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Discontinuity of Reference Hinders Children's Learning of New Words

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When referring to objects, adults package words, sentences, and gestures in ways that shape children's learning. Here, to understand how continuity of reference shapes word learning, an adult taught new words to 4-year-old children (N = 120) using either clusters of references to the same object or no sequential references to each object. In three experiments, the adult used a combination of labels and other object references, which provided informative discourse (e.g., *This is small and green*), neutral discourse (e.g., *This is really great*), or no verbal discourse. Switching verbal references from one object to another interfered with learning relative to providing clustered references to a particular object, revealing that discontinuity in discourse hinders children's encoding of new words.

Children are adept at finding structure in the complexities of language input, but their learning varies substantially. To better understand individual differences, researchers have examined various features of caregivers' input known to influence vocabulary growth, including social cues (e.g., eye gaze and pointing; Booth, McGregor, & Rohlfing, 2008; Brooks & Meltzoff, 2008), structural cues (e.g., repetition and utterance length; Brent & Siskind, 2001; Lew-Williams, Pelucchi, & Saffran, 2011; Schwab & Lew-Williams, 2016a), visual cues (e.g., the size and perceptual salience of objects in the visual field; Pereira, Smith, & Yu, 2014; Pruden, Hirsh-Pasek, Golinkoff, & Hennon, 2006), and auditory cues (e.g., intonation and pitch; Ma, Golinkoff, Houston, & Hirsh-Pasek, 2011; Singh, Nestor, Parikh, & Yull, 2009). Recent research suggests that another contextual cue in caregivers' speech may shape children's vocabulary development: the structure and content of discourse. Caregivers' utterances to their children tend to refer to the same topics or objects across time (e.g., Frank, Tenenbaum, & Fernald, 2013; Hoff-Ginsberg, 1994; Ochs & Schieffelin, 1995), and this discourse continuity may help children learn new words (Horowitz & Frank, 2015; Sullivan & Barner, 2016). The present research examined the mechanisms by which discourse continuity affects word learning. Experiment 1 attempted to confirm that children learn new words better when object-related verbal references are continuous as opposed to discontinuous. Next, Experiments 2 and 3 attempted to clarify *why* this would be the case. First, does the apparent benefit of discourse continuity depend on the content of verbal references, that is, do children only show better word learning from continuous compared to discontinuous verbal discourse when references are descriptive and informative? Second, what is the nature of the relation between word learning and discourse continuity? Do clusters of verbal references to the same object *promote* children's learning, or do interleaved verbal references *hinder* children's learning?

Young children are clearly sensitive to discourse structure. For example, they understand that adults pay attention to—and talk about—information that is new to an interaction. When an object is new to the discourse only from an adult's point of view, 24-month-olds are able to use this novelty to infer reference and learn the object label (Akhtar, Carpenter, & Tomasello, 1996). Relatedly, 2-year-olds have been shown to use speakers' speech disfluencies to predict their intended referents during object labeling (Kidd, White, & Aslin, 2011). Cross-

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linguistic research has revealed that children who hear more consistent referential patterns within discourse—specifically regarding the use of either null, pronominal, or lexical verb arguments—tend to produce more consistent discourse at an earlier age, compared to children exposed to inconsistent discourse patterns (Guerriero, Oshima-Takane, & Kuriyama, 2006). These findings have led researchers to examine whether children can also take advantage of discourse *continuity*: the tendency for neighboring utterances to refer to the same topic (Frank et al., 2013; Horowitz & Frank, 2015; Sullivan & Barner, 2016). For example, if a toddler simply hears, *I rode a camel!*, he or she may come to the incorrect conclusion that a camel is a motor vehicle. If instead the child hears, *I took a trip to the desert. I rode a camel! He was so sweet and let me pet him*, he or she might use topic continuity between "camel" and semantically related words in the discourse to discern its meaning accurately (i.e., an animal that lives in the desert).

Discourse continuity is thought to influence children's learning, given the way discourse patterns tend to unfold in naturalistic child–caregiver interactions (Frank et al., 2013; Messer, 1980; Rohde & Frank, 2014). Rohde and Frank (2014) analyzed discourse continuity in parents' interactions with their children using three different methods: human-coded annotations of a speakers' referent for each utterance, human-inferred utterance sequences based on topic, and model-inferred utterance sequences based on topic. Across the three methods, the researchers determined that certain topic-signaling cues found in adult discourse—the use of pronouns and sentence-final reference—are also present in child-directed speech. They concluded that the function of discourse cues in child-directed speech may be to help children optimize their extraction of referential information from input even when individual utterances are ambiguous. Hoff (2010) revealed that children produce topic-continuing discourse themselves, particularly during language-rich activities such as reading, presumably because the context of such activities may provide conversational scaffolding. Other work suggests that speakers' discourse continuity might be relevant for understanding a key component of children's language development: the learning of new words. Frank et al. (2013) found that caregivers' references to objects in a child–parent play session were more continuous (or "clumpy") than would be expected by chance. This finding is complemented by computational models suggesting the importance of discourse continuity for word learning. In a word-learning model by Luong, Frank, and Johnson (2013), speakers' intended referents were presented continuously across utterances. This discourse information, combined with social cues, led to modest improvements in the model's success in learning. Together, these studies suggest that discourse continuity exists in adult–child interactions and may play a role in children's word learning. But the nature of the relation between discourse continuity and word learning remains underexplored.

