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Infants' Use of Lexical-Category-to-Meaning Links
in Object Individuation

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Abstract

Infants watched an experimenter retrieve a stuffed animal from an opaque box and then return it. This happened twice, consistent with either one animal appearing on two occasions or two identical-looking animals each appearing once. The experimenter labeled each object appearance with a different novel label. After infants retrieved one object from the box, their subsequent search behavior was recorded. Twenty-month-olds, but not 16-month-olds, searched significantly longer for a second object inside the box when the labels were both proper names than when they were one count noun followed by one proper name. The effect was not significant when proper names were replaced by adjectives. Twenty-month-olds' understanding of meaning distinctions among several word categories guided their object individuation.

Infants' Use of Lexical-Category-to-Meaning Links in Object Individuation

By around two years, infants have learned that words from different lexical categories in their native language convey distinct types of meaning. Specifically, they have acquired the knowledge that novel words (e.g., "FEP") modeled linguistically as count nouns (e.g., "This is a FEP") label object categories, but those presented as members of other lexical categories carry different semantic implications. For example, infants of this age have discovered that words modeled as adjectives (e.g., "This is very FEP") designate object properties (e.g., Booth & Waxman, 2003; Waxman, 1999; Waxman & Booth, 2001; Waxman & Markow, 1998); words modeled as verbs (e.g., "This is FEP-ing") mark action categories (e.g., Echols & Marti, 2004); words modeled as prepositions (e.g., "This is FEP my box") label spatial locations (e.g., Fisher, Klingler, & Song, 2006); and words modeled as proper names (e.g., "His name is FEP") refer to individual objects (e.g., Bélanger & Hall, 2006; Hall, Lee, & Bélanger, 2001).

Knowledge of lexical-category-to-meaning links gives infants a valuable tool for constraining the interpretation of novel words. As a result, it significantly influences categorization behavior in a variety of word extension tasks. For example, in a study of infants' understanding of the distinction between count nouns and proper names, Bélanger and Hall (2006) taught infants a novel label for a stuffed animal. One group heard the word modeled as a count noun (e.g., "He is called a DAX"); another group heard the same word modeled as a proper name (e.g., "He is called DAX"). The animal was then moved to a new location in front of the infant, and a second same-looking animal was placed in the first animal's original location. Infants were asked to look at one of the two objects as a referent of the novel word, modeled either as a count noun (e.g., "Find a DAX") or as a proper name (e.g., "Find DAX"). At 16

months, infants' looking patterns were unaffected by the word's lexical category. At 20 months, however, infants looked first to the labeled animal significantly more often after hearing a proper name than after hearing a count noun (Bélanger & Hall, 2006; for further evidence, see Bélanger & Hall, in preparation; Hall et al., 2001; Liittschwager & Markman, 1993; Sorrentino, 2001; Sorrentino & Halberda, 2001). By 20 months, infants thus appeared to have learned lexical-category-to-meaning links for proper names and count nouns in their language, and this knowledge guided their interpretation of novel words.

Another fundamental task facing infants during conceptual development is object individuation. How do infants make appropriate decisions regarding the number of distinct objects present in a scene? Recent research suggests that labeling can influence these judgments. For example, Xu, Coté, and Baker (2005) presented 12-month-old infants with an opaque box into which they could reach but not see. In the two-word condition, the experimenter looked into the box and said, "Look, a FEP! Look, a WUG!" In the one-word condition, she said, "Look, a ZAV! Look, a ZAV!" After they retrieved one object from inside the box, infants were allowed to reach again. The duration of this second search was the dependent measure of interest, and since the box was empty, search time was interpreted as reflecting the strength of infants' expectation that the box contained two objects. Xu et al. found that 12-month-olds searched significantly longer in the two-word than in the one-word condition, suggesting that after hearing two different count nouns, infants inferred that two objects were hidden in the box. The finding also offers evidence that infants at this age expect that two different count nouns should not apply to one object, perhaps an early manifestation of the assumption of mutual exclusivity (Markman, 1989).

The previous work by Xu et al. (2005) focused on the effect of hearing count noun labels on object individuation among infants who have not yet acquired knowledge of multiple lexical-category-to-meaning links in their language. In the current research, we investigated labeling effects among older infants who have learned at least some of these links. We used a modified version of Xu et al.'s task (cf. Feigenson & Carey, 2003; Van de Walle, Carey, & Prevor, 2000; Xu & Baker, 2005) to explore whether these older infants can use their understanding of the distinct semantic implications of count nouns and proper names to individuate objects.

In our task, we first administered training trials on which infants saw that an opaque box could contain either one or two identical-looking stuffed animals. Infants then took part in two test trials. On each test trial, the experimenter showed infants a new opaque box, retrieved a stuffed animal from inside it, and then placed the animal back inside. The experimenter then repeated these actions, retrieving the same animal from inside the box and returning it. Because the two animal appearances looked identical, the event was ambiguous: It could have involved the same animal being shown twice or two different but identical-looking animals, each being shown once. As a result, it was possible to infer either that there was one animal or that there were two distinct but same-looking animals inside the box. Each time she retrieved the animal, the experimenter labeled it with a different novel word. On one test trial, infants heard a different proper name for each appearance of the animal (e.g., "His name is FEP"; "His name is BLICK"); on the other trial, they heard a count noun followed by a proper name for the two appearances of a stuffed animal of a different kind (e.g., "He is a MUV"; "His name is PRAZ"). On each test trial, the experimenter then invited infants to search for what was inside the box. After retrieving the sole stuffed animal that was inside, infants were allowed to search again. As in Xu et al.

