine the referents of pronouns. These include both linguistic information, such as definiteness, gender and number, and non-linguistic information, such as plausibility considerations mediated by background knowledge and by knowledge of the situation (e.g., Arnold, Eisenband, Brown-Schmidt, & Trueswell, 2000; Clark & Haviland, 1977; Garnham, 2000; Heim, 1982; Kintsch, 1988; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995).

To account for the intricacies of reference resolution in context, formal semanticists have proposed that each sentence is interpreted relative to a propositional representation of the current state of the discourse, and aspects of the situation relevant to it (e.g., Heim, 1982; Kamp & Reyle, 1993). These formal semantic views of a discourse universe are similar to the propositionally encoded mental models developed in the psychological literature (e.g., Bock & Brewer, 1985; Garnham, 2000; Haviland & Clark, 1974; Johnson-Laird, 1983; Kintsch, 1988). For example, Kamp and Reyle's (1993) Discourse Representation Theory proposes that listeners incrementally construct a semantic representation that includes a set of discourse referents. Each noun phrase triggers the addition of a new discourse entity; a definite noun phrase or pronoun triggers an equivalence rule that requires the newly added entity to be identified with a gender- and number-matched referent already introduced into, or implied by, the discourse representation.

A propositionally encoded discourse representation provides a natural way to account for inferences combining discourse-provided information with background knowledge or aspects of the referential context. Many of the sources of information that affect reference resolution by adults or children can be accounted for within these models. For example, 3–4-year-olds give evidence that they can make appropriate inferences from the use of indefinite versus definite noun phrases (*a dog* vs. *the dog*; Maratsos, 1976), and use gender and number to resolve pronoun reference (Arnold, Brown-Schmidt, Trueswell, & Fagnano, in press; Gelman & Raman, 2003). Five-year-olds also show some ability to use information in previous sentences to infer the plausible referents of ambiguous pronouns. For example, the underlined verbs in (3) and (4) require different inferences about who has the pencil (Jane in (3) and Susan in (4)), and thus who can *give* it in the second sentence. Wykes (1981, 1983) reported that 5-year-olds (correctly) chose Jane as the giver more often in enacting (3) than (4).

- (3) Jane_i found Susan's pencil. She_i gave it to her.
 (4) Jane wanted Susan's_j pencil. She_j gave it to her.

In all of these arenas, young children are less reliable than older children and adults in making use of the relevant cues (e.g., Avrutin, 1999; Hickmann, 2002; Maratsos, 1976; Menig-Peterson, 1976; Piaget, 1955; Wykes, 1981, 1983). Nevertheless, evidence that young children show some sensitivity to definiteness, pronoun number and gender, and plausibility in reference resolution, suggests that they use their representation of the preceding discourse in sentence interpretation. To infer that *the dog* is the same dog mentioned in a prior sentence, while *a dog* is probably a different dog (Maratsos, 1976), children must interpret each sentence relative to a semantically interpreted representation of what has been said, and employ different procedures for linking definite and indefinite noun phrases into that representation.

Prominence ranking in the discourse representation

The formal semantic models discussed in the previous section leave out an important dimension of discourse structure. People use a definite pronoun to refer, not to just any discourse entity that matches it in gender and number, but to one that is *prominent* or salient in the discourse (e.g., Ariel, 2001; Brennan, 1995; Clancy, 1980; Fletcher, 1984; Givón, 1983; Gundel, Hedberg, & Zacharski, 1993; Marslen-Wilson, Levy, & Tyler, 1982; Prince, 1992). In comprehension, adults find it easier to interpret a pronoun, but not a lexical noun phrase subject, as coreferential with a prominent entity in the local discourse structure (e.g., Clifton & Ferreira, 1987; Fletcher, 1984; Gordon, Grosz, & Gilliom, 1993; Hudson-D'Zmura & Tanenhaus, 1998).

Many factors influence referent prominence, as reflected in coreference processing by adults. These include syntactic or surface features of sentences such as grammatical function (Gordon et al., 1993; Gordon & Hendrick, 1997; Walker, Joshi, & Prince, 1998), order of mention (e.g., Gernsbacher & Hargreaves, 1988; Gordon et al., 1993; MacWhinney, 1977; McDonald & MacWhinney, 1995), pronominalization, and pitch accent (e.g., Clancy, 1980; Jescheniak, 2000; Levy, 1982). Semantic or pragmatic factors can also influence discourse prominence, including animacy (e.g., Prat-Sala & Branigan, 2000), verb semantics (e.g., Arnold, 2001; Caramazza, Grober, Garvey, & Yates, 1977; McKoon, Greene, & Ratcliff, 1993; Stevenson, Knott, Oberlander, & McDonald, 2000), centrality to the global purpose of the discourse (e.g., Brennan, 1995; Clancy, 1980; Grosz, Joshi, & Weinstein, 1983), and marked episode boundaries (e.g., 10 years later; Fowler, Levy, & Brown, 1997; Marslen-Wilson et al., 1982).

To account for effects of discourse prominence on coreference processing, Gordon and Hendrick (1998) proposed a modification of Kamp and Reyle's (1993) Discourse Representation Theory, incorporating insights from Centering Theory (e.g., Brennan, 1995;

Gordon et al., 1993; Grosz et al., 1983). In the modified framework, Discourse Prominence Theory, discourse entities are ranked in prominence, and their prominence affects the order in which they are considered as antecedents for pronouns. This framework focuses on *grammatical role* and *order of mention* as factors determining referent prominence. Noun phrases in syntactically prominent positions or early in the sentence make their referents more accessible for later reference. Entities made prominent in this way can be described as the local focus or center of attention (e.g., Garrod & Sanford, 1994; Gordon et al., 1993; Grosz & Sidner, 1986; Walker et al., 1998). The form of an anaphoric reference signals how focused its antecedent should be: Pronouns or noun phrase ellipsis are assumed to maintain reference to already highly prominent entities, whereas more specific referential forms, such as lexical noun phrases, indicate a shift in focus.

A substantial body of supporting evidence for this framework—especially the prominence of subjects—can be found in the psycholinguistic literature. Subject referents are more accurately recalled in a sentence memory task (e.g., Clark & Card, 1969), and more likely to be mentioned again in subsequent sentences (Arnold, 1998; Givón, 1983). A repeated referent tends to be realized as a subject pronoun if it was the grammatical subject of the previous sentence (e.g., Brennan, 1995; Clancy, 1980; Crawley & Stevenson, 1990; Fletcher, 1984; Givón, 1976; Marslen-Wilson et al., 1982; Prince, 1992). In comprehension, adults find it easier to interpret a subject pronoun as coreferential with the preceding sentence's subject (e.g., Arnold et al., 2000; Crawley & Stevenson, 1990; Gordon et al., 1993; Stevenson, Nelson, & Stenning, 1995). Comprehension is slowed if a lexical noun phrase, rather than a pronoun, refers to an antecedent that was the subject of the preceding sentence; this *repeated-name penalty* occurs whether or not the antecedent subject phrase was the first noun phrase in its sentence (e.g., Gordon et al., 1993).

Subject role is confounded with word order in most of the research cited above (but not all; e.g., Gordon et al., 1993). Most theorists assume, however, that surface order, independent of grammatical role, affects referent prominence (e.g., Gernsbacher, 1990; Walker & Prince, 1996). An advantage for first-mentioned entities is routinely found in experiments using a probe-word recognition task to examine the activation level of various referents (e.g., Gernsbacher & Hargreaves, 1988; Gernsbacher, Hargreaves, & Beeman, 1989; MacWhinney, 1977; McDonald & MacWhinney, 1995), and in explicit coreference judgments for sentences with ambiguous pronouns (e.g., *Jean and Penelope asked Peter to make an effort and she.*; Stevenson et al., 1995). Readers also exhibit a repeated-name penalty for noun phrases whose antecedents were in sentence-initial modifier phrases (e.g., *In her opinion.*; Gordon et al., 1993).

Other findings suggest that grammatical parallelism across sentences, in addition to referent prominence, affects coreference processing. Chambers and Smyth (1998; see also Stevenson, Nelson, & Stenning, 1995) found a repeated-name penalty in comprehension for direct object noun phrases if their antecedents were direct objects in a syntactically and semantically parallel previous sentence. The finding that a referent can be most accessible for a particular grammatical role suggests that the processing systems for language production and comprehension link grammatical role and referent information and then gain a benefit for subsequent processing if that linking remains the same (e.g., Bock, Loebell, & Morey, 1992).

Children's sensitivity to discourse prominence: Two predictions

Thus, for adults, pronouns are most easily interpreted as coreferential with prominent discourse referents, and both grammatical role and order of mention influence referent prominence. The present research asks whether young children show similar systematicity in their interpretation of pronouns: Do young children treat subjects or first-mentioned noun phrases as more prominent than others in computing pronominal reference? Different theoretical stances on the architecture of the language processing system suggest different predictions on this question.

One prediction is derived from a *cue-competition* view of early language processing. This view holds that each linguistic regularity should be learned in a sequence predictable from its validity as a predictor (and thus its detectability in the input), and should be weighted in the language processing system in proportion to both the validity and the salience of the cue (e.g., Bates & MacWhinney, 1989; Hanna, Tanenhaus, & Trueswell, 2003; Nadig & Sedivy, 2002). This view suggests that children should be slow to develop sensitivity to discourse prominence cues, because of their low *cue validity*. Arnold et al. (in press) pointed out that subject status or order of mention can only be fairly weak predictors of pronoun reference, in the context of other strong influences on pronoun use and interpretation such as pronoun gender and semantic content. In a sample of children's books, for example, Arnold (1998) found that only a modest majority (64%) of subject pronouns referred to the subject of the preceding clause. Given the relative unreliability of grammatical role and order as cues to pronoun reference, Arnold et al. (in press) argued that it should take children a long time to learn that they predict pronoun reference at all, and that these cues, even once learned, should be weighted weakly in a multiply constrained comprehension system, compared to more reliable cues such as pronoun gender.

A different prediction can be derived from theoretical considerations suggesting that cue validity and salience, though important features of any theory of learning from input, are not the only determinants of developmental sequence. In particular, the effects of syntactic structure or order of mention on discourse prominence may not be arbitrary cues to be detected in the input, but instead may be natural products of: (a) processes involved in sentence comprehension, or (b) sentence memory; each factor is discussed in turn. We will call this the *natural prominence* view.

First, many linguistic analyses propose a general notion of semantic prominence that determines the linking of verbs' arguments with grammatical functions like subject and object. A long-standing consensus in linguistic theory is that semantic roles that are higher in a hierarchy of thematic roles are assigned to more prominent syntactic positions (e.g., Jackendoff, 1990). Other formulations propose a distinction between two macro-roles: For example, Dowty (1991) proposed a Proto-Agent/Proto-Patient continuum, in which the argument of a transitive verb with more of the semantic properties of a Proto-Agent is linked to subject position. Properties contributing to Proto-Agency include volition, sentience, causation, and movement. Aissen (1999; following Legendre, Raymond, & Smolensky, 1993) proposed that dimensions of syntactic (subject > object) and semantic prominence (e.g., proto-agent > proto-patient; contextually accessible > inaccessible) should be aligned harmonically, with structurally prominent sentence positions expressing semantically prominent roles. Suggestions that subjects are more "in perspective" than objects (e.g., Clark, 1990; Fillmore, 1977; Kuno, 1987; Talmy, 1983) appeal to a related general notion of semantic prominence. These accounts differ greatly in their theoretical assumptions, but share the fundamental insight that the syntactic prominence of subjects corresponds to an abstract semantic or thematic-role prominence.

If this is so, then children might not have to learn that syntactic subjects should be treated as relatively prominent in a semantically interpreted discourse representation. Instead, the prominence of subject referents in a propositionally encoded discourse representation might follow naturally from their prominence in the meaning of each sentence. Notice that this argument requires two additional assumptions, discussed above: that young children interpret sentences (a) in accord with a syntactic structure in which subjects are prominent, and (b) relative to a semantically interpreted representation of the discourse, along the lines described by formal semantic or mental model accounts of discourse representation (e.g., Garnham, 2000; Gordon & Hendrick, 1998; Heim, 1982; Kamp & Reyle, 1993; Kintsch, 1988).

