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Children's Developing Ability to Interpret Adjective-Noun Combinations

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1. Introduction

Adjectives are difficult for young children for a variety of reasons. Unlike nouns that tend to label objects or people, adjectives denote properties, and properties that often vary in their meaning depending on the nouns they modify. Even a relatively independent, perceptually accessible adjective like *red* can change in the color it refers to depending on whether it is used to describe a sunset, an apple, or a nose. Adjectives are much less frequent in the speech children hear than nouns (Sandhofer, Smith, & Luo, 2000) and may be difficult to differentiate from nouns using syntactic distributional cues (Thorpe & Fernald, in press). Moreover, one especially tricky feature of adjectives is that they are often heard within a noun phrase, and thus their meanings must not only be apprehended, but also *integrated* with those of the nouns they modify. As a child interprets an adjective-noun phrase, she must combine the adjective and noun in order to understand that a *red car* is both red and a car at once.

How do young language learners interpret adjective-noun phrases as they are heard? Adult listeners may wait until they have heard an entire adjective-noun phrase in order to interpret the adjective in relation to the noun (e.g., Clifton & Ferreira, 1989). However, under certain circumstances, when an adjective can clearly help narrow down possible referents, adult listeners interpret adjective-noun combinations incrementally, using information from moment to moment without waiting for the noun to begin interpretation (Sedivy, Tanenhaus, Chambers, & Carlson, 1999). Little is known about how young children process adjectives, though one recent paper by Ninio (2004) proposed a theory of how children interpret adjective-noun phrases involving two proposed steps of integration. While adults can combine an adjective and noun in a single streamlined step according to Ninio, young children must interpret the noun first and then the adjective in two discreet steps, often failing to complete the process and relying on the noun alone for interpretation. This theory predicts that children should have more difficulty interpreting phrases that require integrating an adjective and a noun than phrases where only one or the other is necessary, and also that when children make mistakes integrating adjectives with nouns

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they should err more often on the adjective rather than the noun because it is the second of two steps.

Do children really process adjective-noun combinations in such a two-step sequence, and if so, would interpreting adjective-noun phrases in this way contribute to the difficulty young children have in adjective comprehension? Ninio (2004) tested Hebrew-speaking children from 18-months to 5-years old on their ability to integrate adjectives and nouns by using a picture-pointing task, in which two objects were crossed with two properties in a set of four pictures (e.g., a black shoe, white shoe, black sock and white sock). In order to choose the correct picture when children were asked to point to the *black shoe*, it was necessary to integrate the meaning of *black* and *shoe* and find the picture that represented the combination of both adjective and noun. While children were only about 65% correct when they had to integrate an adjective and a noun, they were 87% correct when they only needed to use an adjective or a noun alone. It was also found that when children chose the wrong picture on integration trials, their error patterns reflected a noun-bias. That is, children chose the picture with the correct object but wrong property (e.g., the white shoe) twice as often as they picked the wrong object with the correct property (e.g., the black sock). This finding was interpreted as evidence that children do process adjective-noun phrases in two steps, getting the noun category first, but not always completing the process to narrow down the correct picture based on the adjective. However, this interpretation implies a temporal order of processing that is confounded with word order in Hebrew, where adjectives come after nouns.

Ninio's (2004) study leaves open some important questions. First, given the wide age-range that was tested, it is unclear if there are developmental differences in how children interpret adjectives and nouns in combination. Is difficulty with integration general or limited within the age-range tested? There may also be differences between younger and older children in their familiarity with the adjectives tested. English glosses of the adjectives children were tested on include words that an English-learning 18-month-old is quite unlikely to know (e.g., *short, naked, whole*) (Dale & Fenson, 1996), and there is no reason to believe young Hebrew-speaking children would be any more familiar with these properties. Thus, a second question is whether integration would still pose difficulty for children when they are only tested on words we are confident they are familiar with. Finally, a third question is whether the order of adjective and noun matters. Would the same pattern of integration difficulty emerge for English-speaking children who often hear adjectives *pre*-nominally? Would these children also be likely to interpret the noun first and then the adjective even when the two are heard in the reverse order?