(2005), our dependent measure was the duration of this second search, interpreted as a reflection of how strongly infants expected that the box contained two objects.

A test trial in our task had several distinctive features. To begin, it differed from a test trial in Xu et al.'s (2005) task in three primary ways. First, *the experimenter showed an object to accompany each novel word*, unlike Xu et al.'s task, in which the experimenter simply looked into the box when providing the labels. Second, *the experimenter provided a different novel label for each object emergence*, unlike Xu et al.'s task, in which the experimenter provided different novel words on one trial but repeated a single novel word on the other. Third, *the experimenter varied the lexical category of these labels*, unlike Xu et al.'s task, in which the experimenter presented all words as count nouns. Note also that infants in our task could not use spatio-temporal information to resolve the ambiguity surrounding the number of objects present in the box, because they saw only one object appearance at a time. Similarly, they could not use property or kind information, because the two object appearances had the same properties and were of the same kind. Infants could, however, potentially resolve the ambiguity by using the lexical category information accompanying each object appearance. The linguistic information differed between test trials, and for this reason, we interpreted differences in the duration of the second search on the two trials as reflecting infants' use of these lexical category cues to disambiguate the event.

If infants understand that novel count nouns designate object categories, whereas proper names mark individual objects, we expected that they would individuate the event differently on the two test trials. On the two proper names trial, we predicted that they would infer the presence of two stuffed animals inside the box (i.e., an animal named FEP, and another same-looking animal named BLICK), because they would judge two proper names for one object to be a

violation of the contrast principle (i.e., different words have different meanings; see Clark, 1993). If both words referred to the same object, they would both provide a name for the same individual object, in violation of the principle. As a result, we expected that infants would reject this possibility (see Hall & Graham, 1999). On the count noun-proper name trial, however, we anticipated that infants would be more likely to infer that the box contained only one object (i.e., an animal that was a MUV, whose name was PRAZ), because they would judge that one count noun and one proper name for one object would not violate contrast (i.e., the two words would have different meanings, one an object category term and the other a name for the individual object). As a result, we expected that they would allow the possibility that this pair of words applied to the same object. After they retrieved the single object inside the box, we thus expected that infants would search more persistently (i.e., longer) on the two proper names trial than on the count noun-proper name trial.

In Study 1, we tested 20-month-olds, using sentences that contained multiple cues to distinguish proper names from count nouns. We expected that these infants would know the semantic distinction between count nouns and proper names (cf. Bélanger & Hall, 2006) and, as a result, would individuate the event differently on the two trials. Study 2 was a modified replication of Study 1, in which the sentences containing the novel words held fewer cues to distinguish between count nouns and proper names. Study 3 was a replication of Study 1 with 16-month-olds. We predicted that they would not individuate the event differently on the two trials (cf. Bélanger & Hall, 2006). Studies 4 and 5 examined the basis for 20-month-olds' success on our task. Together, the studies provide the first assessment in the literature of whether infants' nascent understanding of distinct lexical-category-to-meaning links guides them in the fundamental task of object individuation.

Study 1

Method

Participants. Participants were 16 infants (8 girls and 8 boys) with an average age of 20.3 months (range = 18.5 - 22.5 months). We also tested, but excluded from the final sample, five infants for failing to complete the task, and one for having a search time longer than 2.5 standard deviations from the mean on at least one trial. In this and subsequent studies, all infants were acquiring English as their native language, and most were from middle- or upper-middle-class Caucasian families. Infants were recruited from a database maintained by a developmental research group in a university psychology department. Infants received a t-shirt and a certificate for participating; parents were reimbursed for parking or transit expenses.

Materials. On training trials, we used one stuffed dog and two identical stuffed monkeys. On test trials, we used one stuffed bear and one stuffed rabbit. All were between 12 cm and 18 cm in their longest dimension.

We also used one opaque box on training trials (44 cm x 30 cm x 21 cm) and two others on test trials (29 cm x 25 cm x 21 cm and 29 cm x 25 cm x 23 cm). Each had an opening on one side (roughly 17 cm x 10 cm), covered in fabric strips. As a result, infants could reach but not see inside.

The study was conducted at a table in a playroom of a developmental laboratory in a university psychology department. The experimenter sat at a 90-degree angle to the infant on the infant's left side. The infant sat either in a booster chair or on her parent's lap. A digital video camera recorded the infant's search behavior and was placed so that it faced the experimenter and captured the infant's right side profile.

Design and Procedure. All infants took part in two training trials followed by two test trials.

Training trials. The purpose of the training trials was to ensure that infants understood that a box could contain either one or two stuffed animals, and to give them experience in reaching inside. On the first trial, the experimenter placed the empty training box on the table in front of the infant, put the stuffed dog inside, and asked the infant, "Can you get what's inside?" If the infant did so, the experimenter offered praise, took the toy, and thanked her. Keeping the stuffed dog in the infant's view, the experimenter pushed the box back towards her and asked, "Do you think there's anything else inside the box?" The infant then received a second opportunity to search. Regardless of the infant's response, the experimenter took the box after 10 s, shook it, and said, "It's empty!"