Second, some commentators have proposed that effects of order on discourse prominence could follow

from quite general features of memory for sequentially presented information. Gernsbacher (1990; see also MacWhinney, 1977) argued that the first-mention advantage in sentence processing follows from the incremental construction of representations of sentence meaning: Earlier referential elements provide a context for the encoding of later elements. Thus order itself, independent of a syntactic analysis, may affect the representation of utterances in memory, causing early referential phrases to be represented more prominently than later ones. If this is so, then children may not need to learn to treat first-mentioned elements in sentences as more prominent or accessible for later reference.¹

In sum, whereas a cue-competition view of early language processing predicts that sensitivity to discourse prominence cues in pronoun interpretation should develop slowly due to their low cue validity, the natural prominence view just described predicts that children might show early sensitivity to discourse prominence. If syntactic subjects are interpreted in part as playing semantically prominent roles, and if initial phrases are more prominent in an incrementally constructed memory representation, then subject status and order of mention might naturally affect discourse prominence, without having to be separately detected as cues to pronoun interpretation.

Developmental evidence of sensitivity to discourse prominence

Studies of early language production show that young speakers' referential choices depend on the structure of the prior discourse (e.g., Hickmann & Hendriks, 1999; MacWhinney & Bates, 1978). For example, 2-year-olds learning Inuktitut or Korean omitted noun phrases less often for new referents than for those recently mentioned (Allen, 2000; Clancy, 1997). Children as young as 4, like adults, treat subject (or initial) noun phrases as more prominent for later reference. In elicited narratives produced by children learning English,

French, German, or Chinese, a referent established as grammatical subject was more likely to appear as subject of the next clause, and these continued subjects tended to be pronominalized or omitted (Hickmann & Hendriks, 1999; see also Clancy, 1992).

These local discourse-structure influences on pronominalization and ellipsis are modulated by global semantic factors, as they are for adults. In spontaneous narratives from children as young as 3, pronouns or ellipsis were more often used for the hero of the story than for a secondary character (Gomme & Johnson, 1997). French-speaking 6-year-olds used pronouns almost entirely for the main character (Karmiloff-Smith, 1981), and reduced their use of pronouns for highly focused referents when crossing episode boundaries in a story (Hickmann, Kail, & Roland, 1995).

In sum, although full competence in the use of linguistic form to reflect information status in narrative takes a long time to develop, comparisons of children's productions across discourse contexts show that even very young children are influenced by local discourse structure in their choice of referential forms (e.g., Hickmann, 2002). Given evidence of sensitivity to discourse prominence in children's speech, we might expect to find the same in their comprehension. However, the evidence from comprehension has been mixed.

Some findings are consistent with the hypothesis that by 5 years of age children treat some discourse entities as more prominent than others in their comprehension of pronouns. For example, in a mispronunciation detection task, 5-year-olds more rapidly interpreted pronoun-subject sentences when the antecedent of the pronoun had been established as a clear topic (Tyler, 1983). In addition, in the pronoun interpretation study by Wykes (1983) mentioned above, 5-year-olds more accurately assigned a plausible antecedent to a subject pronoun when that antecedent had been the first noun phrase in the preceding sentence. Choices were most accurate when the plausible antecedent was both the subject and sentence-initial.

Other recent findings suggest limitations in preschoolers' sensitivity to local information structure in sentence comprehension. Arnold, Novick, Brown-Schmidt, Eisenband, and Trueswell (2001) tracked 5-year-olds' eyes while they looked at pictures described by sentence pairs as in (5). Like adults, children quickly fixated the referent of a pronoun subject if gender made it unambiguous. When gender was uninformative, however, children's visual fixations did not converge on the referent of the pronoun until the children heard disambiguating words later in the sentence (e.g., in (5) only one pictured character was seated on a rock), showing little or no sign of a subject or first-mentioned bias in pronoun interpretation. Arnold et al. (in press) found similar results in an off-line comprehension task with 3.5–4.5-year-olds.

¹ The evidence for an effect of surface order on adult pronoun interpretation, independent of syntax, is mixed. Different tasks have tended to reveal systematically different findings: Experiments using a probe-word recognition task yield strong effects of surface order (see Gernsbacher, 1990; for a review), while experiments using a whole-sentence reading-time measure do not (Gordon, Hendrick, Ledoux, & Yang, 1999; with the exception of preposed adjunct phrases such as *In her opinion*; Gordon et al., 1993). These mixed results may stem from the difficulty of teasing apart syntactic, sequential, and semantic factors in sentences. Given all these findings, it seems likely that sequential order plays some role in promoting discourse prominence, but further research using multiple methods will be required to determine the nature of the order effect.

- (5) Mickey is reading a story to Donald (Daisy) under a big tree outside.
He (She) is sitting on a rock.

The present research

The evidence reviewed above tells us that children's language production is affected by some of the same local structural or sequential factors that operate in adult language use. Subject or first-mentioned referents are more likely to be mentioned as subjects again, and to appear in a relatively reduced form, much as they are in adults' speech (e.g., Hickmann & Hendriks, 1999). However, we know much less about when and how the language comprehension system begins to exploit discourse prominence cues in pronoun interpretation. In contexts in which adults show a robust subject-assignment or first-mention bias in pronoun interpretation, a similar bias has been found in preschoolers in some studies (e.g., Wykes, 1983), but not in others (Arnold et al., 2001; in press). The comprehension data therefore do not unequivocally support either of the two predictions we sketched above. The present research begins to fill this gap, by looking for effects of discourse context on 3-year-olds' comprehension of pronouns.

We hypothesized that the effect of local discourse structure on young children's comprehension might be more consistently seen with very simple stories, and with a stronger discourse manipulation in which multiple sentences establish one character's prominence. The experiments used an elicited imitation task (Experiment 1) and a looking-preference comprehension task (Experiments 2–4) to measure children's comprehension of sentences presented in a story context.

In Experiments 1 and 2, each test sentence followed three context sentences in which one of two characters was more prominent because it was: (a) first in all three sentences, (b) the subject of two sentences, and (c) realized once as a pronoun. The two characters were both mentioned in each context sentence, so that sheer frequency of mention did not differentiate them. The final (test) sentence of each story either continued the grammatical subject established in the prior sentences or shifted to a new one, and had either a pronoun or a lexical noun phrase subject. The structure of these stories is similar to those used by Gordon et al. (1993) to explore the effect of local discourse structure on adults' language comprehension. If the discourse cues manipulated in these sentences influence referent prominence in young children's representations of the story as they do in adults', we should find that children more easily understand test sentences that continue the established subject rather than switching to a new one; this preference should make continued-subject pronouns easier to understand than shifted-subject pronouns. In Experi-

ments 3 and 4, we systematically reduced the discourse support for a continued-subject interpretation, to test the robustness of 3-year-olds' sensitivity to discourse structure.

Experiment 1

Elicited imitation is a task often used to study children's comprehension of words and sentences (e.g., Church & Fisher, 1998; Gerken, Landau, & Remez, 1990; Tyler & Marslen-Wilson, 1978), and evidence suggests that, for adults and young children, immediate sentence recall involves the ordinary processes of both sentence comprehension and production (Potter & Lombardi, 1990). Thus, in Experiment 1 we asked whether 3-year-old children found it easier to comprehend and then repeat sentences that followed more coherently from their contexts.

To ensure that our materials had the intended structure, we pre-tested them on adults in a self-paced reading task modeled on the one used by Gordon et al. (1993), and in a comparable self-paced listening task adapted from Kjelgaard and Speer (1999). The self-paced listening task used the same materials we recorded for the children, to ensure that none of the decisions we made in recording the sentences (e.g., about intonation) altered the intended discourse structure. We will describe the adult self-paced reading and listening studies briefly first (Experiment 1A), and then the children's elicited imitation task (Experiment 1B).

Experiment 1A

Method

Participants

Forty-eight college-aged native speakers of English participated in exchange for course credit or for a small payment; 24 (14 male, 10 female) were tested in the reading task and 24 (12 male, 12 female) in the listening task. One subject in the reading task was replaced due to low accuracy in answering comprehension questions (fewer than 80% correct).

Stimuli and design

Thirty-two stories were constructed with the structure illustrated in Table 1; one additional story was used as a practice trial. The first three sentences of each story were the context sentences; the fourth was the test sentence. Four versions of each story were constructed, such that the test sentence either *continued* the subject of the preceding context or *shifted* to a new subject, and the subject of the test sentence was realized as a *pronoun* or as a repeated *lexical noun*. Subject continuity

Table 1
Structure of stimulus stories, Experiment 1

	Continue	Shift
Context	Meet <i>the crocodile</i> and the toad <i>The crocodile</i> went on vacation with the toad And <i>she</i> swam in the sea with the toad	Meet the toad and <i>the crocodile</i> The toad went on vacation with <i>the crocodile</i> And she swam in the sea with <i>the crocodile</i>
Target	<i>She/The crocodile</i> walked along the beach with the toad (pronoun vs. noun)	

was manipulated by changing the context sentences (see Table 1); thus the test sentences were the same for the continue and shift versions. Each test sentence contained three content words other than the subject noun phrase (e.g., {The crocodile/She} *walked* along the *beach* with the *toad*); mean test sentence length was 7.03 words (range 5–9).

The 32 stories were divided into four subsets of eight items, with content words in test sentences matched across subsets on number of syllables and initial consonant, and roughly matched in frequency (Carroll, Davies, & Richman, 1971; Francis & Kucera, 1982) and appearance in young children's speech (Fenson et al., 1994). These subsets were combined to create four lists, such that each story occurred in all conditions across participants and each participant experienced one subset of eight stories in each condition. Stories were randomly ordered within each list, with the constraints that two stories in each of the four conditions appeared in each quarter of the list and no more than two stories from the same condition appeared in a row. These constraints were not applied in the self-paced reading task; instead, the items were simply presented in a random order.

The stories were digitally recorded in a sound-attenuated booth. The materials were spoken by a female native English speaker in a child-directed style. All context sentences were recorded first, then all test sentences, in a random order. Half of the continue-condition contexts were recorded before the corresponding shift-condition contexts, and half of the noun-subject test sentences were recorded before their pronoun-subject counterparts.

In recording the stories, a decision had to be made about where stress peaks should occur. In the first two context sentences, all of the nouns were relatively stressed (e.g., Meet the *crocodile* and the *toad*. The *crocodile* went on *vacation* with the *toad*). In the third context and test sentences, the verb and the object (object of the verb or a preposition) were stressed relative to both the subject and non-subject characters (e.g., {The crocodile/She} *walked* along the *beach* with the toad). To determine whether the test sentences displayed the intended stress patterns, the test sentences were played in a random order to 7 judges. The judges circled the word that they thought was most emphasized in each sentence. Additional sentences recorded for a replication

experiment (see below) were interleaved with these items, and rated in the same session. Each content word was assigned a stress score equal to the proportion of judges who selected that word as the most stressed in its sentence. As intended, the perceived stress profiles of the pronoun- and noun-subject sentences were highly similar. In both pronoun- and noun-subject test sentences, the subject (pronoun: 0% of 224 judgments, noun: 0.4%) and non-subject characters (pronoun: 0.4%, noun: 0.4%) were almost never judged as stressed relative to the verb (pronoun: 28.6%, noun: 24.1%), and the object (pronoun: 70.5%, noun: 74.6%).

A comprehension question was constructed for each story for use in the adult pretests only. Six of the eight questions in each condition concerned the test sentence, and two concerned context sentences. Half of the questions would be correctly answered "yes," half "no."

Procedure

The self-paced reading and listening tasks were run using the Psyscope software (Cohen, MacWhinney, Flatt, & Provost, 1993) and button box. Participants sat in front of a computer with the dominant hand on the response box. They were asked to read (self-paced reading) or listen to (self-paced listening) the sentences carefully, so that they could answer questions about them.

In the *reading task*, the stories were presented one sentence at a time on the computer screen. At the start of each trial, a plus sign appeared at the left edge of the screen. When the participant pressed the middle response button (of 3), labeled "next sentence," the first sentence appeared beginning where the plus sign had been. Participants pressed the same button as soon as they understood the sentence; the next sentence appeared immediately in the same position. Reading times for test sentences were measured from the onset of the test sentence display.

In the *listening task*, recorded stories were played one sentence at a time over headphones. No written sentences were presented. A ready signal appeared on the computer screen before each story began. Participants pressed the middle response button to begin, and pressed the same button as soon as they understood each sentence. The next sentence began immediately. Listening times were measured from test sentence onset.

At the end of each story, subjects answered a visually presented comprehension question by pressing the right- or left-most buttons on the button box, labeled “Yes” and “No.” In both tasks, subjects began with one practice trial.

Test-sentence reading or listening times more than two standard deviations from the mean for each subject were treated as missing in the analyses (5.3% of test sentence response times).