Hoff (2003) began to test the relevance of continuity by examining topic-continuing replies, that is, caregivers' utterances that continue a topic previously introduced by the child. She found that children whose mothers used more topic-continuing replies showed greater vocabulary growth after 10 weeks. Horowitz and Frank (2015) went further by testing whether or not children can use a speaker's discourse continuity as a strategy for determining object reference in ambiguous word-learning situations. Children of ages 2-6 years were exposed to new words such that the only cue to reference was a single labeling event within a discourse. All labels were spoken in an ambiguous fashion, in which two objects were present and a label was provided without gestural cues. However, the timing of the object label within the discourse was manipulated: children heard labels embedded between two sentences referring to either the *same* object or two *different* objects. Results revealed that children were only able to successfully determine reference when labels were continuous in the discourse (i.e., occurred between sentences referring to the same object). Moreover, children only started showing successful disambiguation by age 3–4, and showed even better learning through ages 5 and 6, suggesting that children's use of discourse information in determining object reference increased over the course of early childhood.

Discourse continuity thus seems to support children's abilities to learn new words, but how? What are the mechanisms behind this documented effect on word learning? One possibility is that providing context for each labeling episode through topic continuity helps children successfully encode and remember multiple new object labels (Schwab & Lew-Williams, 2017). More specifically, structured information, such as clusters of word repetition, may promote children's learning by enhancing attention or processing abilities (e.g., Schwab & Lew-Williams, 2016a; Vlach & Johnson, 2013). Yet it is also possible that continuous discourse is beneficial only to the extent that it is *not* erratic or disorganized. That is, *dis*continuous discourse might be

harmful to word learning, given limitations in children's working memory capacities and information rehearsal speeds (see Baddeley, 1992). Interleaved object references may in fact serve as a distraction and/or increase cognitive load (in a similar manner to background speech, e.g., McMillan & Saffran, 2016). Thus, this study aimed to determine whether continuity of discourse actually promotes children's encoding of new words, or if instead, discontinuity of discourse interferes with children's encoding.

To further clarify our understanding of the mechanisms underlying children's learning from discourse continuity, this study also examined whether the information content of discourse matters for learning. This general topic has been explored in research on human memory. For example, memory strategies that invoke meaningful information and detail, known as elaboration, have been shown to promote item recall (e.g., Levin, 1988; Pressley & Levin, 1987). In a study with preschoolers, memory for a list of words was enhanced when word pairs were embedded in sentences describing an interaction between them, or when an interaction was depicted visually (Reese, 1972). Such elaborative discourse is thought to support memory because content becomes meaningful to the learner (Levin, 1988). In the context of word learning, research has shown that exposure to causally rich information about new objects, such as how their parts enable their functions, supports preschoolers' and kindergarteners' learning (Booth, 2009; Booth & Alvarez, 2015). Additionally, Sullivan and Barner (2016) found that children could use surrounding discourse to identify the referent of an ambiguous novel word only when the content was meaningfully relevant (e.g., when an adult was "thirsty" and asked for a "pliff" while the child looked at drinkable, edible, and unrelated objects) as opposed to irrelevant (e.g., "happy" in the same scenario). However, it is not yet clear how meaningful or visually informative cues interact with discourse continuity in promoting children's word learning.

This study furthers existing literature by trying to understand why children learn words from continuous discourse. In three experiments with 4-year-old children, an adult taught three new words in a live demonstration, either with or without discourse continuity. We focused on 4-year-olds based on previous findings showing age differences in children's ability to disambiguate object referents from the surrounding discourse, with children not doing so reliably and successfully until 3 or 4 years of age (Horowitz & Frank, 2015; Sullivan & Barner, 2016). Experiment 1 aimed to confirm that discourse continuity influences children's word learning in a context where the discourse provides descriptive featural information about objects. Experiment 2 examined whether discourse continuity shapes learning regardless of its content. To do so, we tested children's word learning when surrounding discourse was neutral and uninformative. Finally, the goal of Experiment 3 was to disentangle whether continuous references in discourse are beneficial or discontinuous references are harmful for children's word learning. Here, children's exposure to an object label was not surrounded by discourse, but by visual and gestural continuity or discontinuity. By examining whether continuity helps or discontinuity hurts word learning within a discourse context, and how word learning interacts with the meaningfulness of talk, we aimed to expose the mechanisms behind children's learning from continuous discourse.

Experiment 1

In Experiment 1, we tested the extent to which discourse continuity influences children's learning of new object/label pairs when the discourse contained meaningful descriptions of new objects. In the *continuous-informative* condition, clusters of utterances included one utterance that labeled a particular object, accompanied by two additional utterances that described—but did not explicitly label—the same object. In the *discontinuous-informative* condition, children were exposed to an identical set of learning trials, but the discourse was not continuous. For example, a label for one object was immediately followed by a comment about features of a different object, with no sequential references to the same object. On all trials, a speaker gazed at and grasped the target object as she spoke, providing unambiguous cues to the focus on each referent. At test, children were presented with a two-alternative forced-choice reaching task in order to measure knowledge of each object label. Assuming discourse continuity does influence children's word-learning abilities, we predicted that children would show more accurate learning of correct object/label mappings in the continuous-informative compared to the discontinuous-informative condition.