The second trial was similar to the first, except that the experimenter placed the two identical-looking stuffed monkeys inside the empty training box. If the infant retrieved one toy on each of the two reach opportunities, the experimenter offered praise, took the toy, and thanked the infant each time. If the infant retrieved both toys on the first reach opportunity, the experimenter offered praise, took the toys, and thanked the infant.

On either training trial, if the infant failed to retrieve a toy that was still inside the box, the experimenter provided assistance by pulling a small part of the object through the opening. Any infant who still failed to retrieve a toy on either training trial was excluded from the study.

Proper Name-Proper Name (PN-PN) test trial. The experimenter placed one of the two test boxes on the table. The box already contained either the stuffed bear or the stuffed rabbit. The experimenter reached into the box, pulled out the toy, and repeated a novel proper name five times. She said, "Look! His name is FEP! Do you see FEP? I think FEP wants to come see you!"

Do you want to play with FEP?" The infant was allowed to play with the toy for approximately 10 s. The experimenter then took back the toy and thanked the infant. The experimenter said, "I'm going to put FEP back inside the box!" and placed the toy back inside.

The experimenter then reached back into the box and repeated the procedure, using a second proper name, "BLICK."

Count Noun-Proper Name (CN-PN) test trial. The experimenter placed the other test box on the table. It already contained the stuffed animal not used on the PN-PN trial. The procedure was the same as on the PN-PN trial, except that the experimenter presented the first novel word as a count noun. The experimenter said, "Look! He is a MUV! Do you see the MUV? I think the MUV wants to come see you! Do you want to play with the MUV?" Following the 10 s play period, the experimenter said, "I'm going to put the MUV back inside the box!"

The experimenter then reached back into the box and repeated the procedure, using a second word, "PRAZ," introduced as a proper name, exactly as on the PN-PN trial.

Note that the only linguistic difference between test trials was in the sentence frames used to introduce the first novel word. On the PN-PN trial, the first sentence frame containing the first novel word (a proper name) was "His name is ___", and the novel word in the four subsequent sentence frames had no determiner. On the CN-PN trial, the first sentence frame containing the first novel word (a count noun) was "He is a ___", and the determiner, "the", preceded the novel word in the four subsequent sentence frames.

On both test trials, the experimenter then pushed the box toward the infant, with the covered opening in front of the infant, and asked, "Can you get what's inside the box?" The infant was required to retrieve the single animal inside. If the infant did not do so, the experimenter provided assistance by pulling a small part of the object through the opening. Any

infant who still failed to retrieve the toy was excluded from the study. After retrieving the toy, the infant was allowed to play with it for approximately 10 s.

The experimenter then took the toy back, placed it in the infant's view, pushed the box back towards the infant, and gave the infant a second opportunity to search inside. The duration of this second search was our dependent variable. It is important to note that there was never a second object in the box on test trials. It is also important to note that infants never received any encouragement or assistance on this second search opportunity. If infants did not initiate a search within 10 s, the trial ended.

We counterbalanced between participants both the order of the two test trials (PN-PN and CN-PN) and the order in which we presented the two kinds of toys (bear and rabbit), ensuring that each kind of toy was used half the time on each type of test trial. We also counterbalanced between participants the order in which we presented the two words associated with each animal (i.e., "FEP" and "BLICK" for the bear; "MUV" and "PRAZ" for the rabbit).

Data Analysis. A primary coder, blind to trial order and trial type, coded the videotapes frame-by-frame for the duration of infants' second search. As in previous research using this paradigm (Van de Walle et al., 2000; Xu et al., 2005), we considered an infant to be searching inside the box when the knuckles that join the fingers to the hand were inside the box's opening. A second coder, also blind to trial order and trial type, subsequently re-coded the data. Inter-coder agreement was calculated to be $r = .99$. Trials on which there was a disagreement of 0.5 s or more between coders were reviewed by both coders together, discussed, and subsequently re-timed by the primary coder.

Results and Discussion

As predicted, 20-month-olds searched longer on the PN-PN trial than on the CN-PN trial. We conducted a 2 x 2 mixed analysis of variance (ANOVA) on the search duration data, with trial order (PN-PN first, CN-PN first) as the between-subjects factor, and trial type (PN-PN, CN-PN) as the within-subjects factor. The only significant effect was that for trial type, $F(1, 14) = 10.73$, $p = .006$, $\text{partial } \eta^2 = .434$ (see Figure 1). In addition, 12 of the 16 infants' second searches were longer on the PN-PN trial than on the CN-PN trial, $p = .038$ (1-tailed), by a sign test.

Twenty-month-olds searched more persistently for a second stuffed animal inside a box after observing two appearances of the same animal labeled with different proper names than after observing them labeled with a count noun followed by a proper name. The result suggests that 20-month-olds distinguished between proper names and count nouns, and it indicates that they were more likely to expect two objects to be in the box after hearing two proper names than after hearing the combination of a count noun followed by a proper name. The finding also suggests that infants' nascent knowledge of the semantics of different lexical categories guided their object individuation.

