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Specific Structural Features of Child-Directed Speech Support Young Children's Word Learning

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SPECIFIC STRUCTURAL FEATURES OF CHILD-DIRECTED SPEECH SUPPORT YOUNG CHILDREN'S WORD LEARNING

Jessica Feigenbaum Schwab

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Abstract

Young children who hear more child-directed speech (CDS) tend to have larger vocabularies later in childhood (e.g., Ramírez-Esparza, García-Sierra, & Kuhl, 2014; Weisleder & Fernald, 2013), but the specific structural characteristics of CDS underlying this link have previously been underspecified. The present studies sought to elucidate how three structural features of parents' language input – the use of word repetition, isolated words, and discourse continuity – support children's language learning. In previous research, I showed that repetition of object labels in successive sentences promotes young children's encoding of new words (Schwab & Lew-Williams, 2016a). Here, Chapter II examines the extent to which parents' repetition relates to children's learning at different time points in development. Next, Chapter III examines how parents' use of isolated words interacts with repetition in promoting children's learning of new words. Finally, Chapter IV investigates how continuity of reference promotes children's learning. Collectively, these studies reveal that the packaging of information within child-directed speech influences children's word learning, although the extent to which each structure matters depends on children's level of language knowledge.

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Chapter I: Introduction[1]

Previous research on child-directed speech (CDS) suggests that young children who hear more language from caregivers often have larger vocabularies later in childhood (Hart & Risley, 1995; Hoff-Ginsberg, 1998; Weisleder & Fernald, 2013), but there is little empirical work aimed at determining the specific features of CDS underlying this relationship. Recent experimental and corpus-based studies have identified several structural features of natural CDS that are likely to influence young children's word-learning abilities: parents' tendency to use the same words repeatedly in adjacent sentences (Brodsky, Waterfall, & Edelman, 2007; Hills, 2013; Onnis, Waterfall, & Edelman, 2008); the use of isolated words in combination with words in sentences (Brent & Siskind, 2001; Lew-Williams, Pelucchi, & Saffran, 2011); and discourse or topic continuity (Frank, Tenenbaum, & Fernald, 2013; Horowitz & Frank, 2015). The proposed dissertation investigates how the use of these structural features in children's language environments affects their efficiency in learning new words.

Since Newport, Gleitman, and Gleitman (1977) first characterized 'motherese,' studies have shown that infants – even newborns – prefer to listen to CDS compared to adult-directed speech (Cooper & Aslin, 1990; Pegg, Werker, & McLeod, 1992; Werker & McLeod, 1989; Werker, Pegg, & McLeod, 1994). Researchers have also characterized the extent to which infants' preference remains intact over the course of early development, and how specific properties of CDS engage attention, e.g., prosody,

[1] Parts of this chapter come from the following papers: 1) Schwab, J. F. & Lew-Williams, C. (2016). Repetition across successive sentences facilitates young children's word learning. *Developmental Psychology, 52*(6), 879-886. 2) Schwab, J. F. & Lew-Williams, C. (under review). How continuity of reference promotes children's learning of new words.

repetition, and utterance length (Cristia, 2013; Hayashi, Tamekawa, & Kiritani, 2001; Newman & Hussain, 2006; McRoberts, McDonough, & Lakusta, 2009; Saint-Georges et al., 2013; Segal & Newman, 2015).

Another domain of research suggests that CDS is not only interesting to infants and young children, but also useful for their learning. Exposure to CDS – as opposed to overheard, adult-directed speech – enhances children's language development (Ramírez-Esparza et al., 2014; Weisleder & Fernald, 2013), and greater lexical and grammatical diversity in CDS has a positive influence on children's vocabulary growth (e.g., Hoff & Naigles, 2002; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010; Rowe, 2012). In addition to these correlational studies, experimental work has uncovered particular features of CDS that are thought to drive successful learning. For example, the exaggerated prosody of CDS influences word segmentation and word recognition in infants (Shukla, White, & Aslin, 2011; Singh, Nestor, Parikh, & Yull, 2009; Thiessen, Hill, & Saffran, 2005), the use of common sentence frames, such as "Look at the...", helps infants identify familiar nouns (Fernald & Hurtado, 2006), and socially contingent interactions support word learning (Roseberry, Hirsh-Pasek, & Golinkoff, 2014). However, there is a relevant, outstanding property of CDS that has not been directly tested as an influence on young children's learning: the structure of words and sentences across time. The proposed dissertation aims to dissect the relationship between three particular structural features of CDS – partial repetition, isolated words, and discourse continuity – and children's word learning.