Method

Participants

Participants were forty 4-year-old children (M = 46.41 months, SD = 3.71, range = 42.1–53.6). Sample size for each experiment was decided a priori based

on related studies on children's word learning (e.g., Schwab & Lew-Williams, 2016a). Twenty-three participants were male, and all participants lived in monolingual English-speaking homes in a middle- to upper-middle class community. Children had no history of developmental delays or disorders. Twenty children were randomly assigned to each of two experimental conditions: a *continuous-informative* or *discontinuous-informative* condition, described in detail next. Three additional participants were tested but not included due to fussiness/refusal to cooperate (n = 2) or taking an extended break halfway through test trials (n = 1). All aspects of this research were approved by the Institutional Review Board at Princeton University.

Stimuli and Design

Three novel words—*gazzer*, *cheem*, and *tobu*—corresponded to one of three novel objects, each characterized by a different color, texture, and shape (see Figure 1). Half of participants were exposed to one set of object/label pairings, and half were exposed to a second, counterbalanced set of pairings.

In the *continuous-informative* condition, blocks of three adjacent trials in the learning phase referred to the same object. Either the first or second trial was a labeling trial, and the other two trials were object-directed reference trials in which sentences provided identifying visual information about the object (e.g., *This is a gazzer./This is small and green./This feels really spiky*, see Table 1). There were two blocks of trials for each novel object/label pair. Each object was referred to six times total; children heard each label two times total.

The *discontinuous-informative* condition consisted of the same exact trials as the continuous-informative condition, but trials within each block of the learning phase were pseudo-randomly ordered such that no two adjacent utterances referred to the same object (see Figure 1). As in the continuous-informative condition, either the first or second trial was a labeling trial, and the other two trials were object-directed reference trials in which

Figure 1. Schematic depicting sample trials in the learning phase for the continuous and discontinuous conditions in Experiment 1. Between each trial, the speaker briefly rested both hands in her lap and smiled at the participant. Note that in all conditions, the labeling trial occurred in either the first position (shown below) or second position (not shown).

Table 1
Sentences Used in Informative and Uninformative Reference Trials

	Informative reference sentences	Uninformative reference sentences
Object 1	This is small and green	This is good and neat
	This feels really spiky	This is fun and pretty
Object 2	This has two handles	This is really great
	This is big and purple	This is nice and cute
Object 3	This is round and pink	This is very cool
	This has a lot of holes	This is pretty awesome

Note. Label/object pairs were randomized, but reference sentences always corresponded to the same object. Informative reference trials were repeated twice each in Experiment 1, and uninformative reference trials were repeated twice each in Experiment 2.

sentences provided identifying visual information about the objects. Thus, participants were exposed to the same number of total labeling trials and reference trials as in the continuous condition, but discourse continuity was absent.

Procedure

During the experiment, an experimenter sat across a table from the participant and told him or her, *We're going to play a game together! First, I'm going to show you some things. Just watch and pay attention because I'm going to ask you some questions about these things later. Are you ready? Here we go!*

During the learning phase, the experimenter placed the three objects in a line directly in front of her on the table (in one of two counterbalanced orders). On each of 18 learning trials, the experimenter began with her hands in her lap. Then she (a) smiled at the participant, (b) looked down at an object, (c) grabbed the object, raised it slightly, and tilted it up, (d) looked back at the participant and said a labeling or object-directed sentence about the object, (e) looked back at the object and set it back down, and (f) put her hands back in her lap. Two counterbalanced trial orders were used for each condition across participants.

The test phase began immediately after the learning phase. The experimenter removed all three objects from the table and told the participant that she was now going to ask some questions. Next, the experimenter took two objects at a time, placed them in an uncovered rectangular basket (on either the left or right side), and placed the basket on the table. Without looking down at the objects, the experimenter slid the basket toward the participant. Next, the experimenter asked the participant to choose one of the objects and hand it to the experimenter, for example, *Which one is the gazzer*? *Can you give me the gazzer*?. Throughout each test trial, the experimenter maintained eye contact with the participant. If a child initially touched more than one object, the object that was finally handed to the experimenter was recorded as his or her choice. There were 12 test trials total (four trials per object/label pairing). Two counterbalanced test orders were used across participants. Across conditions, participants saw presentations of the same pairs of two novel objects.

Finally, children's vocabulary was assessed using the Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 2007). The PPVT is a standardized measure that assesses children's receptive vocabulary by asking them to identify familiar words from an array of pictures. Children were rewarded with stickers following the test phase and again during and after the administration of the PPVT. Note that across all three experiments, there were no significant differences between conditions in age or PPVT (ps > .05), as well as no significant interactions between condition and age or PPVT, ps > .05.

Results and Discussion

Word learning was quantified as the proportion of object/label pairs that children correctly identified in the test phase. A two-tailed independent samples t-test showed that learning was significantly greater in the continuous-informative condition (M = .88, SE = .03) compared to the discontinuous-informative condition, M = .77, SE = .04; $t(38) = 2.05$, $p = .047$, $d = 0.65$; see Figure 2. However, learning was significantly greater than chance for both the continuous-informative, $t(19) = 12.28$, $p < .001$, $d = 2.75$, and discontinuous-informative conditions, $t(19) = 6.20$, $p < .001$, $d = 1.39$. This suggests that children were able to successfully learn the novel words with or without discourse continuity, but that continuity of reference enhanced children's abilities to learn the novel words.