The results are consistent with the claim that 20-month-olds understand that proper names label individual objects, whereas count nouns label object categories. The findings also suggest that infants have knowledge of conditions under which two novel words should pick out two objects, such as when the words would violate the contrast principle if they referred to the same object (Clark, 1993). If infants understand these lexical-category-to-meaning links and honor contrast, then we would expect them to reject two proper names for the same object, because the two words would have the same meaning (i.e., they would both refer to the same individual object). We would not, however, expect infants to reject the combination of one count

noun followed by one proper name for one object, because this word combination would not violate contrast (i.e., the words would have different meanings; one would refer to an object category, whereas the other would refer to an individual object) (see Clark, 1993; see also Diesendruck, 2005; Hall & Graham, 1999).¹

In Study 1, infants received multiple linguistic cues to help them distinguish proper names from count nouns. The sentences containing the first mention of the terms differed by three words (i.e., "His name is ____" vs. "He is a ____"). The sentences containing the subsequent four mentions of the word differed in terms of the absence or presence of the determiner, "the". However, recent research (Bélanger & Hall, 2006, in preparation) has found evidence that 20-month-olds can distinguish semantically between proper names and count nouns, given only the absence or presence of the determiner as a cue. In Study 2, we sought to replicate the results of Study 1, giving infants only this minimal cue.

Study 2

Method

Participants. Participants were 16 infants (7 girls and 9 boys), with an average age of 20.7 months (range = 19.0 - 22.3 months). None had taken part in Study 1. We also tested, but excluded from the final sample, one infant for failing to complete the task, and two for having a search time longer than 2.5 standard deviations from the mean on at least one trial.

Materials. These were the same as in Study 1.

Design and Procedure. These were the same as in Study 1, except that the sentence frames containing the first mention of the proper name and the count noun now differed only in terms of the presence or absence of a determiner ("a" or "the") before the novel word. Proper names were first introduced in the sentence, "This is ____"; count nouns were introduced in the

frame, "This is a ____". Note that this change in wording makes the task of identifying the proper names more challenging, because the frame, "This is ____," leaves open the possibility that the novel word is a proper name (e.g., "This is John"), an adjective (e.g., "This is pink"), or a mass noun (e.g., "This is fur"). As a result, infants in Study 2 needed to rely on the subsequent four sentences to establish unambiguously that the novel word was a proper name (e.g., "I think X wants to come see you" is felicitous only if "X" is a proper name).

Data Analysis. Coding was carried out as in Study 1. Inter-coder agreement was calculated to be $r = .95$.

Results and Discussion

As in Study 1, 20-month-olds searched longer on the PN-PN trial than on the CN-PN trial. We conducted the same ANOVA as in Study 1. The only significant effect was that for trial type, $F(1, 14) = 5.28, p = .038$, partial $\eta^2 = .274$ (see Figure 2). Unlike Study 1, however, only 10 of the 16 infants' second reaches were longer on the PN-PN trial than on the CN-PN trial, non-significant by a sign test.

As in Study 1, 20-month-olds appeared to distinguish between proper names and count nouns, and the findings again suggest that infants were more likely to expect two objects in the box after hearing two proper names than after hearing the combination of a count noun followed by a proper name. However, the trial type effect size was smaller in this study (partial $\eta^2 = .274$) than it was in Study 1 (partial $\eta^2 = .434$), as was the number of infants searching longer on the PN-PN trial (10 in Study 2 vs. 12 in Study 1). This difference between studies suggests that infants' ability to distinguish between the two lexical categories was weaker when they received only the presence or absence of a determiner as a cue to the distinction.

To analyze the effect of the number of linguistic cues on the effect of trial type, we combined the data from Studies 1 and 2 and conducted a 2 x 2 x 2 mixed ANOVA, with number of cues (multiple in Study 1, minimal in Study 2) and trial order (PN-PN first, CN-PN first) as between-subjects factors, and trial type (PN-PN, CN-PN) as a within-subjects factor. There were no interactions involving number of cues, suggesting that despite any apparent differences between the results of the two studies, 20-month-olds distinguished comparably between proper names and count nouns in both.

Study 3 was an attempt to replicate the results of Study 1 with 16-month-olds. In previous research, children of this age have failed to distinguish between proper names and count nouns in a categorization task involving word extension (Bélanger & Hall, 2006; see also Bélanger & Hall, in preparation). As a result, we predicted that 16-month-olds would search equivalently on the two test trials of our individuation task.

Study 3

Method

Participants. Participants were 16 infants (8 girls and 8 boys), with an average age of 16.5 months (range = 15.4 - 17.8 months). We also tested, but excluded from the final sample, seven infants for failing to complete the task, and one for having a search time longer than 2.5 standard deviations from the mean on at least one trial.

Materials. These were the same as in Study 1.

Design and Procedure. These were the same as in Study 1.

Data Analysis. Coding was carried out as in Study 1. Inter-coder agreement was calculated to be $r = 1.0$.