Partial repetition in child-directed speech and children's word learning

Repetitions and partial repetitions of utterances have long been characterized as a defining structural feature of CDS (Hoff-Ginsberg, 1985; Hoff-Ginsberg 1986; Newport et al., 1977; Snow, 1972). Recent analyses of language corpora have suggested that a range of 20-58% of CDS utterances contain words that are repeated in neighboring utterances, also known as partial self-repetitions or variation sets (Küntay & Slobin, 1996; Onnis et al., 2008). The following sequence of child-directed utterances – taken from the Providence corpus of the CHILDES database (MacWhinney, 2000) – provides one example of partial repetition:

Mother: Bear needs a hat, will daddy's yellow hat fit?

Mother: No, the yellow hat is too big.

Mother: See the hat?

While the cumulative frequency of individual words in caregivers' speech is related to children's learning of those words (Hart, 1991; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Goodman, Dale, & Li, 2008; Naigles & Hoff-Ginsberg, 1998; Schwartz & Terrell, 1983) and repetitiveness of caregivers' speech (specifically, the ratio of word types to word tokens) predicts later vocabulary (Newman, Rowe, & Ratner, 2016), less is known about how the spacing of exposures to words over time (e.g., partial repetition across utterances) also influences early word learning. In line with Goldstein et al.'s (2010) theoretical framework proposing that learners integrate regularities over brief windows of time, a study with adult participants found that repeating lexical items across successive sentences improved language learning (Onnis et al., 2008). Participants were exposed to speech in an artificial language that either repeated words across 20% of successive sentences, or repeated no words across successive sentences. Although all

participants heard identical sentences over the course of the experiment, only participants who heard words embedded in neighboring sentences were later able to recognize words from the artificial language, suggesting that the temporal distribution of words in the input influenced learning. Immediately repeated structure also seems to benefit young children's language learning (see Horst, Parsons, & Bryan, 2011). In a longitudinal study of speech in parent-child dyads (ages 14-30 months), parents' partial repetitions of multi-word constituents were correlated with children's later production of those constituent structures (as cited in Brodsky et al., 2007).

Schwab & Lew-Williams (2016a) examined whether repeating words across successive utterances directly promotes young children's learning of new words. Two-year-olds (N=40) were assigned either to a *Structured* condition (in which exposures to object labels were repeated in successive utterances) or *Unstructured* condition (in which exposures to object labels were pseudo-randomly distributed throughout the learning phase). Here we found that two-year-olds learned novel object labels more effectively when words were repeated in successive utterances as opposed to being distributed throughout labeling episodes in the experiment. The fact that partial repetition facilitated two-year-olds' encoding of word/object pairings highlights the importance of understanding how input gives rise to language learning at multiple timescales. While distributing labels across time has been shown to help young children retain word knowledge (e.g., Childers & Tomasello, 2002; Vlach, Sandhofer, & Kornell, 2008), repeating labels in successive sentences seems to boost children's initial learning of new words, which likely has cascading effects on later encounters of those words in diverse contexts.

Isolated words in child-directed speech

Another relevant structural feature of CDS is utterance length. In particular, previous research has revealed that a large proportion of caregiver utterances to infants are isolated words (i.e., single words with pauses at their edges), though the exact proportion varies significantly depending on the age of the infants, the methodology, and the context (from as low as 5.6% to as high as 67% of utterances) (Aslin, Woodward, LaMendola, & Bever, 1995; Brent & Siskind, 2001; Fernald & Morikawa, 1993; MacWhinney & Snow, 1985; van de Weijer, 1998). Brent and Siskind (2001) found that approximately 10% of mothers' utterances consisted of isolated words, and critically, hearing a word in isolation at 9-15 months was a unique predictor of learning that word (by 18 months) above and beyond overall frequency of exposure to that word (see also Swingley & Humphrey, 2017).