These questions motivated the two studies reported here. In Experiment 1 we used a picture-pointing task similar to Ninio (2004) to test English-speaking children in three age groups on their *offline* ability to integrate adjectives and nouns. In Experiment 2 we focused on the age range that tended to show integration difficulty, using an *online* method to explore the moment-by-moment interpretation of adjective-noun phrases by 30- and 36-month-olds.

2. Experiment 1

2.1. Method

2.1.1. Participants

Participants in Experiment 1 were 60 children in three age groups: 18-22 months (M = 20 months, 10 girls and 10 boys), 28-32 months (M = 29 months, 9 girls and 11 boys), and 41-54 months (M = 45 months, 11 girls and 9 boys). All participants were reported to be typically developing children from homes in which English was the primary language spoken. Nine additional children were excluded from the final sample for the following reasons: unwillingness to complete the task (n=5); position bias (i.e., choosing pictures in the same location on over 50% of the trials; n=2); and experimenter error (n=2).

2.1.2. Design

Children in each age group participated in two within-subjects conditions. In the *adjective-noun integration* condition, children saw four pictures on each trial of two object types crossed with two attributes (e.g., a yellow fish, green fish, yellow balloon, and green balloon), and children were asked *Which is the yellow fish?* In the *adjective only* condition, the pictures on each page were of two objects with four different attributes (e.g., a yellow fish, green fish, dirty shoe and clean shoe), and children were asked, *Which is the yellow one?* This condition was designed as a control to test children's understanding of the property terms independent of their understanding of adjective-noun combinations. To keep the conditions comparable in difficulty children always saw four alternative choices and two object types in both conditions. The pictures used in the comprehension trials were identical to those used in the integration trials, only the grouping of the pictures differed by condition.

Each child received 10 trials in each condition. Conditions were blocked, and each subject was tested on the same 10 adjectives (drawn from a list of 20) in both conditions. The target adjective was applied to a different object in each condition, so children never had the same picture as the target more than once. Target location was randomized. Half of the sample received trials from the adjective-noun integration condition followed by trials from the adjective only condition, while the other half were presented with blocks in the reverse order.

2.1.3. Stimuli

The adjectives used in Experiment 1 were English translations of 20 of those used by Ninio (2004). Familiar nouns were chosen based on lexical development norms for 18-month-olds (Dale & Fenson, 1996) and paired with adjectives to make common plausible adjective-noun phrases. The visual stimuli were 8 x 10.5 cm color pictures consisting of a photograph of a familiar object on a neutral gray background. They were presented in square arrays of four each

on laminated pages. Verbal instructions were presented by the experimenter in natural child directed speech with equal stress placed on the adjective and noun.

2.1.4. Procedure

Children sat across a table from the experimenter and were shown the picture pages. Younger children sat in the lap of a parent instructed not to talk about or point to any of the pictures. Children in the youngest age group were first given two 'warm-up' trials in which they were shown pages with four pictures of familiar objects and asked e.g., *Where's the car?* On each experimental trial, children listened to the target sentence (e.g., *Which is the yellow fish?*) while looking at a solid-colored page to reduce distractions. The experimenter then turned the page and gave the child time to point to a picture in response. Children were allowed to self-correct (though only first responses were counted) and the experimenter moved on to the next page when it was clear the child was finished. If the child did not respond, the experimenter repeated the question up to two times and then moved on to the next trial. Test sessions were videotaped and a trained coder, blind to target word, coded the videotape of each session by recording the subject's initial choice on each trial.

2.1.5. Measures

Accuracy was defined as the percent of children's first responses that were correct in each condition. Trials on which children made no response were scored as incorrect. For each age group items that children as a group did not respond correctly to above the level predicted by chance (25%) in the adjective only condition were dropped from both conditions. Using this criterion the adjectives *awake, clean, dressed, little, long, short,* and *white* were dropped for the 18- to 22-month-olds; *clean, long* and *short* were dropped for the 28- to 32-month-olds, and none were dropped for the oldest group.

Errors in the adjective-noun integration condition were coded as one of three possible types: 1) *Noun Distracter* errors were defined as choosing the picture with the same object as the target picture but with a different attribute (e.g., choosing the green fish when asked for the yellow fish); 2) *Adjective Distracter* errors were choices of the picture of the incorrect object with the same attribute as the target (e.g., the yellow balloon); and 3) *Other* errors were choices of the picture that was different from the target by both object and attribute (e.g., the green balloon). Error type was recorded for all trials in which the child's first response was to a picture other than the target.