Results and Discussion

Unlike Study 1, 16-month-olds did not search significantly longer on the PN-PN trial than on the CN-PN trial. We conducted the same ANOVA as in Study 1. There were no significant effects, including that for trial type, $F(1, 14) = 0.23, p = .64, \text{partial } \eta^2 = .016$ (see Figure 3). Only 6 of the 16 infants' searches were longer on the PN-PN trial than on the CN-PN trial, non-significant by a sign test.

Why did 16-month-olds not search significantly longer on the PN-PN trial than on the CN-PN trial? One possibility is that 16-month-olds simply fail at this type of search task. This alternative can be ruled out by prior demonstrations that infants as young as 10 to 12 months succeed in similar search tasks when given spatio-temporal or property/kind information (e.g., Feigenson & Carey, 2003; Van de Walle et al., 2000; Xu & Baker, 2005). Another possibility is that 16-month-olds are unable to use verbal information in search tasks. This alternative can be ruled out by the findings of Xu et al. (2005), revealing that infants as young as 12 months can use verbal information successfully in a similar search task. Given these considerations, we interpret the failure in Study 3 as reflecting the fact that, unlike 20-month-olds, 16-month-olds did not distinguish semantically between proper names and count nouns, and as a result, were no more likely to expect two objects after hearing two proper names than after hearing the combination of a count noun followed by a proper name.

The results of Study 3 (with 16-month-olds) differed clearly from those of Study 1 (with 20-month-olds). In Study 3, the effect of trial type was not significant, the effect size was small ($\text{partial } \eta^2 = .016$), and a non-significant number of infants (6/16) showed the effect. In Study 1, recall that the effect of trial type was significant, the effect size was larger ($\text{partial } \eta^2 = .434$), and a significant number of infants (12/16) showed the effect. To follow up these separate

analyses, we performed a direct between-study comparison. We combined the search duration data from Studies 1 and 3 and conducted a 2 x 2 x 2 mixed ANOVA, with age (16-month-olds in Study 3, 20-month-olds in Study 1) and trial order (PN-PN first, CN-PN first) as between-subjects factors, and trial type (PN-PN, CN-PN) as a within-subjects factor. In this follow-up analysis, there was a main effect of trial type, $F(1, 28) = 6.23, p = .019$, partial $\eta^2 = .182$, but the expected interaction between trial type and age failed to reach significance, $F(1, 28) = 3.16, p = .086$, partial $\eta^2 = .101$. The fact that this interaction approached but did not attain significance is consistent with the possibility that sensitivity to the semantic distinction between proper names and count nouns is starting to emerge at 16 months.

These findings converge with previous results from Bélanger and Hall (2006), who found that 16-month-olds, unlike 20-month-olds, failed to distinguish between proper names and count nouns in a categorization task involving word extension. Note that Bélanger and Hall's task implicated very different abilities from those implicated by the current task: their task assessed whether infants can extend novel proper names and count nouns appropriately; the current task, in contrast, assessed whether infants can use the proper name-count noun distinction to determine the number of objects present in a situation in which numerical identity is ambiguous. The agreement between the results from the two tasks thus lends further support to the proposal that infants acquire knowledge of the distinct semantics of these lexical categories between 16 and 20 months.

Study 4 was an attempt to clarify the basis for the trial type effect uncovered in Study 1. In Study 1, the second novel word was presented in the same sentence frames on both trials (i.e., as a proper name). However, the first novel word was presented in different sentence frames on the two trials, depending on whether it was a proper name or a count noun. We have suggested

that infants relied on the difference between the sentence frames carrying the first word on the two trials to guide them in our task. However, we were also aware of a prosodic difference between trials associated with the sentence frames containing the *second* novel word. On the PN-PN trials (where the previous word had also been a proper name), the experimenter tended to place stress on the word "his" in the initial sentence frame, "His name is ___"; however, on the CN-PN trials (where the previous word had been a count noun), she tended to place emphasis on the word "name" in the same sentence frame. We wondered whether infants relied on this prosodic difference to guide their interpretations.

We began to address this issue by seeking evidence that adults could detect a prosodic difference between the initial sentence frames containing the second word when presented on the two trials. We obtained the audio clips of the presentation of this sentence frame from both trials from all 16 children in Study 1. This yielded 32 clips, each involving the presentation of a novel proper name. For 16 of the recordings, the word had been preceded by another proper name (i.e., on the PN-PN trial); for the other 16, the preceding word had been a count noun (i.e., on the CN-PN trial). Four adults listened to all these clips in a random order and decided, for each one, whether they heard stress on the word "his" or on the word "name."

We scored each adult's set of responses out of 32 to reflect their accuracy in grouping the recordings into those from the PN-PN trial and those from the CN-PN trial. A score of 50% (16/32) was taken to be random performance, and scores higher than 50% were taken to reflect successful categorization (i.e., judging stress on "his" on a PN-PN trial). All four adults were perfect (32/32) in their grouping. They thus detected a prosodic difference between the initial sentence frames containing the second word on the two trials in Study 1.

Our next step was to determine whether the prosodic difference in Study 1 contributed to the trial type effect discovered in that study. To do so, we conducted Study 4 as a replication of Study 1 with one change: We presented the second word with a similar prosody on the two trials.

Study 4

Method

Participants. Participants were 16 infants (8 girls and 8 boys), with an average age of 20.7 months (range = 18.0 - 22.4 months). None had taken part in any previous study. We also tested, but excluded from the final sample, seven infants for failing to complete the task, and two for having a search time longer than 2.5 standard deviations from the mean on at least one trial.