More recent research found that this feature of parents' speech also supports young children's ability to break into the structure of their language environment (Lew-Williams et al., 2011). Specifically, when 8- to 10-month-old infants were exposed to fluent Italian speech containing either fluent speech alone or a combination of fluent speech and isolated words, they were only able to segment words that appeared both in fluent speech and in isolation. Thus, the presence of isolated words in CDS promotes infants' ability to segment fluent speech. These results suggest that not only are isolated words frequently used in CDS, but also, they seem to promote infants' ability to segment words from fluent speech, and potentially their ability to learn new words over the course of early childhood as well.

Discourse continuity in child-directed speech

Finally, a feature of CDS that is related to (but distinct from) repetition is discourse continuity, or the clustering of utterances that reference the same topic. While previous work has shown that caregivers' speech to their children tends to contain discourse continuity (e.g., Frank et al., 2013) and discourse continuity seems to help children's word learning (Horowitz & Frank, 2015; Sullivan & Barner, 2016), there is a dearth of research exploring the mechanisms behind *how* discourse continuity promotes learning.

Young children are clearly sensitive to discourse structure. For example, they understand that adults pay attention to – and talk about – novel aspects of an interaction (Akhtar, Carpenter, & Tomasello, 1996). That is, children are able to learn a new word when an adult labels an object that is novel to the discourse context from only the adult's own point of view. Relatedly, two-year-olds have been shown to use speakers' speech disfluencies (e.g., saying "um" or "uh") to predict their intended referents during object labeling (Kidd, White, & Aslin, 2011). Finally, cross-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 patterns earlier, compared to children exposed to inconsistent discourse patterns (Guerriero, Oshima-Takane & Kuriyama, 2006). Together, 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 child simply

hears, “I rode a camel!,” he or she may come to the incorrect conclusion that a *camel* is some sort of automated 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 the topic continuity between *camel* and other words in the discourse in order to discern the meaning of *camel* (i.e., an animal living in the desert), as well as to encode its meaning more concretely and accurately.

Discourse continuity is thought be an important cue for 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: raw annotations of speakers’ referent, the output of a computational model, and judgments made by human coders. Across the three methods, the researchers determined that many topic-signaling cues – such as pronoun use and sentence-final reference – found in adult discourse are also present in child-directed speech. They concluded that the function of these cues in child-directed speech may be to help children acquire additional referential information from their input, particularly when individual utterances are ambiguous. Hoff (2010) revealed that children produce topic-continuing discourse themselves, particularly during certain language-rich activities such as reading. Other work suggests that speakers’ discourse continuity might be relevant for supporting 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 convergent with 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 supportive role in children's word learning.

Hoff (2003) began to test the importance of continuity across discourse by examining topic-continuing replies, i.e., caregivers' utterances that continue a topic previously introduced by the child. Hoff found that the amount that mothers used topic-continuing replies predicted their children's vocabulary growth ten weeks later, suggesting that continuity in mother-child interactions may indeed promote children's language learning. Horowitz and Frank (2015) went further by testing whether children are able to use a speaker's discourse continuity as a strategy for determining object reference in ambiguous word learning situations. In their study, children ages 2-6 years completed a novel word-learning task, where the only cue to reference was the placement of a labeling event within the discourse structure of the interaction. Specifically, children heard an object label (with no associated gestural cues to the referent) flanked by descriptions of either toy A or toy B (which were accompanied by gestural cues). If children are able to use discourse continuity as a cue to reference, they should be able to determine the object/label pairing if the labeling event occurs between two descriptions of the *same* object (either toy A or toy B), i.e., if the labeling episode is discourse continuous. If the labeling event occurs between two descriptions of *different* objects (toy A and toy B), the label/object pair should be indeterminable. The results revealed that

children were in fact only able to successfully determine the referent when labels were discourse continuous. 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 ability to use discourse information in determining object reference might develop over the course of childhood. Overall, previous literature suggests that discourse continuity is a helpful cue for promoting children's word learning, but the mechanisms underlying its benefits are still unknown.