2.2. Results

2.2.1. Accuracy

Figure 1 depicts the accuracy scores for each age group in each condition. A repeated measures ANOVA revealed a main effect of age group $F(2, 56) = 47.26$, $p < .01$, a marginal main effect of condition, $F(1, 56) = 3.38$, $p = .07$, but no interaction of age group and condition. Planned comparisons revealed that for the 18-22 month group there were no differences between accuracy in the adjective only condition ($M = 46.6\%$, $SD = 17.9$) and the adjective-noun integration condition ($M = 46.2\%$, $SD = 18.1$). There were also no differences between accuracy in the adjective only condition ($M = 89.5\%$, $SD = 8.8$) and the adjective-noun integration condition ($M = 85\%$, $SD = 15.7$) for the 42-54 month group. However, for the middle age group of 28- to 32-month-olds there was a decrease in accuracy in the adjective-noun integration condition ($M = 60\%$, $SD = 18.2$) compared to the adjective only condition ($M = 71.6\%$, $SD = 23.6$), $t(19) = 1.71$, $p < .05$, one-tailed. Thus, for the middle age group only, having to integrate adjectives and nouns reduced accuracy compared to interpreting those same adjectives alone.

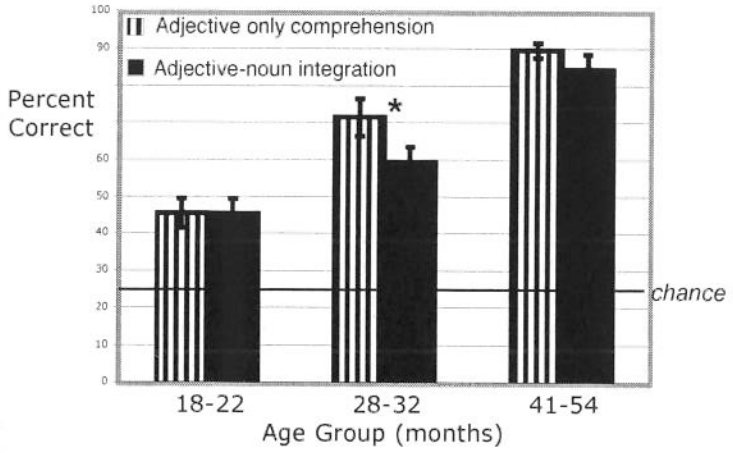

Figure 1: Mean accuracy scores for each age group in Experiment 1.

2.2.2. Errors

An analysis of the types of errors children committed on the integration task was also conducted. A repeated measures ANOVA revealed significant main effects for both error type, $F(2, 56) = 26.78$, $p < .001$, and age group, $F(2, 57) = 30.73$, $p < .001$, and an interaction between error type and age group, $F(4, 114) = 3.01$, $p < .05$. Children in all three age groups made more noun and adjective distracter errors than other errors. Thus, children were not simply choosing randomly; they were attending to at least the correct object or attribute on most of their incorrect choices. Children in the youngest 18-22 month age group made on average 5.2 errors ($SD = 1.5$) out of 10 integration trials, but showed no difference between noun and adjective distracter errors. Children in the oldest age group made very few errors overall ($M = 1.4$, $SD = 1.5$), and also showed no difference between noun and adjective distracter errors. However, in the middle

age group, 28- to 32-month-olds made on average 4.0 errors (SD = 1.6) and significantly more of them were noun distracter (M = 2.7, SD = 1.5) than adjective distracter errors (M = 0.95, SD = 0.8), $t(19) = 4.34$, $p < .001$. Thus again, only in the middle age group did children show a noun-biased error pattern—when asked for a *yellow fish* more often choosing another fish rather than another yellow object.

2.3 Discussion of Experiment 1

Experiment 1 demonstrated that young children do show signs of difficulty *integrating* adjectives and nouns in accord with the findings of Ninio (2004). However, this only held for children who were in their third year, 28- to 32-month-olds, presumably because children a year younger may only be just beginning to understand many adjectives, and children a year older are already proficient. In addition, errors of the two-and-a-half-year-olds show that they focused more on the nouns than the adjectives in adjective-noun constructions. We do not know, however, from these findings if noun-biased errors are the result of processing the noun first, or whether children simply have a better memory for the nouns compared to the adjectives. This is because Experiment 1 tested children's comprehension *after* the whole adjective-noun phrase had been heard, giving children an unlimited amount of time to respond.