Materials. These were the same as in Study 1.

Design and Procedure. These were the same as in Study 1, except that the experimenter was trained to present the second word on the two trials using similar prosody.

Data Analysis. Coding was carried out as in Study 1. Inter-coder agreement was calculated to be $r = 1.0$.

Before analyzing the data, we conducted a manipulation check. We enlisted the same four adults who coded the prosody of the initial sentence frames containing the second word for the Study 1 data to partition clips of these sentence frames for the Study 4 data, given the same directions. Recall that for the Study 1 data, all four adults had perfectly divided the clips into those from the PN-PN trial and those from the CN-PN trial (i.e., the average score was 100%). In contrast, adults in Study 4 were essentially random in the accuracy of their grouping. The average accuracy score was 51% (15/32, 16/32, 17/32, 17/32). This result suggests that adults did not detect a systematic prosodic difference in the way the initial sentence frames containing the second word were presented on the two trials. This finding does not imply that we eliminated all

prosodic differences, or that infants similarly found no systematic prosodic difference between the sentences containing the second words on the two trials. However, the finding does suggest that the prosodic difference between trials identified in Study 1 was significantly reduced in Study 4.

Results and Discussion

As in Study 1, 20-month-olds searched longer on the PN-PN trial than on the CN-PN trial. We conducted the same ANOVA as in Study 1. The only significant effect was that for trial type, $F(1, 14) = 7.24, p = .018, \text{partial } \eta^2 = .341$ (see Figure 4). As in Study 1, 12 of the 16 infants' second reaches were longer on the PN-PN trial than on the CN-PN trial, $p = .038$ (one-tailed), by a sign test.

Despite the fact that we controlled the prosodic information provided with the second word on the two trials, 20-month-olds still appeared to distinguish between proper names and count nouns, and they again seemed more likely to expect two objects in the box when given two proper names than when given the combination of a count noun followed by a proper name. This result suggests that the prosodic difference identified by adults in the data from Study 1 was not the source of the trial type effect observed in that study; instead, the finding suggests that the source of the effect was the difference between the sentence frames in which the proper names and count nouns appeared.

Study 5 was an attempt to clarify further the effect of trial type observed among 20-month-olds. As noted in Study 1, one interpretation is that the effect stems from infants' understanding of the distinct semantics of proper names and count nouns, coupled with adherence to the contrast principle. An alternative, however, is that the effect reflects infants' understanding of the pragmatic implications of a speaker's using two novel object labels from

the same lexical category rather than two labels from different lexical categories. On this alternative, infants infer that a speaker who uses two novel labels from the same lexical category likely intends to use them contrastively to refer to two different objects, whereas they draw no such inference about a speaker who uses two words from different lexical categories. On this alternative, the trial type effect is not due to specific knowledge about the distinct semantics of proper names and count nouns.

In Study 5, we tested between these alternatives by replicating Study 4, but replacing proper name sentence frames with adjective sentence frames. Unlike proper names, which refer to individual objects, adjectives refer to object properties. Recent research suggests that infants have some understanding of the link between adjectives and object properties by as young as 14 months (e.g., Booth & Waxman, 2003; Waxman, 1999). If the findings we obtained with 20-month-olds in our previous studies reflect infants' inferences about a speaker's intended use of two words from the same lexical category rather than two words from different lexical categories, then we should have replicated the significant trial type effect observed in Study 4. In other words, we should have found that the trial type effect that emerged when we compared two proper names to the combination of one count noun followed by one proper name also emerged equivalently when we compared two adjectives to the combination of one count noun followed by one adjective.

If, however, the effect observed with 20-month-olds in our previous studies reflects infants' knowledge of the distinct semantics of proper names and count nouns, coupled with adherence to the contrast principle, then the trial type effect should have been *weaker* in Study 5. To understand this expectation, note that the contrast principle makes different predictions about the interpretation of adjectives in our task than it does about the interpretation of proper names.

Allowing two proper names for one object would violate the contrast principle, because the words would have the same meaning (i.e., they would both be labels for the same individual object). Allowing the combination of one count noun followed by one proper name would *not* violate contrast, however, because the words would have different meanings (i.e., one would label an object category, and the other would label an individual object). As a result, infants in our task should reject two proper names for one object but be willing to accept the combination of one count noun followed by one proper name. This prediction was supported by the significant trial type effect observed with 20-month-olds in the previous studies.

If adjectives replace proper names in our task, however, the prediction changes. Allowing two novel adjectives for one object would *not* necessarily violate the contrast principle, because the words could have different meanings (i.e., they could be labels for different object properties). Similarly, allowing one count noun followed by one adjective would not violate the contrast principle, because the two words would have different meanings (i.e., one would label an object category, and the other would label an object property). As a result, infants should be willing to accept both the possibility that two adjectives apply to the same object as well as the possibility that the combination of one count noun followed by one adjective applies to that object (see also Diesendruck, Hall, & Graham, 2006; Hall & Graham, 1999). The trial type effect that we observed with 20-month-olds in our previous studies should thus be weaker when we replaced proper names with adjectives in our task.