The present studies

Previous work suggests that certain structural features of child-directed speech – the repetition of words in successive utterances, the use of isolated words, and discourse continuity – may promote word learning in young children. It is possible that each of these structural features in some way provide what Linda Smith and colleagues have called an "optimal moment" of word learning, or a unique instance where a word or word/object pair stands out and becomes clearer, allowing children to more fully encode it (e.g., Pereira, Smith, & Yu, 2014). Yet the extent to which each of these three structural features promote word learning over the course of early childhood – and the interactions among these features – remains underexplored. In what follows, I discuss a body of research examining the following research questions:

1) *To what extent does repetition remain a helpful cue at different time points in development?* The hypothesis is that repetition becomes an incrementally less helpful cue over the course of children's development, but it is also possible that repetition continues to promote learning as children's vocabularies develop.

2) *How does the use of isolated words interact with repetition in promoting word learning?* Assuming isolated words occur in combination with repetition in child-directed speech, the hypothesis is that the combination of these two cues promotes children's word learning over and above either cue on its own. However, it is also possible that these two cues are redundant and that there is no added benefit to children's learning when they are used in combination.

3) *How does continuity of reference influence children's learning of new words?* The hypothesis is that discourse continuity is helpful for learning new object labels because *discontinuity* in verbal discourse interferes with learning, but it is also possible that back-to-back references to the same object promote attention to or memory of those objects.

The primary goal of the following seven experiments is to better understand how and why these structural features of child-directed speech shape young children's word learning.

Chapter II: How is parents' repetition related to children's learning at different time points in development? (Experiment 1)[2]

Repetition in child-directed speech (CDS) has been shown to be beneficial for vocabulary growth (Newman et al., 2016), yet the amount of repetition in caregivers' speech declines over the course of early development (e.g., Kaye, 1980; McRoberts et al., 2009). Older infants pay less attention to speech characterized by repetition (Segal & Newman, 2015), thus it is likely that repetition becomes an incrementally less helpful or necessary cue over the course of children's development. That is, parents may repeat words less frequently as their children's language skills increase, or they may continue to repeat words if their children's speech is less developed. Here we addressed this hypothesis with cross-sectional data by examining whether fathers tend to use less repetition when their children have larger vocabularies, compared to fathers of children who have smaller vocabularies. While research adopting a social-interactionist perspective to language learning highlights the important role of parents' input in children's language development (e.g., Vygotsky, 1978), transactional developmental models emphasize the role of children in shaping their own input (e.g., Sameroff & Chandler, 1975). The present study adopts both of these perspectives to examine variability in fathers' repetition of words with their toddlers as a test case for understanding the coupling of language input and children's language development.

Importantly, the influence of particular features of language input on children's language outcomes depends on the language level of the child. One study showed that

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[2] A version of this manuscript has been accepted for publication. Schwab, J. F., Rowe, M. L., Cabrera, N., & Lew-Williams, C. (2018). Fathers' repetition of words is coupled with children's vocabularies. *Journal of Experimental Child Psychology, 166,* 437-540.

among 18-month-olds, parents' input quantity was the best predictor of vocabulary skill one year later, but among 2.5-year-olds, parents' use of diverse vocabulary and rare words while talking to their children best predicted vocabulary growth (Rowe, 2012). In addition to the role of caregivers' speech, children's own productions matter. Research has shown that earlier child speech predicts the quality of caregivers' speech later in development, suggesting mutual influence (Huttenlocher et al., 2010). These findings are consistent with Vygotsky's (1978) interactionist perspective on language learning, which suggests that parents can promote children's vocabulary growth at different time points in development by using features of language input that are best matched to the child's level of understanding.