Experiment 2 was designed to look more closely at the nature of children's difficulty with adjective-noun integration. Do young children have trouble with adjective-noun combinations because they wait to hear the noun before interpreting the adjective and thus have difficulty keeping both the adjective and noun in mind? The best way to begin answering this question was with an online procedure, in which we could track how children respond *as they heard* each word in an adjective-noun phrase. Thus, in Experiment 2 we used a looking-while-listening procedure (e.g., Fernald, Swingley, Pinto, Weinberg, & McRoberts, 1998) in order to test whether young children interpret potentially informative adjectives as soon as they are heard, or whether they wait to hear the noun before beginning interpretation.

Children in Experiment 2 looked at pairs of pictures while listening to speech naming one of them with a familiar color word and noun. We used the color words *red* and *blue* because out of adjectives familiar to young children, these are perceptually accessible and have relatively independent meanings of the nouns they modify. This gave children the best possible chance of being able to respond to the adjectives without waiting to hear the subsequent noun.

3. Experiment 2

3.1 Method

3.1.1. Participants

Participants in Experiment 2 were 64 children in two age groups: 1) 36-months (M = 36 months, 17 girls, 15 boys); and 2) 30-months (M = 30 months, 18 girls, 14 boys). All participants were reported to be typically developing and from families where English was the predominant language spoken. Three additional participants were excluded from the sample due to inattentiveness (i.e., failure to look at the pictures on more than 50% of the trials). All children in this sample were reported to correctly produce both color words.

3.2.2. Design

Children in both age groups participated in three within-subjects conditions. As a sentence was played labeling the target (e.g., *Where's the blue car?*) children saw pictures of either 1) *different objects* of the *same color* (e.g., blue car and blue house) in a control condition; 2) *different objects* of *different colors* (e.g., blue car and red house); 3) or *same objects* of *different colors* (e.g., blue car and red car). In the control condition the adjective did not distinguish which picture was the target, and thus children were expected to wait to hear the noun before responding. In the latter two conditions where the objects pictured differed in color, we expected children to look to the target picture sooner in response to the informative adjective if they could begin interpreting the phrase without waiting to hear the noun.

3.2.3. Stimuli

The speech stimuli were sentences labeling the target with an adjective (*red* or *blue*) and noun (*car* or *house*) recorded by a female native speaker of American English. Adjectives in the critical test sentences were comparable in duration (M = 273 ms, SD = 35), as were the target nouns (M = 585 ms, SD = 67). One of four attention-getter sentences (e.g., *Look at that!*) followed each target sentence to maintain children's interest. Sixteen filler trials naming additional familiar pictures in frames without adjectives were interspersed among 12 critical test trials. Visual stimuli were full-color photographs of objects named by the target words. Pictures were presented in pairs according to condition and matched approximately for size and brightness. Each item served once as the target object and once as the distracter in each of the three conditions. Side of the target picture was counterbalanced throughout the experiment.

3.2.4. Apparatus & Procedure

Children were tested individually with a caregiver present in a testing room containing a 1.5 x 2.1 m rear projection screen. The child sat on the caregiver's lap facing the screen at a distance of approximately 1.2 m. The caregiver wore sunglasses with lenses covered in black tape to block her view of the pictures and prevent her from influencing the child's responses. When the child was

attentive, the trials began. During testing, the pairs of pictures were presented on the screen in 36 x 50 cm rectangles, 64 cm apart. Speech stimuli were played over a central speaker on the floor below the screen. The child's gaze patterns were video-recorded with a camera positioned at eye level between the two pictures. On each trial, the pictures appeared for 2 s before the speech stimulus began to give the child time to look at both. Trials were separated by a 1 s pause when the screen went blank. Trial types were presented in a quasi-random order so that trials from the same condition did not occur consecutively and the target picture did not appear on the same side more than three times in a row.