Study 5

Method

Participants. Participants were 16 infants (8 girls and 8 boys), with an average age of 20.6 months (range = 18.1 - 22.5 months). None had taken part in any previous study. We also

tested, but excluded from the final sample, four infants for failing to complete the task, and two for having a search time longer than 2.5 standard deviations from the mean on at least one trial.

Materials. These were the same as in Study 4.

Design and Procedure. These were similar to those used in Study 4, except that the novel words modeled as proper names in Study 4 were now modeled as adjectives. As a result, the two trials were named the adjective-adjective (ADJ-ADJ) trial and the count noun-adjective (CN-ADJ) trial. The five sentence frames we used to present the adjectives were similar to those used to present proper names in Study 4: "Look! He is really FEP! Do you see? He is very FEP! Look! He is very FEP! I think he wants to come see you! Do you want to play with him? He is very FEP! Look, he is very FEP! I'm going to put him back inside the box!"

Data Analysis. Coding was carried out as in Study 1. Inter-coder agreement was calculated to be $r = .99$.

As in Study 4, we conducted a manipulation check to determine whether adults detected any systematic prosodic difference between the sentence frames containing the first mention of the second word on the two trials (i.e., "He is really ____"). As in Study 4, the four adult raters were essentially random in the accuracy of their partitioning of the 32 recordings into those that were from the ADJ-ADJ trial (i.e., judged stress on "he") and those that were from the CN-ADJ trial (i.e., judged no stress on "he"). The average accuracy score was 50% (18/32, 18/32, 13/32, 15/32). This finding suggests that adults did not detect any systematic prosodic difference between the initial sentence frames containing the second novel word on the two trials.

Results and Discussion

Twenty-month-olds did not search significantly longer on the ADJ-ADJ trial than on the CN-ADJ trial. We conducted the same ANOVA as in Study 1. There were no significant effects,

including that for trial type, $F(1, 14) = 1.38, p = .26$, partial $\eta^2 = .089$ (see Figure 5). Only 8 of the 16 infants' searches were longer on the ADJ-ADJ trial than on the CN-ADJ trial, non-significant by a sign test.

When we replaced proper names with adjectives in the task from Study 4, 20-month-olds did not search significantly more persistently after hearing two novel words from the same lexical category (two adjectives) than after hearing two words from different lexical categories (one count noun followed by one adjective). This discovery suggests that the significant trial type effect observed with 20-month-olds in Study 4 was not driven solely by our use of two words from the same lexical category rather than two words from different lexical categories. Instead, the result offers support for the claim that the effect reflected infants' knowledge of the distinct semantics of count nouns and proper names, coupled with adherence to the principle of contrast.

The results of Study 5 (with adjectives) clearly differed from those of Study 4 (with proper names). In Study 5, the trial type effect was not significant, the effect size was modest (partial $\eta^2 = .089$), and a non-significant number of infants (8/16) showed the effect. In Study 4, however, the effect of trial type was significant, the effect size was larger (partial $\eta^2 = .341$), and a significant number of infants (12/16) showed the effect. To follow up these separate analyses, we carried out a direct between-study comparison. We combined the search duration data from Studies 4 and 5 and conducted a 2 x 2 x 2 mixed ANOVA, with lexical category (adjectives in Study 5, proper names in Study 4) and trial order (two words from same lexical category first, two words from same lexical category second) as between-subjects factors, and trial type (two words from same lexical category, two words from different lexical categories) as a within-subjects factor. In this follow-up analysis, there was a significant effect of trial type, F

(1, 28) = 6.52, $p = .016$, partial $\eta^2 = .189$, but the expected interaction between lexical category and trial type was not significant, $F(1, 28) = 0.46$, $p = .50$, partial $\eta^2 = .016$.

Close inspection of the results from Studies 4 and 5 reveals a way to reconcile the apparent conflict between the non-significant trial type effect in the analysis of Study 5 and the non-significant interaction between lexical category and trial type in the cross-study analysis. In Study 5, although the trial type effect was non-significant, the difference between trial means was in the predicted direction, indicating that infants had a weak tendency to expect two objects upon hearing two adjectives. However, the trial type effect was more than three times *larger* when the study involved proper names (partial $\eta^2 = .341$) than when it involved adjectives (partial $\eta^2 = .089$). The stronger effect in Study 4 (with proper names) and the weaker effect in Study 5 (with adjectives) thus lend support to two claims. First, infants *did* distinguish between the use of proper names and adjectives in our task. This discovery suggests that the effect uncovered in Study 4 reflects infants' knowledge of the semantic distinction between proper names and count nouns, along with adherence to the principle of contrast. Second, infants also had a weaker pragmatic tendency to infer that a speaker who used two words from the same lexical category (either two proper names or two adjectives) intended the words to apply to two different objects.