Results

Mean comprehension times for the test sentences, along with accuracy and response time data for the comprehension questions, are shown in Table 2. As the table shows, subject continuity (continue versus shift) and lexical form (pronoun versus noun subject) influenced comprehension times in both the reading (Table 2a) and listening tasks (Table 2b). Sentences that continued the subject of the preceding story were understood more quickly if they had pronoun rather than lexical noun subjects, but this pattern disappeared or was reversed for test sentences that shifted to a new subject. These patterns were tested in 2 (subject continuity) \times 2 (lexical form) ANOVAs conducted by subjects and by items, separately for the reading and listening tasks. Both tasks showed strikingly similar results.

Self-paced reading

Participants were quicker to read and understand continued- than shifted-subject sentences ($F(1, 23) = 28.31, p < .001$; $F(1, 31) = 118.48, p < .001$). Pronoun- and noun-subject sentences did not differ in overall reading times ($F(1, 23) = 1.64, p > .20$; $F(1, 31) < 1$), but there was an interaction of subject continuity and lexical form ($F(1, 23) = 18.77, p < .001$; $F(1, 31) = 19.42,$

$p < .001$). Planned 2-tailed t -tests showed that subjects read continue-pronoun sentences faster than continue-noun sentences ($t(23) = 4.19, p < .001$; $t(31) = 3.28, p < .01$). This difficulty with noun subjects in continued-subject sentences is the repeated-name penalty found in many text comprehension studies (e.g., Gordon et al., 1993). In contrast, adults understood shift-pronoun sentences more slowly than shift-noun sentences ($t(23) = 2.44, p < .05$; $t(31) = 2.73, p < .05$). In addition, continued-subject test sentences were read more quickly than shifted-subject sentences whether they had noun ($t(23) = 2.47, p < .05$; $t(31) = 2.61, p < .05$) or pronoun ($t(23) = 6.04, p < .001$; $t(31) = 11.14, p < .001$) subjects.

Because pronoun- and noun-subject sentences differed in length, we conducted analyses on reading times adjusted for these length differences. Pronoun-subject sentences averaged 27.1 characters in length (range 20–36, excluding spaces), and noun-subject sentences averaged 31.5 characters (range 21–43). Following Ferreira and Clifton (1986), we computed the best linear fit between sentence length and reading time for each subject, then subtracted the regression-predicted reading times from the raw reading times. This correction is designed to remove all linear variance related to sentence length. Reading times adjusted in this way showed the same patterns of significant results as the analyses of raw reading times reported above.

Self-paced listening

Similar results were found in the self-paced listening task. Adults were quicker to comprehend continued- than shifted-subject sentences ($F(1, 23) = 46.18, p < .001$; $F(1, 31) = 73.34, p < .001$), and pronoun- than noun-subject sentences ($F(1, 23) = 8.17, p < .01$; $F(1, 31) = 5.88, p < .05$); subject continuity interacted with lexical

Table 2
Mean (SE) target sentence response times (msec), and accuracy and response times for comprehension questions, Experiment 1A

	Target sentences	Comprehension questions	
	Response time	Accuracy (%)	Response time
<i>(a) Self-paced reading task</i>			
Continue-noun	2433.86 (157.14)	97.2 (1.3)	2475.67 (170.57)
Continue-pronoun	2075.45 (109.39)	95.8 (1.5)	2406.87 (140.26)
Shift-noun	2688.75 (161.29)	95.8 (1.5)	2778.92 (203.36)
Shift-pronoun	2903.58 (167.00)	86.1 (2.8)	2916.63 (241.55)
Average	2525.41 (80.52)	93.8 (1.0)	2644.52 (97.22)
<i>(b) Self-paced listening task</i>			
Continue-noun	3033.63 (54.22)	95.0 (1.6)	2435.87 (157.07)
Continue-pronoun	2808.18 (57.28)	98.6 (1.0)	2553.97 (124.72)
Shift-noun	3191.79 (64.85)	96.5 (1.4)	2521.48 (142.38)
Shift-pronoun	3220.84 (79.76)	92.3 (2.2)	2827.33 (160.07)
Average	3063.61 (36.03)	95.7 (1.0)	2584.66 (73.75)

form ($F(1, 23) = 13.32, p < .01; F(1, 31) = 14.78, p < .001$). Participants more quickly understood pronoun- than noun-subject sentences in the continue condition ($t(23) = 5.35, p < .001; t(31) = 4.63, p < .001$), but not in the shift condition ($t < 1$). Continued-subject sentences were again more quickly understood than shifted-subject sentences whether they had noun ($t(23) = 2.78, p < .05; t(31) = 4.02, p < .001$) or pronoun subjects ($t(23) = 7.91, p < .001; t(31) = 7.96, p < .001$).

Spoken noun-subject sentences were longer (mean 2503 ms, range 2027–3048) than pronoun-subject sentences (mean 2233 ms, range 1967–2544). Therefore, listening times were corrected for length differences between conditions as described above, except that listening times were predicted from sentence length in seconds rather than in characters. As in the analyses of raw listening times, the analysis of adjusted listening times revealed significant effects of subject continuity and lexical form and a significant interaction of these two factors.

Discussion

These data confirmed that our stories elicited the intended patterns of comprehension ease and difficulty in adults, both in reading and in listening. Though both characters were mentioned equally often, each story made one character more prominent by placing it first, in subject position, and referring to it with a pronoun. A test sentence was easier to understand if it placed this prominent character in subject position. Moreover, as expected, the ease of interpreting noun versus pronoun subjects depended on subject continuity. Sentences that continued an established subject were easier to understand if they had pronoun subjects, while those that shifted to a new subject were easier to understand if their subjects were lexical noun phrases.

Experiment 1B

Do preschoolers, like adults, expect story characters singled out by first mention, subject status, and pronominalization, to appear as the subject of the next sentence? In particular, do children expect a pronoun to refer to the most prominent character? If children more easily comprehend sentences that adhere to this common pattern, then we should expect this differential ease of comprehension across discourse contexts to be reflected in the accuracy with which they repeat the test sentences.

Method

Participants

Twenty-four 3-year-olds ($M = 39.3$ months; range 34.9–42.1; 12 boys, 12 girls), and 24 3.5-year-olds ($M = 46.6$ months; range 44.6–47.9; 13 boys, 11 girls)

participated in the experiment. All were native speakers of English. Families were recruited through a subject file based on birth announcements in a local newspaper. The children received a book and stickers as thanks for their participation. Seventeen additional children were tested but not included because they consistently tried to repeat context as well as test sentences (2 3.5-year-olds), or did not provide enough responses (10 3-year-olds, 5 3.5-year-olds; children who did not respond to the first eight items or ended the task before the last eight items were presented were not included).

Stimuli

The children heard the same recorded stories described in Experiment 1A. Supporting pictures were constructed for the context sentences in each story. Each picture showed both characters, with the left–right position of subject and non-subject characters counterbalanced across conditions. There were no supporting pictures for the test sentences; instead, a large, colorful question mark accompanied the test sentences. The pictures were edited into a video; the stories were recorded onto the soundtrack of the video.

Procedure

Each child watched a video with 33 short stories; the first was a practice trial. Children were told that they would see pictures on a video and hear a story about them, and that a toy bear wanted to listen but sometimes missed things. The children were instructed to tell the bear what they had just heard when he asked. The experimenter started the video, and the child heard the context sentences while watching the supporting pictures. At the end of each story, a question mark appeared on the video screen and the test sentence played. The experimenter paused the video with the question mark visible, and prompted the child to repeat the test sentence. Children got a sticker as a reward for each response. If necessary, the experimenter demonstrated the task in the practice trial. Responses were audio-recorded. The session lasted about 30–40 min.

Coding

The children's responses were transcribed using the International Phonetic Alphabet. Two listeners transcribed and coded all responses using the coding categories defined below, and a third listener settled any disagreements.

Character order accuracy. The order of mention of the two characters was coded as correct or incorrect, independent of pronunciation accuracy. Order was considered correct if the coder could identify an attempt to repeat one character's name and at least one other content word or preposition, and if these two attempts appeared in the correct relative order. If the child

misordered the character names or misplaced one character name relative to another content word or preposition, the attempt was coded as incorrect. Character order was also coded as incorrect if the child's response included no identifiable attempts at either character, or only a pronoun and no reference to the other character. This measure served as a composite measure of repetition accuracy, dependent on the child's ability to produce recognizable imitations of multiple words in the test sentence, and to sequence them correctly.

Character order reversals. We also noted whether children overtly reversed the order of the two character names, rather than simply failing to repeat them. Character order was coded as reversed if an identifiable attempt at a character's name appeared in the wrong position relative to another identifiable content word or preposition. Reversing the order of the characters in the shift condition would suggest that children misunderstood the test sentences as following more coherently from the context sentences.

Second character accuracy. We also coded character name accuracy, since confusion about the referents of noun phrases might be revealed in difficulty accurately encoding and repeating the characters' names. This led to a focus on the second, non-subject character name, since this word (unlike the subject) was the same in all four conditions. Each test sentence was scored for the accuracy of the second character's name, independent of its position. An attempt was coded as correct if it included no more than one of the following errors: (a) omitting or replacing one target phoneme or (b) omitting an initial or medial unstressed syllable from a multi-syllabic target word. Any change that resulted in a different English word was coded as incorrect. These rules were designed to permit some normal childhood mispronunciation, while maintaining a fairly strict criterion of accuracy. Changing the number of a noun was not considered an error.

Responses from 12 randomly selected children were independently transcribed and coded by a fourth listener. The fourth coder agreed with the results of the 3-pass transcription system on most coding decisions: character order accuracy (92.6%), character order reversal (91.2%), and second character name accuracy (90.9%).

Children understood the task well, making some attempt to repeat the test sentence on most trials, and failing to respond in 121 (7.9%) of the 1536 total trials. Failures to respond were not treated as missing data, but were coded as inaccurate on all measures. Some children (12 3-year-olds and 12 3.5-year-olds) repeated parts of the context sentences as the story played in 73 (4.8%) of the trials. These trials were not dropped from the analysis. Eighty-seven trials (5.7%) were treated as missing due to experimenter error or parental interference.

Results

Our analyses focused on two aspects of repetition accuracy: preservation of character order and accuracy in repeating the second character's name. To preview the findings, both measures revealed effects of subject continuity: Children more accurately repeated sentences that continued the established subject rather than shifting to a new subject. These data did not, however, reveal an interaction of subject continuity and lexical form. Instead, children were generally less accurate in repeating the noun- than the pronoun-subject sentences.

These patterns were tested in 2 (subject continuity) \times 2 (lexical form) repeated measures ANOVAs, by subjects and by items. Preliminary analyses revealed that though 3.5-year-olds were more accurate than 3-year-olds, there were no interactions of age and the factors of interest except in one case noted below. Therefore, for simplicity, the analyses reported here collapse the data across the two age groups. We conducted separate analyses for the 3-year-olds to ensure that story context effects were not carried by the older children. In every case the same pattern of significant results was found for the younger children as for the entire group.

Character order accuracy

Fig. 1 shows the mean proportion of children's responses that preserved the relative order of the two characters. Children more accurately preserved the characters' order when repeating continued- than shifted-subject sentences ($F_1(1, 47) = 15.56, p < .001$; $F_2(1, 31) = 14.29, p < .001$). Children also preserved the characters' order more often in pronoun- than in noun-subject sentences ($F_1(1, 47) = 4.80, p < .05$; $F_2(1, 31) = 4.39, p < .05$). Subject continuity and lexical form did not interact ($F_s < 1$). Character order was correct significantly more often in continued-subject sentences both when they had noun ($t_1(47) = 3.63, p < .001$; $t_2(31) = 2.90, p < .01$) and pronoun ($t_1(47) = 2.13, p < .05$; $t_2(31) = 2.57, p < .05$) subjects.

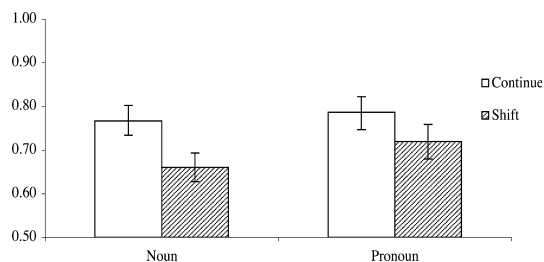


Fig. 1. Mean (SE) proportion responses with character order correct, Experiment 1B.