These results confirmed that discourse continuity affects word learning for 3.5- to 4.5-year-old children when the discourse provided descriptive information about the features of each object, such as its color or texture (in a similar manner to Horowitz & Frank, 2015). However, it is still unclear *why* children showed better learning from continuous verbal discourse compared to discontinuous discourse. One explanation for this effect is that discourse called attention to specific features of objects, and in doing so, provided repeated opportunities to encode information about their colors, shapes, or textures. To understand if informative, contextually meaningful content was key to the effects of discourse continuity,

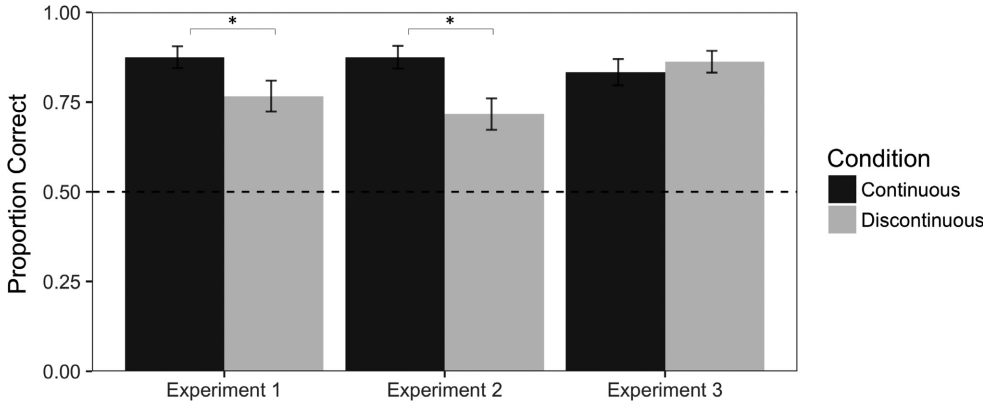

Figure 2. Mean proportion correct for children in Experiment 1 (continuous-informative vs. discontinuous-informative conditions), Experiment 2 (continuous-neutral vs. discontinuous-neutral conditions), and Experiment 3 (continuous-no-discourse vs. discontinuous-no-discourse conditions). Error bars show standard error across participants; the dotted line shows chance proportion correct. Asterisks indicate statistical significance (at the $p < .05$ level).

we removed it. Do children only show enhanced word learning in continuous compared to discontinuous verbal discourse when the content is informative? In Experiment 2, the speaker used only *neutral* discourse (see Table 1), that is, discourse that provided no identifying visual information about the objects (e.g., *This is really great*). This served to extend the findings from Experiment 1 and to examine the source of the effects of discourse continuity on children's word learning.

Experiment 2

Experiment 2 sought to determine whether children showed better learning from continuous versus discontinuous verbal references in Experiment 1 because the discourse contained meaningful content. Object labels were the same as in Experiment 1, but accompanying discourse provided no relevant descriptive information about each object. If discourse continuity only influences word learning when utterances provide salient information about the objects, then learning should be equivalent independent of continuity. However, if there is no interaction between informativity and continuity, we would again expect that children would show more successful learning of object/label mappings when discourse was continuous as opposed to discontinuous.

Method

Participants

Participants were forty 4-year-old children (M = 46.37 months, SD = 3.36, range = 42.27–53.13). Sixteen participants were male, and all participants lived in monolingual English-speaking homes in a middle- to upper-middle class community. Children had no history of pervasive developmental delays. Twenty children were randomly assigned to each of two experimental conditions: a *continuous-neutral* or *discontinuous-neutral* condition, described in detail next. Two additional participants were tested but not included due to experimenter error (n = 1) or being bilingual, defined as < 85% English exposure (n = 1).

Stimuli and Design

Words and objects were identical to Experiment 1. The *continuous-neutral* condition was identical to the continuous-informative condition from Experiment 1, except that object-directed utterances (i.e., reference trials) provided no specific descriptive visual information about each object (e.g., *This is a gazzer./This is good and neat./This is nice and cute*, see Table 1). In choosing relatively neutral words such as "good" and "neat," we avoided cueing specific information about the visual images. Reference trials in the continuous-neutral condition were matched to those in the continuous-informative condition from Experiment 1 in total number of syllables. The *discontinuous-neutral* condition consisted of the exact same trials as the continuous-neutral condition, but trials within each block of the learning phase were ordered such that no two adjacent utterances referred to the same object. Thus, participants in this condition heard the same sentences, the same number of total references to each object, and the same number of object labels as the continuous conditions, but there was no continuity of reference.

Procedure

The procedures for the learning phase, test phase, and administration of the PPVT in Experiment 2 were identical to the procedures in Experiment 1.