A digital time-code accurate to 33 ms, and markers indicating the onset and offset of the pictures and speech stimulus on each trial were recorded onto the video of each participant's looking patterns. Each video record was coded frame-by-frame by trained observers, blind to trial type, target word, and side of target picture. Using custom software, coders indicated on each frame whether the child was fixating the left or right picture, shifting between the pictures, or away from both. Eye movement data were then temporally aligned with the onset of the adjective on each trial. This yielded a high-resolution record of the time course of each child's gaze patterns to the target and distracter pictures as the speech stimulus unfolded.

3.2.5. Measures

In order to investigate whether children would respond more rapidly when they could use information from the prenominal adjective in advance of the noun to identify the target, we measured *reaction time* (RT) to look to the target on trials on which the child happened to be looking to the distracter as the noun phrase began (distracter-initial trials). As in previous research of this kind, RTs less than 300 ms were excluded based on the assumption that the time it takes a child to hear some of a word then program and launch an eye movement in response would mean RTs less than 300 ms were likely initiated prior to the word of interest (e.g., Fernald et al., 1998; Swingley & Aslin, 2000). RTs longer than 2500 ms were also excluded, allowing children time to respond even after hearing the entire adjective-noun phrase, but excluding very late random shifts.

3.2. Results

3.2.1. 36-month-olds

Figure 2 shows the time course of 36-month-olds' orienting to the named target picture in each of the three conditions in Experiment 1. The top three lines depict distracter-initial trials on which children correctly shifted from the distracter to the target picture with changes in the proportion of distracter-to-target shifts plotted at 33 ms intervals as the sentence unfolds. Likewise, the three bottom lines depict target-initial trials with incorrect target-to-distracter shifts plotted as the sentence unfolds. Figure 2 shows that on distracter-initial trials in all three conditions orienting to the target picture began to increase

rapidly as children correctly identified the referent of the phrase. Meanwhile, on target-initial trials, there was relatively little change in the proportion of shifting away incorrectly over time. In both conditions in which the pictures differed in color, there was an earlier rise in distracter-to-target shifting compared to the control. This indicates that when the adjective was informative for identifying the target, children were looking to the correct picture before needing to hear the noun. Further, the overlap in curves for the two test conditions indicates that children were equally efficient at using the adjective early to identify the target regardless of whether both of the pictured objects were of the same kind. In all three conditions children reached the same level of correct looking to the target picture, but in the two conditions in which the color words could distinguish the target, children began shifting to it sooner.

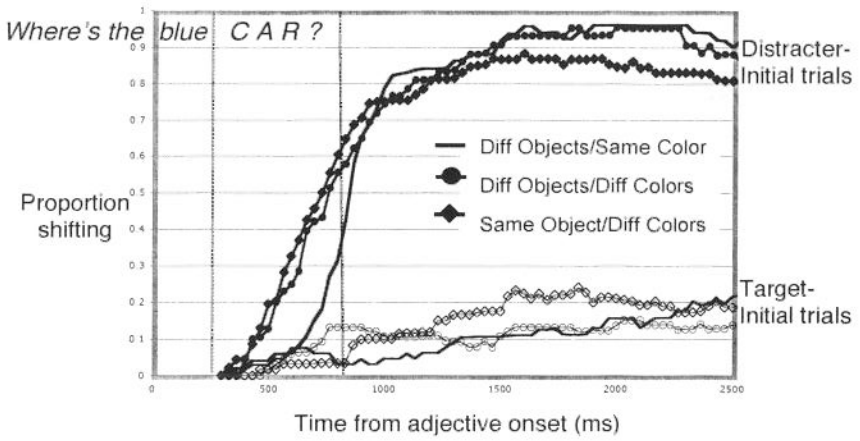

Figure 2: The time-course of 36-month-olds' looking patterns in Expt 2.

The average reaction time to shift from the distracter to the target picture was calculated for each child in each condition: Different Objects/Same Color (M = 868 ms, SD = 242), Different Objects/Different Colors (M = 727 ms, SD = 267), and Same Object/Different Colors (M = 686 ms, SD = 245). A repeated measures ANOVA revealed a marginal main effect of condition, $F(2, 36) = 2.87$, $p = .07$, and planned comparisons indicated that the Different Objects/Different Colors condition was different from the control, $t(22) = -2.10$, $p < .05$, and the Same Object/Different Colors condition was different from the control, $t(23) = -2.35$, $p < .05$. However, the two Different Colors conditions were not different from each other. Thus, 36-month-olds were faster to look to the target picture in both conditions when they heard an adjective that uniquely identified it than when they had to wait for the noun label.