Character order reversal

As shown in Fig. 2, children overtly reversed the order of the two characters significantly more often in shifted- than in continued-subject sentences ($F(1,47) = 20.01$, $p < .001$; $F(1,31) = 26.15$, $p < .001$). Children also tended to reverse the two characters more often in noun- than in pronoun-subject sentences ($F(1,47) = 6.28$, $p < .05$; $F(1,31) = 3.42$, $p = .07$). The effect of lexical form did not interact with subject continuity ($F(1,47) = 2.96$, $p = .09$; $F(1,31) = 2.99$, $p = .09$; although this interaction approaches significance, note in Fig. 2 that it is not in the predicted direction). Children reversed the characters' order more often in shifted- than in continued-subject test sentences whether they had noun subjects ($t(47) = 4.13$, $p < .001$; $t(31) = 4.37$, $p < .001$) or pronoun subjects ($t(47) = 2.65$, $p < .05$; $t(31) = 2.57$, $p < .05$).

Analyses of reversal errors with age as a factor revealed an interaction of age and subject continuity ($F(1,46) = 5.01$, $p < .05$; $F(1,31) = 5.92$, $p < .05$). The 3- and the 3.5-year-olds showed the same pattern of results, with more reversal errors in shift sentences, but the difference was significantly larger for the 3-year-olds. The effect of subject continuity on reversal errors was significant in separate analyses for both the 3-year-olds ($F(1,23) = 16.18$, $p < .001$; $F(1,31) = 22.14$, $p < .001$) and the 3.5-year-olds ($F(1,23) = 5.54$, $p < .05$; $F(1,31) = 4.70$, $p < .05$).

Second character name accuracy

As shown in Fig. 3, children repeated the second character's name more accurately in continued- than in

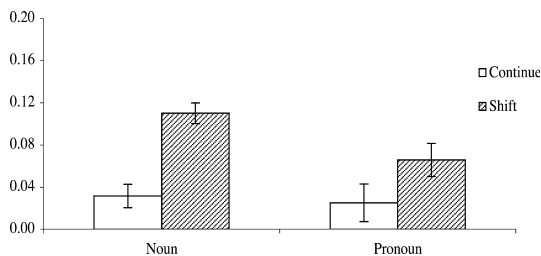


Fig. 2. Mean (SE) proportion responses with character order reversed, Experiment 1B.

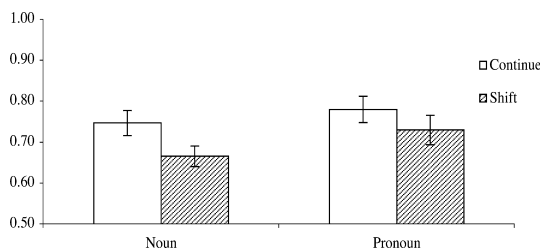


Fig. 3. Mean (SE) proportion responses with second character correct, Experiment 1B.

shifted-subject sentences ($F(1,47) = 6.90$, $p < .05$; $F(1,31) = 8.64$, $p < .01$). Children also tended to repeat the second character's name more accurately in noun- than in pronoun-subject sentences ($F(1,47) = 8.06$, $p < .01$; $F(1,31) = 2.46$, $p = .13$). The effects of subject continuity and lexical form did not interact ($F_s < 1$). The second character's name was repeated significantly more accurately in continued- than in shifted-subject sentences when the subject was a noun ($t(47) = 2.35$, $p < .05$; $t(31) = 2.68$, $p < .05$), but this difference was not significant when the subject was a pronoun ($t(47) = 1.60$, $p = .12$; $t(31) = 1.46$, $p = .15$).

Discussion

Similarities to the adult pattern

Children more accurately repeated sentences that continued the subject of the previous context sentences. The advantage for continued subjects was found in a tendency to more accurately preserve the order of the two characters, and to more accurately repeat the name of the non-subject character, if the test sentence continued the established subject. Children were also more likely to overtly reverse the order of the two characters in the shift than in the continue condition. In other words, they tended to repair the test sentences so that they followed more coherently from their contexts.

These findings reveal an influence of local structural or sequential cues on the relative prominence of story referents in 3-year-olds' representations of a story. Entities that came first in context sentences, were established as grammatical subjects, and were pronominalized, became more prominent. In children's elicited imitations, as in reading- and listening-time measures of adults' comprehension, a test sentence was easier to process if the more prominent character appeared in subject position. These findings are consistent with the early sensitivity prediction sketched in the Introduction—discourse prominence cues, including order and grammatical role, contribute to a prominence ranking in the child listener's representation of a story.

Differences from the adult pattern

We also found one way in which the children's data departed from the adult pattern. For the children, the continued-subject advantage did not depend on whether the test sentence's subject was a lexical noun phrase or a pronoun. Many text comprehension studies, including Experiment 1A, have shown that adults find pronoun subjects easier to understand than lexical noun phrase subjects when the sentence continues the prior subject, but that this pattern disappears or reverses for shifted-subject sentences (e.g., Gordon et al., 1993; Hudson-D'Zmura & Tanenhaus, 1998). The children in our imitation task showed no evidence of the adult interaction between lexical form and subject continuity.

Why did children show no sign of this interaction? We considered that one feature of our stories might have minimized the repeated-name penalty: The lexical subjects in our stories were relatively unstressed, and therefore may have been easier to interpret as continued subjects than stressed lexical subjects would have been. Stressed definite noun phrases cue adult listeners that a less focused or new referent is intended (Dahan, Tanenhaus, & Chambers, 2002). To rule out this possibility, we replicated Experiments 1A (self-paced listening) and 1B (elicited imitation) with new groups of adults and 3-year-olds, using noun-subject test sentences that were recorded with stress on the subject noun phrase; all other sentences were those described above. This change did not materially alter the results (Song & Fisher, 2001). As in Experiment 1A, adults were quicker to understand pronoun- than noun-subject sentences in the continue condition, and showed the reverse pattern in the shift condition.² As in Experiment 1B, 3-year-olds were reliably more accurate in repeating continued- than shifted-subject sentences; this continuity advantage did not depend on subject lexical form. Consistent with this finding, several comprehension studies have found that adult-like sensitivity to stress in interpreting pronouns or other definite noun phrases is a relatively late development (Cutler & Swinney, 1987; Maratsos, 1973; Solan, 1983). Cutler and Swinney (1987) proposed that children only slowly learn to use stress as a cue to semantic focus.

This replication suggests that the absence of an interaction between lexical form and subject continuity in the children's data was not due to our use of relatively unstressed definite noun phrase subjects. Two likely possibilities remain.

First, the repetition task may not be sensitive enough to reveal discourse-based differences in the difficulty of comprehending sentences containing pronouns and nouns. The noun and pronoun-subject sentences differed in their length and corresponding ease of both perception and repetition; uniformly greater difficulty with the longer noun-subject sentences might have made it difficult to detect an interaction of subject continuity and lexical form in this task.

² The only difference in the self-paced listening results of Experiment 1A and the stressed noun phrase replication study was in a lessening of the main effect of continuity. In Experiment 1A, analyses of both reading and listening times revealed that continued-subject sentences were understood more quickly than shifted-subject sentences both when they had pronoun and noun subjects; in the replication study, continued-subject sentences were more quickly understood than shifted-subject sentences only when they had pronoun subjects. This finding is consistent with recent results suggesting that accented noun phrase anaphors cue adult listeners to seek an antecedent that appeared in a different grammatical role in the previous sentence (Dahan et al., 2002).

Second, 3-year-olds may not yet use the form of a definite noun phrase (full noun phrase versus pronoun) to predict its relationship to the prior discourse. While adults use lexical form and stress as cues about where to seek an antecedent for a definite noun phrase, we have no evidence that young children do. We will return to these possibilities in the General Discussion.

Remaining questions

We began by asking: (a) whether young listeners assign differential prominence to discourse referents, based in part on grammatical role and order, and (b) whether children use this prominence ranking to guide pronoun interpretation. The effect of discourse continuity on children's imitation accuracy strongly suggests a positive answer to the first question. As children listened to the stories, they created a representation in which the subject or first-mentioned character was more prominent; this differential prominence or accessibility then affected their accuracy in repeating the test sentence. The evidence on the second question is less clear, however. Children both listened to and repeated the test sentences, raising the possibility that the effect of continuity on imitation accuracy may have been mediated by mechanisms of sentence production. Children might have had difficulty producing sentences with the less prominent character in initial or subject position. Prior evidence reveals effects of discourse prominence on argument realization and grammatical role in children's spontaneous speech. To isolate any effect of discourse prominence on pronoun resolution in comprehension, we need a task that taps comprehension processes without the mediation of sentence production.

Another limitation of Experiment 1 is that the repetition task was an off-line task. Since the task involved a delayed response, it could provide no information about the time course of children's recruitment of discourse context information as each sentence unfolded. Studies of adults' comprehension of written texts have sometimes suggested that readers delay commitments about pronoun reference until disambiguating information arrives; early decisions are observed only when both pronoun gender and referent accessibility make pronoun reference easy to resolve (see Garrod & Sanford, 1994; for a review). A recent study of pronoun interpretation in spoken sentences, however, strongly suggests that adults can make rapid decisions about the likely referents of ambiguous pronouns (Arnold et al., 2000): Listeners' eye movements as they looked at pictures in a referential sentence-verification task showed effects of both pronoun gender and a bias toward subject or first-mentioned antecedents, occurring almost immediately after the pronoun was heard. This result suggests that the adult comprehension system recruits discourse context information incrementally as sentences unfold, seeking to link a pronoun with a prominent antecedent early in the process of understanding a sentence.

Experiments 2–4 addressed these two issues, using a preferential-looking comprehension task to assess children's assignment of referents to pronouns without the mediation of sentence production, as the sentence unfolded. In each experiment, children saw pictures on two video monitors as they listened to stories structured much like those in Experiment 1. While the test sentence played, each video monitor showed one of the two story characters. We measured children's visual fixations to the two pictured characters, to determine whether and when children recruited discourse context cues in their comprehension of an ambiguous pronoun.

In the preferential-looking task, we anticipated a large baseline difference in looking patterns between the pronoun- and noun-subject conditions. When the test sentence had a lexical noun phrase subject, the sentence was unambiguous almost from the start. As soon as the children heard the subject noun, they could look toward the named referent, without first seeking a suitable antecedent in their representation of the story. The pronoun-subject sentences, in contrast, were ambiguous until additional information arrived. Based on the different information available in the two conditions, we predicted that we would see an effect of discourse continuity in the pronoun but not in the noun condition. This pattern might lead to an interaction between subject continuity and lexical form, but not the theoretically meaningful interaction found in adults' comprehension times. Because of this anticipated baseline difference, in Experiments 2–4 we used the noun-subject items essentially as fillers, to reduce the apparent ambiguity of the task and to confirm that children were engaged in the task, but did not compare the data directly with those in the pronoun condition.

Experiment 2

Method

Participants

Twenty-four 3-year-olds ($M = 39.8$ months; range 36.2–42.3; 12 boys, 12 girls) participated. All were native speakers of English. Children received a book as thanks for their participation. Two additional children were tested but not included because of side biases (looking at one screen for more than 70% of the time during the test sentences).

Table 3
Structure of stimulus stories, Experiment 2

	Continue	Shift
Context	See <i>the turtle</i> and the tiger <i>The turtle</i> goes downstairs with the tiger And <i>he</i> finds a box with the tiger	See the tiger and <i>the turtle</i> The tiger goes downstairs with <i>the turtle</i> And <i>he</i> finds a box with <i>the turtle</i>
Target	Now what does <i>he/the turtle</i> have? Look, he has a kite! (pronoun vs. noun)	

Stimuli

Sixteen experimental stories were constructed with the same structure used in Experiment 1; one additional story was used as a practice trial. As in Experiment 1, one of the two characters in each story was made more prominent through first mention, subject status, and pronominalization. The test sentence either continued the subject established in the preceding context or shifted to a new subject, and had either a pronoun or a full noun phrase subject. Subject continuity was manipulated by changing the context sentences. Sixteen different pairs of animal names were inserted into four story templates; an example story is shown in Table 3. In all four story templates, the second-mentioned character appeared in a sentence-final prepositional phrase in the second and third context sentences. The purpose of the repeated story templates was to reduce the difficulty of the task, giving our stories the repetitive style of many children's story books. The stories were digitally recorded as in Experiment 1.

The 16 stories were divided into four subsets of four items. These subsets were combined to create four experimental lists, such that each story occurred in all conditions across participants and each participant experienced one subset of four stories in each condition. Stories were randomly ordered within each list, with the same constraints as in Experiment 1.

As in Experiment 1, we asked seven judges to decide which word was the most emphasized in each test sentence. In both pronoun- and noun-subject test sentences, the subject character was rarely chosen as the most emphasized word (in less than 1% of judgments). Thus, as intended, the perceived stress profiles of the noun and pronoun-subject sentences were highly similar.