General Discussion

The results of these five experiments provide the first evidence in the literature that infants' emerging understanding of distinct lexical-category-to-meaning links guides them in the fundamental task of object individuation. The findings make three main contributions. First, they reveal a previously unidentified source of information available to drive individuation in infancy. Prior work has established that by 12 months (or earlier), infants can use information about both

spatio-temporal differences and property/kind differences between objects to guide individuation (Bonatti, Frot, Zangl, & Mehler, 2002; Wilcox & Baillargeon, 1998; Wilcox & Schweinle, 2002; Xu & Baker, 2005; Xu & Carey, 1996; Xu, Carey, & Quint, 2004). Previous research has also identified a role for language. For example, 10-month-old infants often fail to use property/kind differences between objects to individuate them in a complex task, but they may succeed when the objects receive distinct count noun labels (Xu, 2002). Moreover, Xu et al. (2005) found that 12-month-olds who heard two different novel count nouns were more likely to infer the presence of two objects hidden inside an opaque box than those who heard one count noun repeated. The current work reveals that, in addition to these cues, 20-month-old infants can use lexical category information to guide object individuation. Specifically, they can exploit this information to disambiguate an event that involves two sequential appearances of an object.

It would be interesting to push this line of research further by removing the presence of the object(s) from the task. The results from the current task do not allow us to determine whether infants needed to see the object appearances in order to use the lexical category information appropriately in drawing inferences about the number of objects hidden in the box. Eliminating the objects from the task would enable a test of whether infants can use lexical category information *alone* to set up a mental model of the number of objects present in an ambiguous scene. Moreover, if we take the presentation of one or more objects to be a defining property of an object individuation task, infants' success on this modified task would suggest that they have the ability to use lexical category cues to predict the number of objects present in the ambiguous situation, without individuating objects *per se*. In future work, it would be interesting to examine infants' use of lexical category information in this type of modified task (see Dewar & Xu, 2007; Xu et al., 2005).

Second, the results provide the first evidence from a manual search task that by 20 months, infants have acquired knowledge of appropriate semantic distinctions among three word categories (proper names, count nouns, and adjectives). The results are consistent with a body of research reporting knowledge of several distinct lexical-category-to-meaning links in children younger than two years (e.g., Booth & Waxman, 2003; Echols & Marti, 2004; Waxman, 1999; Waxman & Booth, 2001; Waxman & Markow, 1998). More specifically, the current results corroborate recent findings from a study that used a categorization task involving word extension to investigate infants' knowledge of the distinct semantics of proper names and count nouns (Bélanger & Hall, 2006). In that study, as in the current one, 20- but not 16-month-olds distinguished appropriately between these two lexical categories. The agreement between the results of the two studies provides evidence that lexical category knowledge is available to guide infants in a manual search task as soon as it can be used to direct them in word extension. The convergence between the search and word extension results also bolsters the claim that knowledge of lexical-category-to-meaning links for proper names and count nouns first arises between 16 and 20 months.

Finally, the findings offer new evidence that infants use the principle of contrast in the acquisition of novel words. The effects we observed among 20-month-olds cannot be due solely to their knowledge of the semantics of different lexical categories. Infants must also have an understanding of circumstances under which the use of two novel words implies reference to two different objects, such as when the two words would violate the contrast principle (Clark, 1993) if they referred to just one object. In our task, two novel proper names for one object would violate the contrast principle, because both words would have the same meaning (i.e., the words would both refer to the *same* individual object). Two novel adjectives for one object, however,

would not necessarily violate the contrast principle, because they could be taken to have different meanings (i.e., the words could refer to *different* object properties). The combination of a count noun followed by a proper name or a count noun followed by an adjective for one object would not violate contrast, because the two terms would have different meanings (i.e., one would refer to an object category and the other to an individual object or an object property). It is possible that infants represent the contrast principle as a semantic constraint on the possible meanings that can be assigned to novel words; but it is also possible that it is a pragmatic assumption about a speaker's intended use of words within a discourse context (see Bloom, 2000; Clark, 1993; Diesendruck, 2005; Diesendruck & Markson, 2001).² Furthermore, the results from Study 5 suggest that infants have an additional, weaker expectation that a speaker who uses two novel words from a single lexical category intends to refer to two different objects, even when the words would not necessarily violate the contrast principle if applied to one object (as in the case of two novel adjectives). Further research manipulating the conditions under which infants are exposed to multiple novel words for objects should help to clarify the nature of their assumptions about the possible semantic relations that can hold among them.

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Footnotes

1. Note that our interest was in determining whether there were *any* circumstances under which infants would distinguish a trial involving two proper names (i.e., a PN-PN trial) from a trial involving one count noun and one proper name. We obtained our positive evidence using a trial on which the count noun *preceded* the proper name (i.e., a CN-PN trial). We make no claim about 20-month-olds' ability to distinguish a PN-PN trial from a PN-CN trial, though we have no a priori reason to expect that they would be unable to do so.

2. One piece of evidence favoring the pragmatic account is that many objects do have more than one proper name (e.g., one man may be called "William," "Bill," or "Mr. Smith" by different people and/or in different settings); however, it is unclear whether 20-month-olds possess this knowledge (for further discussion of pragmatics and the contrast principle, see Bloom 2000; Diesendruck, 2005).

Figure Captions

Figure 1. Results of Study 1. Bars represent 1 standard error.

Figure 2. Results of Study 2. Bars represent 1 standard error.

Figure 3. Results of Study 3. Bars represent 1 standard error.

Figure 4. Results of Study 4. Bars represent 1 standard error.

Figure 5. Results of Study 5. Bars represent 1 standard error.