3.2.2. 30-month-olds

Upon first inspection, the 30-month-olds, unlike the 36-month-olds, appeared not to use the adjectives in advance of the nouns in the two test conditions since the group as a whole showed no RT differences between conditions. However, closer examination of the response patterns of individual subjects indicated that we were actually averaging over two distinct groups of response types. These two response types were made clear when we divided children into *pre-nominal responders* and *post-nominal responders* based on their tendency to initiate a correct distracter-to-target shift before acoustic information from the noun could have been guiding responses (300-600 ms post adjective onset). *Pre-nominal responders* were children who made 50% or more of their correct shifts before 600 ms (n=13), and *post-nominal responders* were those children who never made an early shift to the target (n=13).

Figure 3 shows the time-course of responding for both groups of 30-month-olds. *Pre-nominal responders* (Fig 3A) appeared to respond similarly to the 36-month-olds, shifting early from distracter to target in the test conditions, and infrequently shifting incorrectly from target to distracter. However, *post-nominal responders* (Fig 3B) actually began shifting to the target *later* in the test conditions compared to the control. Additionally, the increase of *incorrect* target-to-distracter shifting in the Same Object/Different Color condition indicates serious confusion or disruption. As these children heard a sentence such as *Where's the blue car?* and were already looking at the blue car as the adjective began, they mistakenly shifted to the red car after hearing the noun and only shifted back to the target after some delay. These responses suggest that *post-nominal responders* at first had difficulty combining *blue* and *car* to refer to the only picture that matched both words. Most children in both groups did eventually look to the target by the end of the trial, and looking profiles for the control condition did not differ between the two groups, indicating that the latency and disruption that *post-nominal responders* demonstrated was a fleeting response only in the conditions that offered an informative adjective.

Reaction times for the two groups of 30-month-olds were compared, and pair-wise comparisons revealed that in the control condition *pre-nominal responders* (M = 883 ms, SD = 364) and *post-nominal responders* (M = 873 ms, SD = 159) were equally fast to look to the target. However, in the test conditions combined *pre-nominal responders* (M = 695 ms, SD = 229) were faster to look to the target than *post-nominal responders* (M = 1077 ms, SD = 205), $t(24)$ = 3.98, $p < .01$. Thus, *post-nominal responders* were not simply slower than their peers in general; rather, specifically having to integrate an informative adjective resulted in a delay for this group.

3.3 Discussion of Experiment 2

Experiment 2 showed that by 3 years, children are able to use adjectives efficiently, in advance of a noun to identify a referent. Additionally, around 30 months old children may be at an important developmental juncture. While