Results and Discussion

Again, word learning was quantified as the proportion of object/label pairs that children correctly identified in the test phase. A two-tailed independent samples *t*-test showed that learning was significantly greater in the continuous-neutral condition ($M = .88$, $SE = .03$) compared to the discontinuous-neutral condition, $M = .72$, $SE = .04$; $t(38) = 2.93$, $p = .006$, $d = 0.92$; see Figure 2. Similar to Experiment 1, learning was significantly greater than chance in both conditions (continuous-neutral: $t(19) = 11.83$, $p < .001$, $d = 2.64$; discontinuous-neutral: $t(19) = 4.95$, $p < .001$, $d = 1.11$), suggesting that continuity of reference supports word learning even in the absence of informative discourse.

Next, we compared children's learning across Experiments 1 and 2. A 2 × 2 mixed analysis of variance (ANOVA) with Experiment (1 or 2) as a between-subjects factor and condition (continuous or discontinuous) as a within-subjects factor revealed a significant main effect of condition, $F(1, 76) = 12.47$, $p < .001$, $\eta_p^2 = .14$, but no significant main effect of Experiment, $F(1, 76) = 0.44$, $p = .51$, $\eta_p^2 < .01$, and no significant Condition × Experiment interaction, $F(1, 76) = 0.44$, $p = .51$, $\eta_p^2 < .01$. Thus, Experiment 2 replicated the results of Experiment 1 using an uninformative discourse context with neutral object-focused sentences. Together, findings from Experiments 1 and 2 suggest that continuity of reference in general—and not continuity of informative discourse—influences children's word learning. Yet the mechanism behind this finding is still unclear; that is, does continuity of reference help children's learning or does discontinuity hinder learning?

Experiment 3

Experiments 1 and 2 demonstrated that clustered verbal references to objects affect 4-year-old children's learning of their labels, regardless of the content or informativity of utterances. However, it is still unclear whether discourse continuity *promotes* learning (e.g., by increasing attentional focus or ease of processing) or if discontinuous discourse *interferes* with learning (e.g., by increasing distraction or cognitive load). Additionally, given the capacity limits of visual short-term memory (Logie, 1995), including for sequential information (e.g., Kumar & Jiang, 2005), it is also possible that continuity in *object reference*—in the absence of discourse—helps children learn new words relative to discontinuous references. Thus, Experiment 3 examined continuity and discontinuity of object reference with no verbal discourse surrounding object labels. In addition to labeling each object once, the experimenter performed identical reference actions as in Experiments 1 and 2, but instead of producing speech, she drew children's attention to each object in silence. If continuity of reference in general shapes word learning, we would expect to see greater word learning in the continuous compared to the discontinuous condition, even in the absence of surrounding verbal discourse. If specifically *verbal* continuity helps children's word learning, we would expect that in the absence of surrounding discourse, there would be less successful learning in both conditions (i.e., similar performance to the discontinuous conditions of Experiments 1 and 2). Finally, if discontinuity in verbal discourse *hinders* children's word learning, we would expect that in the absence of surrounding discourse, there would be more successful learning in both conditions (i.e., similar performance to the continuous conditions of Experiments 1 and 2).

Method

Participants

Participants were forty 4-year-old children ($M = 45.58$ months, $SD = 3.16$, range = 42.1–53.8). Seventeen participants were male, and all participants lived in monolingual English-speaking homes in a middle- to upper-middle class community. Children had no history of pervasive developmental delays. Twenty children were randomly assigned to each of two experimental conditions: a *continuous-no-discourse* or *discontinuous-no-discourse* condition, described in detail next. Four additional participants were tested but not included due to experimenter error ($n = 2$), unwillingness to finish the test phase ($n = 1$), or having a speech delay ($n = 1$).

Stimuli and Design

Words and objects were identical to Experiments 1 and 2. The *continuous-no-discourse* condition was identical to the continuous conditions from Experiments 1 and 2 except that reference trials provided no verbal content about each object (e.g., *This is a*

gazzer./[child's attention drawn to the *gazzer* in silence]/[child's attention drawn to the *gazzer* in silence]). The *discontinuous-no-discourse* condition consisted of the exact same trials as the continuous-no-discourse condition, but trials within each block of the learning phase were ordered such that no two adjacent trials referred to the same object (e.g., *This is a gazzer.*/[child's attention drawn to the *cheem* in silence]/[child's attention drawn to the *tobu* in silence]). Thus, as in Experiments 1 and 2, participants in the discontinuous-no-discourse condition saw the same number of total references to each object and heard the same number of object labels as the continuous conditions, but the source of continuity across time was visual and gestural, not verbal.

Procedure

The procedure for the learning phase of Experiment 3 was identical to the procedure in Experiments 1 and 2, except that 12 of the 18 learning trials occurred in silence. On silent trials, the experimenter: (a) smiled at the participant, (b) looked down at an object, (c) grabbed the object, raised it slightly, and tilted it up, (d) looked back at the participant and smiled in silence for approximately 2s, (e) looked back at the object and set it back down, and (f) put her hands back in her lap. Two counterbalanced trial orders were used for each condition across participants.

The procedures for the test phase and administration of the PPVT in Experiment 3 were identical to the procedures in Experiments 1 and 2.