Fig. 4 shows a sample video sequence. During the first context sentence, the two story characters were shown, one on each screen (5s). During the second and third context sentences, both screens showed the same picture, depicting the characters in the scene described by the sentences (5s each). During the test sentence, each character appeared by itself on one screen, with an object. The picture accompanying each test sentence was displayed for 7s; the subject noun phrase of the test sentence (e.g., *He* or *The turtle*) began 1s after the picture appeared. The next story began after a 2s interval. The picture backgrounds were the same for each use of the same story template, with different pairs of characters inserted into the pictures.

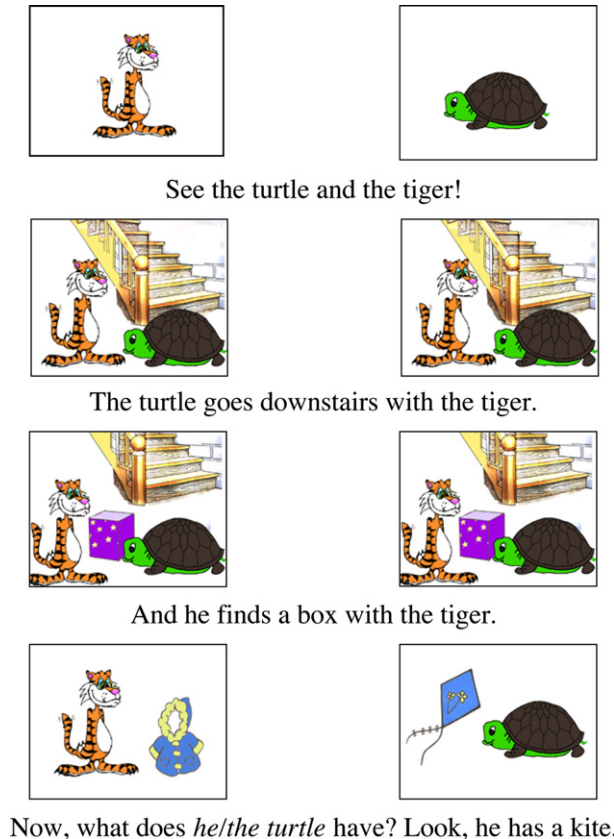


Fig. 4. A sample video sequence, Experiment 2.

The stimulus videos and sentences were designed so that the pronoun subjects were ambiguous for several seconds: For example, in the test sequence shown in Fig. 4 (*Now what does he have? Look, he has a kite!*), *kite* is the first word that establishes the referent of the pronoun subject (because only the pictured turtle has a kite). The average onset of the disambiguating word was 3.7s after subject onset. In the noun-subject condition the test sentence was unambiguous at the subject noun phrase.³ The picture matching the test sentence

³ In each stimulus story we paired characters whose names began with the same consonant or consonant cluster (as in Fig. 4). This was done in hopes of reducing the anticipated baseline difference between the noun- and pronoun-subject conditions by making the noun phrase subjects referentially ambiguous for a slightly longer period. Even 2-year-olds take longer to shift their eyes to a named target if the target word overlaps in initial phonemes with the name of a distractor object (e.g., Swingley, Pinto, & Fernald, 1999); we speculated that such a delay might enable us to see effects of continuity in the noun-subject condition. As both the adults' and children's data reported below make clear, however, this strategy did not permit us to measure any effect of continuity in responses to noun-subject test sequences.

(the correct choice) appeared equally often on the left and right screens within each condition for each child. The stimulus stories were presented in a fixed order.

Apparatus and procedure

Children sat on a parent's lap facing two 20 in. color monitors, at a distance of about 30 in. The screens were about at child's eye level, laterally separated by 12 in. All video equipment was concealed behind a black panel; white curtains hung to the left and right, blocking the child's view of the room. The stimulus stories were played from a speaker concealed between the monitors. A hidden camera, centered between the screens, recorded the child during the experiment. Parents wore opaque glasses so that they could not see the pictures.

Coding

We coded where children looked (left screen, right screen, or away) during the test sentences, frame by frame, from the video record. Coding was done without sound. A second coder judged visual fixations for eight randomly selected children (33% of the data); the two coders agreed on 98.2% of video frames.

We examined the proportion of fixations to the correct screen in a 4 s period beginning at the onset of the subject noun phrase. This 4 s period ended 300 ms after the mean onset of the disambiguating word in the test sequence. Based on previous studies using visual-fixation measures of word recognition, we reasoned that eye movements within 300 ms of the onset of the disambiguating word were unlikely to be triggered by recognition of that word (e.g., Dahan, Swingley, Tanenhaus, & Magnuson, 2000; Swingley et al., 1999); therefore the 4 s test period was the effective region of ambiguity for the subject pronoun. To examine the time course of discourse prominence effects on pronoun interpretation, we divided the 4 s test period into four 1 s windows. Individual trials were excluded from analysis if the child looked away for more than half of the 6 s period during which the choice pictures were visible after the onset of the subject noun phrase, and looking times were treated as missing within each 1 s window if the child never looked at either screen during that 1 s period. These criteria resulted in the exclusion of 18 values (4.7% of 384 trials) in the first 1 s window, 15 (3.9%) in the second, 12 (3.1%) in the third, and 14 (3.6%) in the fourth 1 s window.

The long period of ambiguity was designed to give children time to develop a preference before the disambiguating word arrived. In a pilot experiment in which disambiguating information arrived early (e.g., *Now, he has a kite. Look, what does he have?*), adults showed a reliable preference for the continued-subject interpretation, but children did not (Song, 2001).

Pretest with adults

To ensure that our stories had the intended structure, we pretested the materials with adults. Twenty college students were recruited and compensated as in Experiment 1A. The procedure was the same as for the children, except that participants sat on a low stool in front of the apparatus, and were instructed to look at the screen that matched the audio as soon as possible, and not to look away until the trial ended.

Table 4 shows the proportion of fixations to the correct screen (out of looks to either screen) within each 1 s test window, for noun- and pronoun-subject test sen-

tences. As predicted, when adults heard a noun-subject sentence they quickly looked at the correct screen regardless of subject continuity. A 4 (window) \times 2 (subject continuity) repeated measures ANOVA conducted for noun-subject test sentences revealed only a main effect of window ($F(3, 57) = 54.28, p < .001; F_2(3, 45) = 32.54, p < .001$; other $F_s < 1$). Fixations during pronoun-subject sentences, however, were strongly affected by subject continuity. As shown in Table 4, the adults tended to look at the character established as subject in the preceding context; this led to correct fixations in the continue condition, and incorrect fixations in the shift condition. An ANOVA revealed a main effect of continuity ($F(1, 19) = 16.36, p < .001; F_2(1, 15) = 62.57, p < .001$) and an interaction of subject continuity with time window ($F(3, 57) = 11.79, p < .001; F_2(3, 45) = 22.01, p < .001$). There was no main effect of window ($F_s < 1$). Planned comparisons (directional t tests) revealed that the continued-subject advantage began to emerge in the first 1 s window ($t_1(19) = 1.39, p = .09; t_2(15) = 2.60, p < .05$), and was reliable in the three subsequent 1 s windows (second: $t_1(19) = 3.66, p < .001; t_2(15) = 7.24, p < .001$; third: $t_1(19) = 4.89, p < .001; t_2(15) = 7.26, p < .001$; fourth: $t_1(19) = 4.78, p < .001; t_2(15) = 9.06, p < .001$). These data confirmed that our stories elicited a strong continuity preference for pronoun interpretation in adults.

Results

Fig. 5 shows the proportion of children's fixations to the correct picture within each test window, for noun-

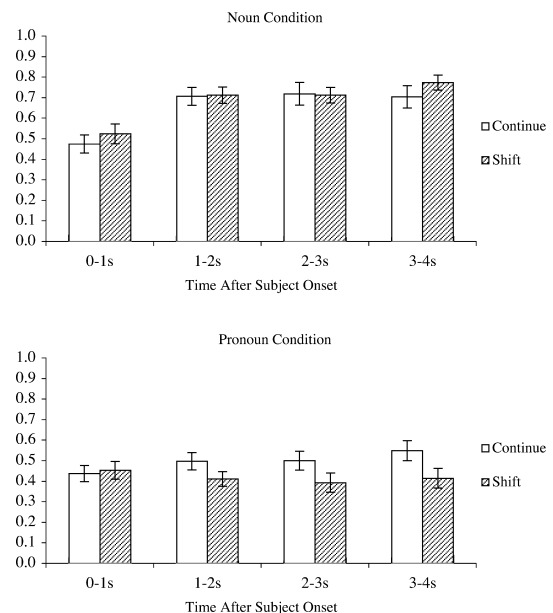


Fig. 5. Mean (SE) proportion of correct fixations, Experiment 2.

Table 4
Mean (SE) proportion of looks to target in adults, Experiment 2

	Time after subject onset			
	0–1 s	1–2 s	2–3 s	3–4 s
Noun condition				
Continue	0.69 (.04)	0.90 (.03)	0.91 (.04)	0.93 (.04)
Shift	0.69 (.04)	0.90 (.03)	0.91 (.03)	0.91 (.03)
Pronoun condition				
Continue	0.56 (.06)	0.67 (.06)	0.69 (.05)	0.72 (.07)
Shift	0.42 (.05)	0.30 (.06)	0.24 (.05)	0.23 (.05)

and pronoun-subject test sentences. During noun-subject items, fixations rapidly converged on the correct picture, suggesting that the children attended to the stories. As for adults, the timing of children's correct fixations for noun-subject items was not affected by subject continuity. A 4 (window) by 2 (subject continuity) repeated measures ANOVA for noun-subject sentences revealed only a main effect of time window ($F(3, 69) = 16.93$, $p < .001$; $F(3, 45) = 17.17$, $p < .001$). In the second, third, and fourth 1 s windows, children fixated the referents of the noun subjects more than expected by chance (0.50; all $t_s > 5$, $p < .0001$).

During pronoun-subject trials, children looked longer at the correct screen during continued- than shifted-subject test sequences. As shown in Fig. 5, the difference in correct fixations between the continue and shift conditions began to emerge between 1 and 2 s after pronoun onset. A 4 (window) \times 2 (subject continuity) ANOVA revealed a main effect of continuity (reliable by subjects but not items; $F(1, 23) = 5.49$, $p < .05$; $F(2, 15) = 3.25$, $p = .09$). The effect of subject continuity did not interact with window ($F(3, 69) = 1.08$, $p > .30$; $F(3, 45) = 2.43$, $p = .08$). Planned comparisons revealed a reliable continuity preference in the fourth window (3 to 4 s after pronoun onset: $t(23) = 2.06$, $p < .05$; $t(15) = 1.77$, $p < .05$), and trends toward a continuity preference in the second and third 1 s windows (second: $t(23) = 1.74$, $p < .05$; $t(15) = 1.62$, $p = .06$; third: $t(23) = 1.48$, $p = .08$; $t(15) = 2.21$, $p < .05$).

Discussion

The results of Experiment 2, like those of Experiment 1B, suggest that as 3-year-olds listen to sentences, they build a representation in which discourse referents are ranked in prominence. Some combination of the cues we used in Experiments 1 and 2—subject status, first mention, and pronominalization—succeeded in promoting the prominence of one character in the discourse representation. Since the looking-time comprehension task does not involve sentence production, we can conclude that the prominence of entities in the discourse representation affected children's comprehension of the test pronoun. Three-year-olds found it easier to interpret a pronoun subject as referring to the character established as most prominent in the story.

The results of Experiment 2 also tell us that 3-year-olds, like adults in previous studies (e.g., Arnold et al., 2000), need not wait until disambiguating information arrives to interpret a pronoun. Although the effects of discourse prominence were noticeably weaker for 3-year-olds than for adults (compare Fig. 5 and Table 4), children tended to interpret pronoun subjects as coreferential with the most prominent character in the story, and to do so while the pronouns were still ambiguous. Thus both 3-year-olds and adults can use dis-

course prominence incrementally to interpret pronouns before all the necessary information is available.

In Experiments 1 and 2, multiple cues promoted the salience of one character. Using these materials, we found that even 3-year-olds tended to assume that the character mentioned first, established as subject, and pronominalized in the preceding context was the referent of a pronoun subject. In Experiments 3 and 4 we tested the robustness of children's sensitivity to discourse prominence cues by removing some of the cues used in each story. In Experiment 3, the stories contained the same number of sentences as in Experiment 2, but no character was pronominalized in the context sentences. In Experiment 4, we shortened the stories, removing the third context sentence altogether. Therefore, in both Experiments 3 and 4, only grammatical role and order of mention differentiated the two characters in each story. If children still showed a continued-subject preference based on these stories, then we could conclude that grammatical role and/or order of mention affect referent prominence in young children's discourse representations.