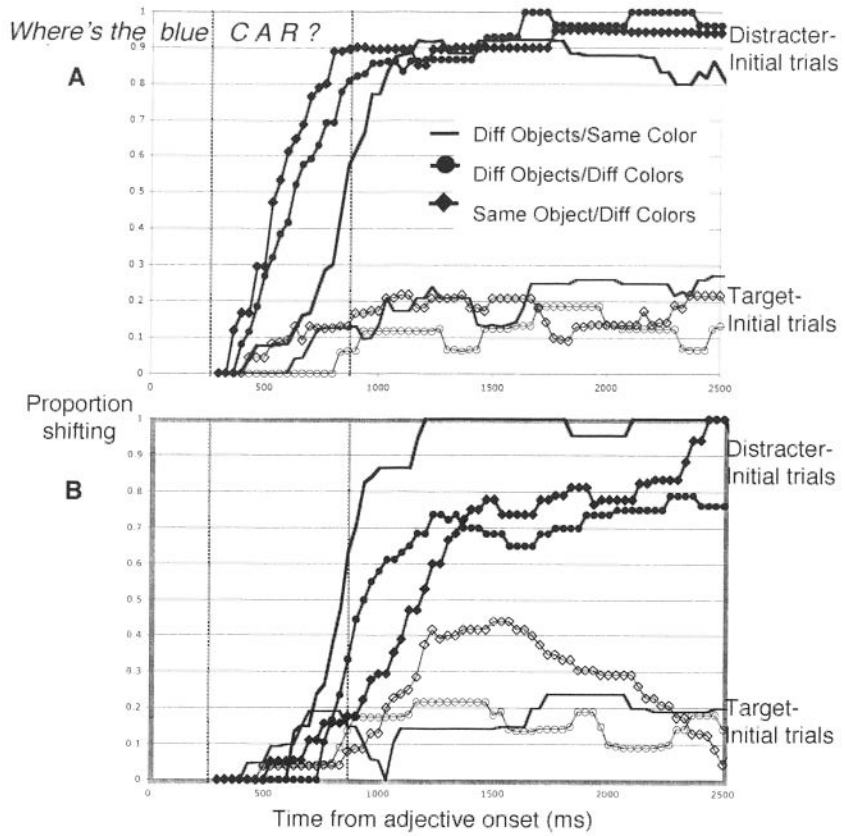

Figure 3: The time-course of 30-month-old pre-nominal (A) and post-nominal (B) responders' looking patterns in Experiment 2.

some were able to use adjectives as soon as they were informative like their peers six months older, other 30-month-olds were delayed and temporarily disrupted by hearing a potentially informative adjective. These children responded to the adjective-noun phrases qualitatively differently, not processing the adjective and noun in combination until after they had heard both, despite the fact that in the test conditions the adjectives alone could have distinguished the target.

4. General Discussion

Taken together, Experiments 1 and 2 illuminate the process of adjective-noun phrase processing for young English-speaking children. We now know that during the middle of the third year children have difficulty integrating adjectives and nouns in an task that requires keeping track of both words and combining

them. Additionally, around this time children may go through a change in how they process adjective-noun phrases *as* they are heard. Less mature children appear to process adjective-noun phrases sequentially, only integrating the two words once the whole phrase has been heard. More mature children can process adjective-noun phrases incrementally using adjectives to rapidly narrow down a possible referent without waiting to hear the noun when it is not necessary. For those children who do wait to hear the noun before interpreting the adjective-noun phrase, it may be that having to hold the adjective in mind while listening to the noun poses a memory demand. This demand may contribute to the difficulty children this age have with integration, and explain why children may be more likely to remember the noun correctly but forget the adjective.

What might determine whether 30-month-old children are *pre-* or *post-nominal responders*? This question is still open, but one likely possibility is that overall productive vocabulary may predict when children make this developmental shift. Recent research by Fernald, Perfors & Marchman (2006) shows that vocabulary size and processing speed are strongly related, such that the more words children have in their vocabularies, the faster they are at responding to familiar words, and the better they are at leveraging off those words to learn interpret word *combinations*.

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Children's Representation of Verbs: Evidence from Priming during Online Sentence Comprehension

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1. Introduction

The grammar of a natural language consists of generalized structures (or rules) defined over syntactic categories. To creatively produce sentences, a speaker needs to know which words in the language can instantiate which categories. An important question in language acquisition is how categorization unfolds over development. One influential proposal is that children gradually merge their representations of individual verbs to form abstract categories (the Verb Island hypothesis; see Tomasello, 2000). Early evidence for this view came from children's spontaneous production. For example, Tomasello (1992) found that his one-year-old daughter restricted most verbs to a single construction type, failing to use them in alternate permissible constructions, which she had used with other verbs. For example, while draw was used with locative and benefactive prepositional phrases, cut appeared only in simple transitive sentences. Observational studies, however, cannot tell us whether restricted usage reflects the input that the child receives, differences in the meanings of the verbs, or the limited range of situations that the child wishes to discuss. These issues have been addressed in production experiments with novel words (see Tomasello, 2000 for a review). For example, Tomasello & Brooks (1998) exposed children to a novel verb in an intransitive construction while modeling an action (e.g., The sock is tamming). Subsequently, they modeled the same action and tried to elicit transitive constructions from the children (e.g., He's tamming the car). While older children extended novel verbs to new constructions, 2-to-3-year-olds primarily used them in the constructions they were exposed to during training. The authors concluded that abstract representations of verbs and their thematic roles are generalizations over narrow lexical patterns that begin emerging around three to four years of age.

Fisher (2002) pointed out some problematic assumptions behind this interpretation. First, the constructions in which a verb can occur depend on a complex set of semantic constraints. Consider drop and fall. They have similar meanings and both can occur intransitively. Drop can also occur in transitive

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