Results and Discussion

As in Experiments 1 and 2, word learning was measured as the proportion of object/label pairs that children correctly identified in the test phase. A two-tailed independent samples *t*-test showed that learning was not significantly different in the continuous-no-discourse condition ($M = .83$, $SE = .04$) compared to the discontinuous-no-discourse condition, $M = .86$, $SE = .03$; $t(38) = -0.61$, $p = .54$, $d = 0.19$; see Figure 2.

To compare results across Experiments 1, 2, and 3, accuracy scores were analyzed using a 3 × 2 mixed ANOVA with Experiment (1, 2, and 3) as a between-subjects factor and condition (continuous or discontinuous) as a within-subjects factor. There was no significant main effect of experiment, $F(2, 114) = 1.02$, $p = .36$, $\eta_p^2 = .02$, but there was a significant main effect of condition, $F(1, 114) = 7.07$, $p < .01$, $\eta_p^2 = .06$ and a significant Experiment × Condition interaction, $F(2, 114) = 3.55$, $p = .03$, $\eta_p^2 = .06$. Follow-up independent samples *t*-tests showed no significant difference in proportion correct between the continuous-no-discourse condition and either the continuous-informative condition from Experiment 1, $t(38) = -0.87$, $p = .39$, $d = -0.28$, or the continuous-neutral condition from Experiment 2, $t(38) = -0.86$, $p = .40$, $d = -0.27$. However, accuracy was higher in the discontinuous-no-discourse condition (in Experiment 3) compared to the other discontinuous conditions (in Experiments 1 and 2). There was a marginally significant difference in proportion correct between the discontinuous-no-discourse condition and the discontinuous-informative condition from Experiment 1, $t(38) = 1.82$, $p = .08$, $d = 0.58$, and a significant difference in proportion correct between the discontinuous-no-discourse condition and the discontinuous-neutral condition from Experiment 2, $t(38) = 2.74$, $p < .01$, $d = 0.87$.

The absence of a significant difference between conditions in Experiment 3 suggests that continuity of visual information and manual actions cannot sufficiently explain the benefits of discourse continuity for children's learning of multiple new object/label mappings. Moreover, given that children in all three continuous conditions performed equally well, and that children in the discontinuous-no-discourse condition performed significantly better than children in the discontinuous conditions from Experiments 1 and 2, it is likely that discontinuous discourse *interferes* with learning, as opposed to continuous discourse boosting learning. Critically, this finding suggests that clusters of verbal references to a particular object are beneficial for children's learning to the extent that parents are not rapidly switching reference from one object to another.

One possible explanation for children's more successful learning in continuous conditions overall—compared to discontinuous conditions—is that they may have shown increased attention to objects or to the experimenter during the learning phase. In order to determine whether children's attention differed by condition, a trained coder blind to the experimental hypotheses coded children's attention during the learning phase for 25% of participant videos. Three different measures of attention were coded: children's overall proportion of looking (a) to the target object (i.e., the object that was currently the focus of the experimenters' reference and attention; $M = .51$, $SD = 0.13$), (b) to the experimenter ($M = .31$, $SD = 0.12$), or (c) away (i.e., looking to the other two objects or anywhere else in the

room; $M = .18$, $SD = 0.08$). Results of one-way ANOVAs showed no significant main effect of condition (for all six conditions across three experiments) on children's proportion time spent looking at the target objects during the learning phase, $F(5, 24) = 0.42$, $p = .83$, $\eta_p^2 = .08$, as well as no significant main effect of condition on children's proportion time spent looking at the experimenter, $F(5, 24) = 0.02$, $p > .99$, $\eta_p^2 < .01$. Follow-up independent samples *t*-tests confirmed there were no significant differences between any conditions across experiments in terms of children's proportion looking time to target during the learning phase (all *p*s > .1) or children's proportion looking time to experimenter (all *p*s > .1).

Additionally, it is possible that differences in experimenter enthusiasm across conditions influenced children's learning in continuous compared to discontinuous conditions. To test this, 50 learning phase trials were randomly selected across participants: five labeling trials for each of the six conditions (30 total) and five reference trials for each of the four conditions in Experiments 1 and 2 (20 total). We chose not to include reference trials for the no-discourse conditions from Experiment 3 because enthusiasm judgments for silent trials would be inevitably lower than verbal trials. Twelve adult participants were recruited at Princeton University to rate experimenter enthusiasm. None of the participants were familiar with the premise of the original experiment. They were told, "In the following clips, you will see a person labeling an object. Your task is to rate the enthusiasm of the person in each video clip. You will see each clip only once." Participants were then presented with video clips of each of the 50 randomly selected learning phase trials. After each video clip, participants were shown a rating scale of 1 through 5 (with 1 being *very unenthusiastic* and 5 being *very enthusiastic*) and asked to indicate the experimenter's enthusiasm level. The order of presentation for the 50 trials was randomized across participants. Participants wore headphones throughout the task.