Experiment 3

In Experiment 3, as shown in (6), the third context sentence used a repeated definite noun phrase (*the turtle*) rather than a pronoun to continue the subject of the preceding sentence. This manipulation weakens the discourse support for a continued subject interpretation of the test pronoun in two ways relative to Experiments 1 and 2: First, if pronoun use itself is a focusing device in English (e.g., Clancy, 1980; Levy, 1982), then this change should reduce the set of cues promoting the prominence of one character. Second, the third context sentence in the revised materials contained a continued subject realized as a repeated name. Given previous studies of adults' language comprehension (e.g., Gordon et al., 1993; Experiment 1A of the current study), this change should make the context stories less coherent, and therefore harder to understand.

(6) Context: See the turtle and the tiger.

The turtle goes downstairs with the tiger.
And the turtle finds a box with the tiger.

Test: Now what does he have? Look, he has a kite!

Furthermore, in the materials of Experiments 1 and 2, although half of the pronoun-subject test sentences were continued-subject sentences and half were shifted-subject sentences, each context story contained a continued-subject pronoun. Thus the majority (83%) of the pronoun subjects that the children heard in the experiment turned out to refer to the subject of the preceding clause. In principle, children could have developed a bias

to interpret pronouns as continued subjects in the course of the experiment itself. Inspection of the results of Experiments 1 and 2 did not support this alternative interpretation: In both experiments, a clear continuity preference appeared in the first half of the trials, suggesting that this preference was not due to the development of a strategy during the experiment. The materials of Experiments 3 and 4, however, removed the possibility that children could learn to treat pronouns as continued subjects in the course of the experiment. Only the test sentences contained pronouns, and children heard shifted- and continued-subject pronouns equally often during the experiment.

Method

Participants

Twenty-four 3-year-olds ($M = 39.4$ months; range 36.3–42.0; 11 boys, 13 girls) participated. All were monolingual speakers of English. Six children were tested but not included because of side bias ($n = 2$), parental report of language delay ($n = 1$), equipment failure ($n = 1$), sibling interference ($n = 1$), or failure to complete the task ($n = 1$).

Stimuli

The stories were as described for Experiment 2, except that the continued subject of the third context sentence in each story was realized as a full noun phrase rather than as a pronoun (see example 6). The altered context sentences were re-recorded; all other sentences were the same recordings used in Experiment 2.

Apparatus and procedure

The apparatus and procedure were identical to those of Experiment 2.

Coding

Coding and data analysis were carried out as for Experiment 2. Reliability was assessed for eight randomly selected children; primary and reliability coders agreed on 96.5% of video frames. Looking times within each window were treated as missing based on the same criteria described for Experiment 2: 17 values (4.4% of 384 trials) in the first 1 s window, 16 (4.2%) in the second, 16 (4.2%) in the third, and 13 (3.4%) in the fourth 1 s window.

Results

As shown in Fig. 6, the children's responses closely duplicated the findings of Experiment 2. In the noun condition, children quickly looked toward the correct screen. The proportion of correct fixations in the noun condition differed across the four test windows ($F(1, 69) = 8.60$, $p < .001$; $F(3, 45) = 7.29$, $p < .001$),

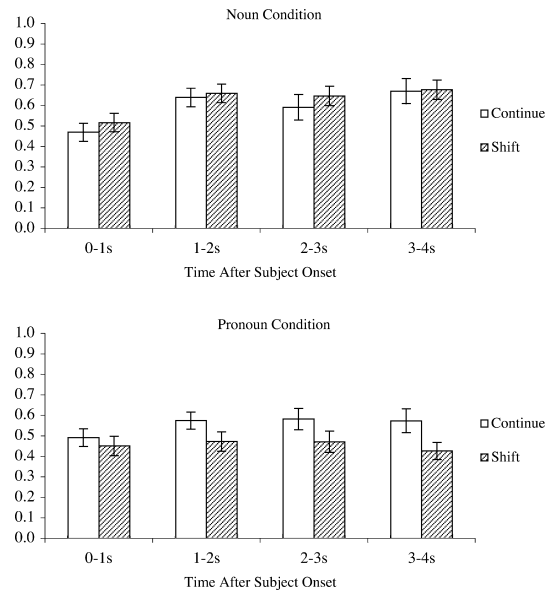


Fig. 6. Mean (SE) proportion of correct fixations, Experiment 3.

but was unaffected by subject continuity ($F(1, 23) < 1$; $F(1, 15) = 1.20$, $p > .20$) or by the interaction of subject continuity with time window ($F_s < 1$). In the second, third, and fourth 1 s windows, children correctly fixated the referents of the noun subjects more than expected by chance (0.50; $t_s > 3$, $p < .01$).

During pronoun-subject test sentences, children looked longer at the correct picture in the continue than in the shift condition ($F(1, 23) = 7.71$, $p < .05$; $F(1, 15) = 8.14$, $p < .05$). This continuity advantage did not interact with time window, and there was no main effect of window ($F_s < 1.1$). Planned comparisons revealed an advantage for continued-subject pronouns in the fourth 1 s window after pronoun onset ($t(23) = 2.01$, $p < .05$; $t(15) = 2.82$, $p < .05$), and a trend toward a continued-subject advantage in the second and third windows (second: $t(23) = 1.47$, $p = .08$; $t(15) = 1.49$, $p = .08$; third: $t(23) = 1.67$, $p = .05$; $t(15) = 1.69$, $p = .06$).

Discussion

As in Experiment 2, children's interpretation of ambiguous pronouns was affected by the discourse prominence manipulation. The 3-year-olds in Experiment 3 tended to expect pronoun subjects to refer to the character placed in subject and initial position in the preceding sentences. This continued-subject bias appeared despite the reduction in discourse prominence cues relative to Experiment 2.

The results of Experiment 3 also allow us to rule out an alternative interpretation of the continued-subject

bias for pronoun interpretation in Experiments 1 and 2. Since pronouns were used to refer to shifted subjects as often as to continued subjects during the experiment, children could not have learned that pronoun subjects are likely to be continued subjects in the course of the experiment.

Experiment 4

In Experiment 4, we further reduced the discourse support for a continued-subject interpretation by removing the third context sentence. In the resulting stories, as shown in (7), one character was made more prominent in the context because it appeared first in two sentences, and was the grammatical subject of one context sentence.

- (7) Context: See the turtle and the bunny.
 The turtle takes the bunny to the store.
 Test: What does he have? Look, he has a kite!

Method

Participants

Twenty 3-year-old children ($M = 38.4$ months; range 36.1–41.7; 10 boys, 10 girls) participated. All were native speakers of English. Five children were tested but not included because of side bias ($n = 1$), activeness ($n = 1$), and equipment failure ($n = 2$), or because the mean proportion of correct fixations in one of the two pronoun conditions was more than 4 standard deviations from the mean for that condition ($n = 1$). An additional six children (three girls, three boys) were excluded from the analyses because their productive vocabulary, measured by parental report on the MacArthur Communicative Development Inventory: Level III, was more than 2 standard deviations lower than the mean vocabulary score of the included children, and lower than the tenth percentile for children 36–37 months old in a norming study for the Level III inventory (Dale, Reznick, Thal, & Marchman, 2001). No children in Experiments 1–3 were excluded based on vocabulary scores because we did not collect vocabulary data for the children in those experiments.

Stimuli

New stories were created in which only two context sentences preceded the test sentence, as shown in (7). We made four additional changes to the materials to make the stories easier to understand. First, we paired character names with different initial consonants (*turtle* and *bunny* rather than *turtle* and *tiger*), to make the character names less confusable. Second, the second-mentioned character was no longer sentence-final, but appeared in direct object position (e.g., *The turtle takes*

the bunny to the store) or as a sentence-medial adjunct (e.g., *The deer walks with the cat in the park*). To the extent that recency of mention affects immediate referent prominence (e.g., Gernsbacher, 1990), the sentence-final character in the previous materials might have tended to compete with the subject character in the selection of the test pronoun's antecedent. Third, we removed the word *Now*, which preceded all test sentences in Experiments 1–3. *Now* can indicate a new subtopic (Grosz & Sidner, 1986; Hirschberg & Litman, 1993), and so might have tended to reduce the effect of the discourse manipulation. Fourth, only the pronoun *he* was used; in Experiments 1–3, half of the trials included *he* and half *she*.

We digitally recorded the stories as in previous experiments. All of the nouns were relatively stressed in the context sentences. We again asked seven judges to decide which word was most emphasized in each test sentence. The subject character of the test sentence was rarely judged as stressed, whether it was realized as a pronoun (0%) or as a full noun phrase (4.5%).

Procedure

The procedure was as described for Experiments 2 and 3.

Coding. We coded and analyzed visual fixations as in Experiments 2 and 3. A second coder coded the data from five randomly selected children; the two coders agreed on 97.1% of frames. Using the criteria described above, we excluded three values (0.9% of 320 trials) in the first 1 s window, 3 (0.9%) in the second, 4 (1.3%) in the third, and 7 (2.2%) in the fourth 1 s window.

Results

As shown in Fig. 7, the looking preferences of the 3-year-olds in Experiment 4 were similar to those of Experiments 2 and 3. Responses to the noun-subject items again confirmed that the children were attentive to the stories, looking toward the matching picture when they heard a lexical noun phrase subject. Children's visual fixations in the noun condition were not affected by subject continuity ($F_s < 1$) or the interaction of subject continuity with time window ($F(1, 3, 57) = 1.73$, $p > .10$; $F(3, 45) = 2.56$, $p = .07$). Looking patterns across the four time windows in the noun condition revealed only a main effect of window ($F(1, 3, 57) = 29.01$, $p < .001$; $F(3, 45) = 20.76$, $p < .001$). In the second, third, and fourth 1 s windows after subject noun phrase onset, children looked longer at the noun-subjects' referents than would be expected by chance (0.50; $t_s > 5.5$, $p < .0001$).

In the pronoun condition, the proportion of correct fixations across the 4 1 s windows depended on subject continuity ($F(1, 19) = 4.64$, $p < .05$; $F(1, 15) = 6.71$, $p < .05$); subject continuity did not interact with window ($F_s < 1$) and there was no main effect of time window

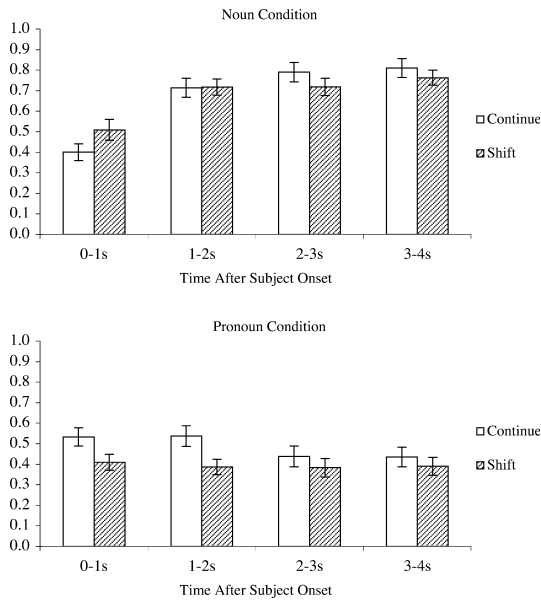


Fig. 7. Mean (SE) proportion of correct fixations, Experiment 4.

($F(3,57) = 1.37, p > .20$; $F(3,45) = 1.37, p > .20$). As in Experiments 2 and 3, children preferred to interpret pronouns as referring to the subject or first-mentioned character established in the previous sentences.

The continuity preference for pronoun interpretation appeared somewhat earlier in Experiment 4 than in Experiments 2 and 3. Planned comparisons revealed a reliable continuity advantage for pronoun-subject sentences in the second window, 1–2s after pronoun onset ($t(19) = 2.18, p < .05$; $t(15) = 2.57, p < .05$), and a continuity advantage, significant by subjects but not by items, in the first 1s window after pronoun onset ($t(19) = 1.95, p < .05$; $t(15) = 1.62, p = .06$). The continuity advantage disappeared in the third and fourth 1s windows ($ts < 1$).