First, we examined experimenter enthusiasm on labeling trials only, using a 3 × 2 factorial ANOVA with Experiment (1, 2, and 3) and continuity (continuous vs. discontinuous) as between-subjects variables. Results revealed a significant main effect of experiment, $F(2, 354) = 7.0$, $p < .01$, $\eta_p^2 = .04$, but no significant main effect of continuity, $F(1, 354) = 0.44$, $p = .51$, $\eta_p^2 < .01$, and no significant Experiment × Continuity interaction, $F(2, 354) = 0.44$, $p = .12$, $\eta_p^2 = .01$. Second, we examined whether or not there were differences in enthusiasm ratings across conditions for *reference* trials (although note, as described earlier, that we did not include reference trials for Experiment 3). A 2 × 2 factorial ANOVA was performed to determine the effect of Experiment (1, 2) and continuity on enthusiasm ratings for reference trials. Results showed no significant main effect of experiment, $F(1, 236) = 0.32$, $p = .57$, $\eta_p^2 < .01$, no significant main effect of continuity, $F(1, 236) = 0.004$, $p = .95$, $\eta_p^2 < .01$, and no significant Experiment × Continuity interaction, $F(1, 236) = 1.42$, $p = .23$, $\eta_p^2 < .01$. Thus, while there were subtle differences in overall experimenter enthusiasm on labeling trials across experiments, importantly, for both labeling and reference trials, there was no main effect of continuity across experiments and no significant Continuity × Experiment interaction. These findings suggest that differences in children's word learning across experiments were not driven by differences in experimenter enthusiasm.

General Discussion

In three experiments, we uncovered how continuity of reference within object-related discourse shapes 4-year-old children's word learning. Three core conclusions can be drawn from this investigation. First, reflecting previous research, we confirmed that children best learn new words from continuous—as opposed to discontinuous—discourse references. Second, we found that children's word learning was not better when the discourse provided informative (as opposed to uninformative) content about the visual features of objects. Third, by exploring both verbal and nonverbal aspects of an adult's object references, we specifically found that discontinuous discourse—or rapidly switching verbal references between objects—*hindered* children's encoding of their labels and visual features. Thus, our findings suggest that verbal continuity from adults is important for helping children learn words because discontinuity disrupts children's encoding of new object labels.

The finding that informative descriptions of objects did not influence learning in the present experiments may not generalize across all word-learning contexts. Unlike in previous experiments examining children's learning of new words from the surrounding discourse (e.g., Horowitz & Frank, 2015; Sullivan & Barner, 2016), here we tested word learning in a relatively unambiguous context; that is, there were additional cues that helped establish

reference, such as eye gaze and pointing. While informative content about the visual features of objects is important in helping children determine which object is being talked about in an ambiguous context, it does not seem to be necessary when children are encoding new words in an unambiguous context. However, this conclusion could differ if the test had occurred after a protracted retention interval (e.g., Kucker, McMurray, & Samuelson, 2015; Vlach & Sandhofer, 2012). Moreover, we tested just one form of detailed content: dimensions of visual appearance, such as color and texture. We know from other research that causally rich information is helpful for children's word learning, such as how an object's features enable its main function (Booth, 2009; Booth & Alvarez, 2015). Future research should scrutinize which types of elaborative content might be important for children's word learning and under what circumstances.

Our findings regarding discourse continuity are in some ways convergent with studies showing that repetition of words across neighboring utterances is helpful for learning (Onnis, Waterfall, & Edelman, 2008; Schwab & Lew-Williams, 2016a). Yet interestingly, while previous research has suggested that repetition is beneficial because it enhances attention or enables the detection of recurring words across utterances (Onnis et al., 2008; Schwab & Lew-Williams, 2016a), the present study shows—at least for discourse continuity—a more precise explanation for the idea that clustered references support learning: that disorganized information *interferes* with word learning. However, it remains unclear whether word repetition and discourse continuity reflect the same—or different—underlying processes. More specifically, is repetition of object labels only helpful insofar as discontinuity of object labels is harmful? Would repetition of object labels boost learning over and above continuity of discourse? Future research should address these questions by directly comparing the influence of repetition of object labels versus continuity of reference on children's learning. Relatedly, given the relatively high performance of children across conditions in this word-learning task, it will also be important to test these research questions across different age groups, with different amounts of exposure, and under more naturalistically complex testing conditions. Dense video data of parent–child interactions will also provide a means of understanding effects of discourse on children's learning in everyday environments.

As shown in previous work, the quantity and quality of language input in children's environments varies widely across families (e.g., Hart & Risley, 1995; Hoff-Ginsberg, 1998; Weisleder & Fernald, 2013) and has a significant influence on children's language learning (e.g., Hoff, 2006; Schwab & Lew-Williams, 2016b). One recent study found that the use of repetition differs across the socioeconomic status (SES) spectrum, with higher-SES caregivers using more repetition across successive utterances compared to lower-SES caregivers (Tal & Arnon, 2018). It may be the case, then, that children's exposure to discourse continuity is meaningfully different across families, which may affect different children's processing and learning from continuous compared to discontinuous discourse. Detailed characterizations of household language input will be useful for understanding variation in children's learning from continuous and discontinuous discourse, as well as for evaluating how individual differences in discourse-related experiences influence children's language learning trajectories.