Several changes in the materials might have contributed to the more rapid use of contextual information than in Experiments 2 and 3. For example, in Experiment 4 the stories were shorter, and therefore contained fewer propositions to understand and maintain in the discourse representation. Studies of adult reading comprehension suggest that a simpler propositional structure should make the context stories easier to understand and remember (Kintsch & Keenan, 1973). The removal of the connective *Now* might have tended to help children link the test sentence closely with the preceding context; we also removed the second-mentioned character from the most recent, sentence-final position, which may have decreased its prominence relative to the subject referent. Consistent with these speculations, previous findings suggest that enhancing the

prominence difference between story characters (by mentioning one character more often) can cause adults to show earlier effects of order of mention in pronoun interpretation (Arnold et al., 2000; Experiment 2).

Discussion

The results of Experiment 4 confirm that a character placed in subject and sentence-initial position becomes more prominent in 3-year-olds' discourse representations, and that discourse prominence affects pronoun interpretation. The continued-subject preference in pronoun interpretation held true despite the shortened stories of Experiment 4. How can we reconcile our findings with those of Arnold et al. (in press, 2001), reviewed in the Introduction? The shortened stories of our Experiment 4 were not much shorter than those used by Arnold et al. In both cases the contexts consisted of one full sentence establishing one of two characters as the sentence-initial subject, though each such sentence in Experiment 4 was preceded by an introductory sentence accompanied by pictures (e.g., *See the turtle and the bunny*).

One possibility is that the discrepancy between our results and those of Arnold et al. (2001) was due to differences in the timing of disambiguating information. In the looking-preference experiments reported here, disambiguating words arrived on average 3.7s after pronoun onset, leaving a test window of 4s before identification of the disambiguating word could plausibly affect children's eye movements. In contrast, Arnold et al. (2001) looked for effects of a subject or first-mention bias only within 1s of pronoun onset; disambiguating information was provided by the verb or direct object following the pronoun. In the present experiments, we found robust evidence of a subject continuity or first-mention bias 1–2s after pronoun onset at the earliest (Experiment 4). Children may be slower than adults to use discourse prominence information in interpretation of a pronoun. Further evidence for this possibility comes from the results of the pilot study mentioned in Experiment 2; when disambiguating information arrived early in the test sentences in materials otherwise identical to those of Experiment 2 (e.g., "Now he has a *kite*. Look, what does he have?"), 3-year-olds showed little evidence of a continued-subject preference (Song, 2001).

Another possibility has to do with the design of the context sentences used by Arnold et al. (2001): In each story, a clause or modifying phrase intervened between the context clause establishing one character as the sentence-initial subject and the clause containing the target pronoun (e.g., *Donald is bringing some mail to Mickey, while a violent storm is beginning*). This intervening clause (*while a violent storm is beginning*) may have tended to reduce the effect of the discourse manipulation. Pronouns are most easily understood if their ante-

cedents appeared in the immediately prior clause (e.g., Clark & Sengul, 1979; Ehrlich & Rayner, 1983).

In a later experiment, Arnold et al. (in press) used test sentences with no disambiguating information (e.g., *He wants some milk*), and found no effects of discourse prominence in either off-line comprehension or on-line eye movement data (with the possible exception of the youngest boys in the study, who only chose systematically when the referent was specified both by gender and first mention). These negative results could be due to children's difficulty with generating an explicit answer to the comprehension question while integrating information from the previous sentence (e.g., "Can you show me who wants the milk in the story?").

General discussion

In interpreting sentences, listeners must use information presented in the preceding sentences to assign referents to pronouns. For adults, this information includes syntactic constraints on coreference within sentences, pronoun gender and number, and inferences based on background knowledge, as well as the syntactic and sequential cues to discourse prominence examined in the present research (e.g., Arnold et al., 2000; Clifton & Ferreira, 1987; Fletcher, 1984; Garrod & Sanford, 1994; Gordon et al., 1993). Our findings provide new evidence for early sensitivity to discourse prominence in pronoun interpretation: In both repetition and looking-preference tasks, 3-year-olds treated some characters as more prominent than others, and assigned prominence based on some of the same cues that guide adults' interpretation of pronouns.

Continuity in the language processing system

These findings suggest a model of sentence comprehension with considerable continuity from age 3 to adulthood.

First, our data suggest that young children, like adults, interpret sentences relative to a representation of the current state of the discourse. When listening to sentences, the children in the present experiments formed a representation of the story that affected their interpretation of later sentences. This finding comports with previous evidence that preschoolers can interpret referential terms relative to a representation of the discourse context. For example, preschoolers make appropriate inferences from the use of indefinite versus definite noun phrases (Maratsos, 1976), and recruit information from previous sentences to infer which character is a plausible subject for a particular verb (Tyler, 1984; Wykes, 1981, 1983). When the context includes only one referent, even 18-month-olds can interpret a phrase anaphorically (Lidz, Waxman, & Freedman, 2003b).

Second, our findings suggest that the prominence of discourse referents in young children's representations of sentences is influenced by at least some of the same factors that promote prominence in adults' discourse representations. The results of Experiments 3 and 4 made clear that some combination of grammatical role and order of mention in two or three context sentences was sufficient to promote the prominence of one of two characters in children's representations of a story. The incremental creation of the discourse representation at age 3 thus appears to be guided by syntactic and sequential information, as it is for adults.

Third, as for adults, the prominence ranking of discourse referents affects how children interpret pronouns. In all four experiments, children found it easiest to interpret a pronoun subject as coreferential with the subject or first noun phrase of the preceding sentences. These findings are in accord with prior findings from act-out comprehension judgments by older children (Wykes, 1981), and suggest that young children's comprehension of pronouns shows some of the same sensitivity to discourse prominence routinely found in analyses of their production of pronouns and argument ellipsis (e.g., Allen, 2000; Clancy, 1992; Hickmann & Hendriks, 1999).

Finally, children's looking patterns in Experiments 2–4 revealed a continued-subject preference in pronoun interpretation while the pronoun was still ambiguous. In all three experiments, a reliable continuity preference was found during the 4s period of ambiguity following the onset of the pronoun subject. This result suggests that the child's comprehension system, like the adult's, recruits discourse prominence information incrementally as sentences unfold. This conclusion is in accord with several influential arguments that incremental use of phonetic, syntactic, and semantic information is an early emerging property of the comprehension system. Many of these findings concern the rapid use of very local information. For example, 2-year-olds use phonetic information continuously to identify words (Swingley et al., 1999), and look toward a plausible object when they hear a semantically constraining verb (Fernald, 2003); moreover, 5-year-olds quickly use the subcategorization biases of particular verbs to resolve syntactic ambiguities (Snedeker, Thorpe, & Trueswell, 2001). Other findings suggest that the less local constraints of a semantically interpreted discourse representation can also be brought to bear during on-line sentence comprehension by preschoolers. Five-year-olds more accurately (Cole & Perfetti, 1980) and more quickly (Tyler, 1983) detect mispronunciations in words that are highly predictable based on information presented in previous sentences. The present findings add to this literature by revealing that the prominence of each referent in the preceding linguistic context influences 3-year-olds' initial interpretation of an ambiguous pronoun.

Differences from the adult pattern

In addition to these dimensions of continuity in the basic architecture of the language comprehension system across development, we also found two ways in which children differed from adults. First, and not surprisingly, children were noticeably slower and less accurate than adults in the preferential looking task. This can be seen in the looking time data for adults and children in Experiment 2 (see Table 4 and Fig. 5), both in the timing and the consistency of looks toward the named referent in the noun conditions, and of looks toward the continued-subject referent in the pronoun conditions. It is not entirely fair to compare the speed and accuracy of adults' and children's visual fixations in this task, because the 3-year-olds were not given an explicit task, whereas the adults were told to look at the correct picture as soon as they could. Nevertheless, this difference is almost certainly a real one. Children are generally slower and less accurate in spoken word identification and sentence processing (e.g., Cole & Perfetti, 1980; Fernald, Pinto, Swingley, Weinberg, & McRoberts, 1998; Tyler & Marslen-Wilson, 1981), though recent experiments using on-line measures of sentence comprehension found little or no timing difference between 5-year-olds and adults in their use of gender in pronoun interpretation (Arnold et al., 2001).

Second, we also found a qualitative difference in children's and adults' responses. The results of Experiment 1 revealed no evidence of a repeated-name penalty in children's sentence comprehension, as measured by the accuracy of their sentence repetitions. The adults in the reading- and listening-time studies, in contrast, showed a robust interaction of subject continuity and the form of the anaphor (repeated lexical noun versus pronoun). The results of Experiment 1 thus yielded no evidence that 3-year-olds can use the lexical form of an anaphor as a cue to the prominence of its antecedent.

In the discussion of Experiment 1 we considered a possible methodological reason for this null result: It might have been that the repetition task was simply not sensitive enough to detect a brief disruption in sentence processing caused by the use of a full noun phrase where a pronoun would suffice. We also predicted that the preferential-looking task used in Experiments 2–4 would not be well suited to measuring a repeated-name penalty, because of the anticipated baseline difference in looking patterns between the noun and pronoun conditions. However, inspection of children's looking patterns early in the trial revealed a hint that children might consider the lexical form of an anaphor in locating its referent. As shown in Figs. 5–7, in each experiment children tended to look longer at the shifted subject referent in the noun condition, and at the continued subject referent in the pronoun condition, within the first 1 s window following the onset of the subject

noun phrase. This pattern is particularly evident in Experiment 4 (Fig. 7).

To examine this pattern more closely, we conducted an additional analysis of the proportion of correct fixations during the period 300 ms to 1 s after subject onset in Experiments 2–4. This 700 ms segment was chosen as the earliest in which we might expect to find an influence of the subject noun phrase on children's fixations. Two (subject continuity) \times 2 (lexical form) \times 3 (experiment) ANOVAs revealed an interaction of subject continuity with lexical form ($F(1,65) = 5.14, p < .05$; $F(1,45) = 5.08, p < .05$). There was no main effect of experiment ($F_s < 1$), and experiment did not interact with the other factors of interest ($F_s < 2.50, p > .10$). In separate analyses of the same time segment for each experiment, we found a reliable interaction between subject continuity and lexical form only in Experiment 4 ($F(1,19) = 6.85, p < .05$; $F(1,15) = 6.99, p < .05$). Children looked longer at the continued-subject referent during pronoun-subject trials ($t(19) = 2.24, p < .05$; $t(15) = 1.74, p = .05$), but tended to show the reverse pattern during noun-subject trials ($t(19) = 1.70, p = .05$; $t(15) = 2.17, p < .05$). These analyses are post hoc, but raise the intriguing possibility that 3-year-olds may not be impervious to the relationship of lexical form (full noun phrase versus pronoun) and discourse prominence. This pattern showed up most strongly in Experiment 4, in which we used the simplest stories, and found nearly adult-like timing of the continued-subject advantage in pronoun interpretation.

In addition, however, there are many reasons to predict real developmental change in the ability to use discourse context information in sentence interpretation, perhaps particularly in the ability to use the lexical form of a noun phrase as a cue to the prominence of its referent.

One set of reasons has to do with the basic cognitive requirements of sentence processing (e.g., Bock & Brewer, 1985). To interpret an anaphoric expression, children must retain information derived from preceding utterances, use the anaphor to recover information about its most likely antecedent while inhibiting other candidate referents, and incorporate information in the current sentence into the discourse representation (e.g., Garrod & Sanford, 1994, 1999). To the degree that young children and adults differ in working memory capacity or in the efficiency of inhibition (e.g., Adams & Gathercole, 2000; Diamond, 1985), we should predict developmental improvements in the on-line use of prior context to constrain sentence interpretation.

Consistent with this possibility, studies of text processing in adulthood suggest that individual differences in verbal working-memory capacity constrain adults' ability to integrate multiple sources of information in on-line sentence processing (Just & Carpenter, 1992). Similar influences of individual differences in working

memory capacity on comprehension can be found when readers must integrate information across distant sentences to identify the referent of a pronoun (e.g., Almor, MacDonald, Kempler, Andersen, & Tyler, 2001; Daneman & Carpenter, 1980; Light & Capps, 1986; Yuill & Oakhill, 1988).