In developmental science, researchers often write about factors that promote learning, such as joint attention between caregivers and infants, or certain cues in infant-directed speech. Less is known about factors that inhibit or derail learning, both in the moment and across the protracted timescale of development. One relevant exception is research on visual and auditory clutter. Visual clutter in the environment has been shown to interfere with infants' and children's low-level discrimination abilities (Farzin, Rivera, & Whitney, 2010), retention of new word-object pairs (Horst & Samuelson, 2008), and learning in the classroom (Fisher, Godwin, & Seltman, 2014). These studies complement research showing that children's learning of new labels in naturalistic environments tends to occur when objects appear in clear, uncluttered views (Yu & Smith, 2012; Yurovsky, Smith, & Yu, 2013). Auditory clutter, in the form of background speech, has also been shown to interfere with children's encoding of new words (McMillan & Saffran, 2016). Here, in a similar manner, verbal interference disrupted children's ability to encode new words, likely because it hindered perception of consistent structure, increased cognitive load, and/or served as a distraction (e.g., McMillan & Saffran, 2016). Only with a robust understanding of these mutually reinforcing "positive" and "negative" aspects of word exposures will we be able to uncover broadly generalizable mechanisms for learning across contexts.

While previous research has suggested that repetition of object labels in blocks of successive utterances shapes toddlers' word learning (Schwab & Lew-Williams, 2016a; Vlach & Johnson, 2013), here, with *older*

preschool-age children, simply referencing an object for several sentences in a row—without repeating the label itself—influenced word learning relative to referencing an object in a distributed manner across the discourse. Does the importance of these two features of adult speech—repetition of labels and continuity of reference in general—change over development? The need for caregivers to repeat object labels in neighboring sentences decreases between ages 7 months to 2 years, as young children become more proficient in language (Newman, Rowe, & Ratner, 2016; Schwab, Rowe, Cabrera, & Lew-Williams, 2018). And critically, children's ability to exploit discourse continuity in ambiguous word learning contexts *increases* with age, particularly during the preschool years (Horowitz & Frank, 2015). Following from these general trajectories, the usefulness of repeated labels may decline as children's ability to better understand the discourse context comes online. Young children are likely to have evolving abilities to exploit word repetition and continuity of reference as they learn new information from the environment, and individual differences in this evolution are likely to depend on the specifics of caregivers' naturalistic use of discourse cues in the home.

Importantly, the present experiments focused on unidirectional speech from caregiver to infant. That is, we aimed to unravel the mechanisms behind caregivers' discourse continuity and children's learning, but in naturalistic parent–child interactions, there is a social feedback loop wherein parents' and children's speech mutually influence one another (e.g., Warlaumont, Richards, Gilkerson, & Oller, 2014). Moreover, topic-continuing replies to children's speech may be particularly helpful for learning, given that caregivers are able to elaborate on a topic or object that children find particularly interesting (see Hoff, 2003). In fact, the temporal dynamics of parents' and children's joint attention in a word-learning episode, alongside infants' sustained attention on objects, seem to influence learning (Trueswell et al., 2016; Yu, Suanda, & Smith, 2018). Tomasello and Farrar (1986) found that children learned new words better when their attentional focus was already on the target object at the time of labeling (also known as "follow-in labeling"), and Masur (1997) found that children whose mothers used more follow-in labeling at 13 months had larger vocabularies several months later. Therefore, there are various intersecting dimensions of the quality of labeling episodes: children's own attention and interests, parents' and children's joint attention, and the timing and content of labels and social references to objects. Disentangling their independent and interdependent contributions to word learning across time will be a challenge for both lab-based and home-based investigations.

While a great deal of recent research has focused on children's ability to track statistical co-occurrences in language in order to learn object/label mappings (e.g., Smith & Yu, 2008), fewer studies have investigated children's ability to exploit the content and structure of discourse in the service of word learning. Because children are adept at tracking object-label regularities over time (Smith, Suanda, & Yu, 2014), discourse cues may not be needed for word learning. More likely, however, discourse cues, in combination with socio-pragmatic cues, change children's encoding of information about object/label co-occurrences over time, presumably by increasing or decreasing objects' salience in the moment. Relatedly, Pereira et al. (2014) have suggested that there are optimal visual moments for learning new object/label pairs. That is, during an instance of labeling, a child is more likely to learn an object's label if it appears in a clean and stable view. Here, we show that continuity of reference (or more precisely, lack of discontinuity of reference) may contribute to the definition of an optimal contextual moment for learning a new object/label mapping. When a word and its referent are transparently linked within the discourse over a short burst of utterances, without the distraction of interleaved discourse, it is likely that children can attend to and encode their features more accurately. Given these findings, continuity of reference may also be important for children's learning of other types of contextually relevant information, such as the functions of objects, the role of objects in events between agents and patients, and links to semantically and syntactically related words.

Together, this research indicates that the timing and manner of speakers' rapid shifting of focus within conversational episodes matters for children's learning. The three experiments presented here suggest that discontinuous discourse interferes with children's word learning, and that continuity of discourse is therefore important for children's learning of new object labels, independent of the informative content of sentences. Previous research has found that natural child-directed discourse often contains strings of sentences about a particular object or topic (Frank et al., 2013), and discourse continuity helps children resolve referential ambiguity (Horowitz & Frank, 2015). The present work goes further by investigating *how* discourse continuity influences word learning. Our findings suggest that there is a benefit to parents' use of continuity in child-directed discourse, driven by inhibitory

effects of *discontinuous* object-related discourse on children's learning. This research provides insight into the intersecting auditory, visual, and communicative mechanisms that bind the structure and content of caregivers' discourse to children's encoding of new words.

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