Another set of reasons for children and adults to differ in their use of discourse-provided information in comprehension stems from the partial arbitrariness and language-specificity of cues relevant to reference resolution. Despite broad similarities across languages (including the prominence of subject referents, and the use of pronouns or ellipsis for the most prominent referents), languages differ in the particular devices they offer for making anaphoric reference, and for marking and manipulating referent prominence (e.g., Croft, 1990; Lambrecht, 1994). For example, Italian speakers learn that null or clitic pronouns and overt pronouns are associated with different kinds of discourse transitions (Di Eugenio, 1998), and Japanese speakers learn that the morpheme *-wa* marks the noun phrase to which it is affixed as a topic, and thus as a preferred antecedent for a null pronoun (Iida, 1998). Some languages have special verb forms to mark cases of ‘switch reference’ between the subjects of conjoined clauses (Haiman, 1980). The children who learn to speak these languages must learn language-specific strategies for reference resolution. Further developmental (and cross-linguistic) research will be required to explore the contribution of increases in working-memory capacity and of language-specific learning in the development of the integration of local lexical and structural cues to reference.

Early sensitivity to discourse structure

What is the source of the early sensitivity to discourse structure revealed in our experiments? In the Introduction we laid out two theoretical stances yielding different predictions for children’s use of discourse cues in pronoun interpretation.

On the one hand, considerations of cue validity provide reasons to expect sensitivity to structural and sequential features of prior sentences to affect pronoun interpretation relatively late, and weakly, in the process of development (e.g., Arnold et al., *in press*). Because subject status and order of mention in a prior sentence are not terribly reliable cues to pronoun reference, it should take children some time to detect their predictive power in the input.

On the other hand, we sketched reasons why subjects or first-mentioned noun phrases might become naturally prominent in discourse representations as part of the ordinary process of sentence interpretation, and hence might affect pronoun interpretation earlier in development than their sheer validity as discourse cues would predict. If children interpret sentences relative to a

semantically interpreted and incrementally constructed representation of the discourse, then subject referents might achieve discourse prominence because of their prominence in the semantic interpretation of each sentence; first-mentioned referents might become prominent because the incremental construction of the discourse model allows early referents to serve as the context for the encoding of later referents.

Can we take our findings of early sensitivity to discourse prominence cues as additional support for this natural-prominence view? To evaluate this question, we need to establish that young children treat grammatical subjects or first-mentioned characters as prominent arguments in the interpretation of single sentences, and to assess possible alternative versions of the cue-validity view.

Effects of word order in early comprehension

Even infants take word order into account in interpreting sentences: By about 18 months, children use word order to understand reversible sentences containing familiar verbs (Hirsh-Pasek & Golinkoff, 1996). Children’s early word combinations rapidly come to respect the word order of their native language (e.g., Bloom, 1991), and even the invented gestural communication systems of young Deaf home signers use word order to convey relational semantics in sentences (e.g., Goldin-Meadow & Mylander, 1998). These findings make clear that sequential information in sentences is salient to children, and that word order is preserved in memory representations that are relevant for sentence comprehension. The ubiquity of primacy effects in memory retrieval, both in adults and in infants (e.g., Ebbinghaus, 1964; Gulya, Rovee-Collier, Galluccio, & Wilk, 1998; Wright, Santiago, Sands, Kendrick, & Cook, 1985), also makes clear that the sequential presentation of information affects memory performance in many domains, across ages.

These findings raise the possibility that order could affect the accessibility of various discourse entities, without requiring the listener to learn that first-mentioned entities tend to be mentioned in subsequent sentences.

This conclusion remains tentative: As we pointed out in the Introduction (see footnote 1), the difficulty of disentangling sequential, syntactic, and semantic factors in texts, along with systematically divergent results in different tasks, makes it difficult to evaluate the independent effect of order on referent prominence in adults. However, the bulk of the evidence suggests that constituent order (but perhaps not the order of nouns within major constituents, see Gordon et al., 1999) plays some role in determining pronoun antecedents; further research both with adults and with children will be needed to disentangle effects of constituent order from those of syntax.

Subjects as prominent arguments

In diverse linguistic analyses, subjects have been described as linked with roles that are dominant in a traditional thematic role hierarchy (in which agents outrank patients or themes; Jackendoff, 1990), roles that are both thematically and aspectually prominent (Grimshaw, 1990), roles that require more of the semantic properties of a prototypical agent (including causation, animacy, and sentience; Dowty, 1991), or roles that can be construed as a conceptual figure in a figure-ground relation (Talmy, 1983). These approaches vary in important ways, but share a general notion of semantic prominence that predicts which argument will be the sentence subject. Even in syntactically ergative languages, which cause difficulties for a universal definition of syntactic subject, the transitive agent argument (the A argument, in the terminology of typological linguistics) and the intransitive subject (S) are alike in their tendency to contain discourse-old referents, and to serve as the antecedents of reflexive pronouns within the same clause (Dixon, 1994; Du Bois, 1987). Dixon argued that there is a universal category ‘subject’ that unites the transitive A argument and the intransitive subject; these two argument roles are similar on semantic grounds, since both have the possibility of initiating or controlling the event described by the verb.

In accord with the hypothesis that subjects are semantically prominent, adult listeners interpret the roles of the subject and object of a sentence asymmetrically even when the semantics of the predicate invoke inherently symmetrical relationships (Gleitman, Gleitman, Miller, & Ostrin, 1996). For example, although in (8) two objects must be equally near each other, Talmy (1983) suggested that the interpretation of the subject as the conceptual figure explained why it ordinarily makes more sense to say (8a) than (8b). In the ordinary scheme of things, a bicycle is more mobile than a house, and thus makes a better conceptual figure, or lends itself to more prominent thematic roles.

- (8) (a) The bicycle is near the house.
 (b) The house is near the bicycle.

Gleitman et al. (1996) documented preferences of this type in adults who judged sentences like those in (8). Judges thought the first sentence was more natural, preferring subject nouns that were smaller, more mobile, or less famous. But adults also found uses for the less preferred arrangement of noun phrases. Reversing the assignment of entities to grammatical roles had the effect of inviting readers to re-interpret the subject as the conceptual figure. For example, (8b) could describe a house located near a fixed landmark, a large bicycle sculpture. This pattern suggests that adults interpret the subject/object asymmetry in terms of semantic prominence; a

noun phrase in subject position is interpreted as playing a thematically prominent role.

Thematic prominence and animacy systematically affect adults’ language production as well. Speakers produced passives more often when using verbs that have theme subjects and experiencer objects, and when the theme was inanimate (e.g., *John was scared by a passing car*; Ferreira, 1994). The sentence production system tends to put thematically prominent arguments in subject position. The strong cross-linguistic association of animate entities with transitive subject position, and inanimates with transitive object position, is reflected in morphological markedness patterns that are widespread in the world’s languages (e.g., Silverstein, 1976).

The results for children are strikingly similar. Children as young as 2 find it easier to assign dynamic entities—thus good conceptual figures—to the subject role. Children’s spontaneous productions favor animate subjects, for example (e.g., Bloom, 1970; Bowerman, 1973; Brown, 1973; Tomasello, 1992), and children under 3 years of age more readily produce or comprehend passive sentences when the passive allows an animate participant to appear in subject position (e.g., Lempert, 1984, 1990). Two-year-olds more accurately comprehend transitive sentences when an animacy contrast helps to differentiate the subject and object referents, both with familiar verbs (e.g., Corrigan, 1988; Corrigan & Ody-Weis, 1985), and novel verbs (Childers, 1998).

Crucially, the preference for dynamic subjects cannot be reduced to a preference for animate or agent subjects. Inanimates can be subjects, too, as long as they play a prominent role: When the patient in a caused-motion event underwent enduring rather than fleeting motion, 2-year-olds became more likely to arrive at a patient-subject intransitive interpretation of a made-up verb (Braine, Brody, Fisch, Weisberger, & Blum, 1990). Fisher and Song (in press) showed 3-year-olds non-causal motion or location events involving two participants, and found that children chose animate or moving inanimate entities as the subjects of novel transitive verbs, even though none of these participants were causal agents. These results suggest that the more mobile and active participant in a scene has some claim on subject position in default descriptions.

This preference is consistent with recent findings from idiosyncratic Home Sign systems invented by linguistically isolated deaf Nicaraguans (Coppola & Newport, 2003). The adult Home Signers had established a systematic *subject* position in their sentences, marked by features like word order and spatial agreement specified on the verb. Coppola and Newport (2003) argued that this position served as a true subject because it was used to mark the primary thematic role in each event—one higher on the traditional thematic role hierarchy (e.g., Jackendoff, 1990).

Although it remains a contentious question when true syntactic representations emerge in development, most observers would agree that by the age of 3, children possess representations of sentences abstract enough to be called syntactic (see Fisher, 2002; for a review). Compelling evidence for this abstraction comes from findings of syntactic priming across different novel verbs (e.g., Brooks & Tomasello, 1999). The evidence reviewed in this section suggests that children as young as 3, like adults, make use of an abstract notion of a semantically prominent argument that is preferentially realized as a syntactic subject. This bias to align semantically and syntactically prominent roles guides early comprehension and production, the creation of language without a conventional linguistic model, and adult language processing. Here we have argued that this bias also makes it possible for subject referents to achieve greater discourse prominence than non-subject referents, because the discourse representation is constructed from semantic interpretations of sentences in which subject referents play prominent roles.

Reconsidering cue validity

Arnold et al. (in press) argued that the developing parser should incorporate gender cues to pronominal reference earlier than order of mention or other discourse prominence cues, because of the lesser validity of the latter set of cues. The present experiments, however, tell us that sensitivity to discourse prominence cues may not appear so late after all.

The cue competition view could be salvaged in several ways, of course. Most obviously, it might be that subject status and order of mention are more valid cues to pronominal reference than Arnold et al.'s calculations suggested. Topic continuity and the likelihood of occurrence of pronoun subjects vary considerably across genres (e.g., Chafe, 1980; Francis, Gregory, & Michaelis, 1999). Written stories may provide less evidence than spoken discourses for the tendency of subject pronouns to refer to previous subjects. If analyses of spontaneous speech, perhaps especially speech to children, produced much higher estimates of the validity of subject status or first mention as cues to pronominal reference, then a cue competition model could easily encompass our findings.

In addition, it could be argued that the multi-sentence stories we used in our experiments created a context in which *repeated* first mention provided a more reliable cue to pronominal reference than a single introduction of a character in subject and first-mentioned position. Our results provide no evidence that this is the case: The earliest signs of a preference for a continued-subject interpretation were found following the shortest stories, those used in Experiment 4.

Concluding remarks

Whatever the outcome of future investigations of the true validity of subject status or order as cues to pronoun interpretation, we argue that cue validity and cost calculations alone are unlikely to lead to accurate predictions of developmental sequence. Some cues will beat the cue validity odds. In the present case, we have argued that the discourse prominence of subjects might follow from their interpretation as prominent arguments in a semantic representation. If so, then the significance of a cue at one level of interpretation (the prominence of subject referents in a discourse representation) may be inherited from its significance at another linguistic level (the prominence of subject referents in the meaning of the sentence). Similarly, effects of constituent order on referent prominence could result from ordinary influences of sequential presentation on structured memory representations relevant to sentence interpretation.

A similar argument was advanced by Snedeker and Trueswell (2003) to explain why adult listeners strongly weight within-sentence prosodic boundary cues in interpreting prepositional phrase attachment ambiguities, despite the demonstrable rarity of such cues in language production. They argued that the prosodic cues used to mark phrase boundaries within utterances could be seen as 'borrowed' from the prosodic cues used—very reliably—to mark clause boundaries.

These arguments suggest at least two ways in which cues might 'beat the odds.' First, some cues might be used earlier by children than we would predict based on their validity, because their significance has *already been learned* through analysis at a different level of linguistic structure. Second, young children might show earlier use of some cues than their validity would predict because some cues are *not learned at all*, but instead follow naturally from the way sentences are processed (see Lidz, Gleitman, & Gleitman, 2003a; for a related argument).

Built-in learning biases are often described in multiple ways by different commentators—as innate principles of Universal Grammar (UG), or as based on more general features of human cognitive organization that also apply in non-linguistic domains. The bias to interpret syntactically prominent noun phrases as playing semantically prominent roles has been described as an alignment principle of UG (e.g., Aissen, 1999; Manning, 2003; Pinker, 1989; among many others), but similar biases have been considered possible targets for explanation based on non-linguistic cognitive organization (e.g., Slobin, 1985; Tomasello, 2000). A tendency to treat first-mentioned elements as more prominent, based on general features of memory for sequentially presented material, would be an example of a general cognitive constraint on language processing (e.g., Gernsbacher, 1990; MacWhinney, 1977).

The need for constraints on learning, of some sort, is assumed by virtually every theory of learning. In the present case we suggest that constraints imposed by the architecture of the language processing system cause systematic mismatches between predictions derived from the validity and computational cost of each cue, and its developmental timing and weight in comprehension. By searching for cases of such mismatches, we can explore the nature of the constraints that make language learning possible.

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