The idea of a 'social feedback loop' between infants and parents (usually mothers) has been studied in many realms of child development research (see Warlaumont, Richards, Gilkerson, & Oller, 2014). Researchers have measured mothers' responsiveness to their infants, where a "response" is a time-locked change in mothers' behavior or speech that is contiguous with and contingent on the child's action or speech (see Tamis-LeMonda, Kuchirko, & Song, 2014 for a review). This type of responsiveness predicts the timing of children's language milestones, such as first words and combinatorial speech (Nicely, Tamis-LeMonda, & Bornstein, 1999; Tamis-LeMonda, Bornstein, Kahana-Kalman, Baumwell, & Cyphers, 1998), as well as the size of infants' receptive and expressive vocabularies (Tamis-LeMonda et al., 1998; Tamis-LeMonda, Shannon, Cabrera, & Lamb, 2004). Other studies have found that mothers dynamically change the prosodic features of their CDS in response to infant feedback (Braarud & Stormark, 2008; Ko, Seidl, Cristia, Reimchen, & Soderstrom, 2016; Smith & Trainor,

2008). These results are consistent with various models of human development that emphasize the influence of reciprocal adult-child interactions. According to Shonkoff (2010), these models (e.g., the transactional model and the bioecological model) suggest that children play an active role in influencing their caregivers' interactions, and thus, their own development. Not only does parents' language input influence children's language development, but also, differences in children's own language abilities and behaviors influence parents' speech to their children.

Repetition offers an ideal test case for interactionist models, as the amount of repetitiveness in parents' input has been shown to change over the course of children's development. Specifically, parents' repetition in CDS has been shown to peak when infants are 4 to 6 months of age, and then decline ca. 24 months (e.g., Kaye, 1980; Stern, Spieker, Barnett, & MacKain, 1983). This pattern of change over time is also evident in studies of infants' attention to speech. For instance, McRoberts et al. (2009) showed that 6-month-olds only show a preference for CDS directed toward other 6-month-olds, but do not show a preference for CDS directed toward older 12- to 14-month-old infants (relative to adult-directed speech (ADS)). However, 6-month-old infants did show a preference for older CDS if the stimuli contained more repetition, suggesting that repetition might be a particularly important component of CDS for young infants. Infants at 12 and 16 months of age continue to prefer speech with the prosodic features of CDS compared to ADS, but they do not prefer speech with the structural features of CDS, e.g., lexical repetition and short utterance length (Segal & Newman, 2015). Thus, it is possible that while repetition supports learning in early infancy (Newman et al., 2016) and in difficult lab tasks involving new words (Schwab & Lew-Williams, 2016a), it may

generally become less important for children's language learning over time, particularly as children gain familiarity with words used most commonly in their environments. Based on this collection of findings, we hypothesize that parents tailor their use of repetition to the language level of the child, using less repetition as the child makes gains in language proficiency.

The present study contributes to research on caregivers' speech to their children – and its relation to children's language knowledge – by determining whether variation in fathers' use of repetition aligns with their children's language abilities. Interestingly, fathers have been shown to be more challenging communication partners in some instances (e.g., in using more *wh*-questions and eliciting more speech) relative to mothers, and this seems to benefit children's language development. Children are able to rise to the challenge of communicating with fathers in these slightly more demanding interactions, as their utterances are often longer when communicating with fathers than mothers (Rowe, Coker, & Pan, 2004), and fathers' uses of *wh*-questions with toddlers is positively related to children's language outcomes (e.g. Rowe, Leech, & Cabrera, 2016). Here we examined fathers' repetition of words in the context of play interactions with their 2-year-old children. Three different measures of repetition were used – type-token ratio, automated repetition index, and partial repetition coding (see Method section for details) – to address whether variability in children's vocabulary size at 24 months is meaningfully related to repetition in fathers' input. Because prior literature has revealed wide variability in caregivers' speech to their children (e.g., Weisleder & Fernald, 2013), we first aimed to quantify the amount of variability in the use of repetition and partial repetition of words across utterances in fathers' speech to their two-year-old children.

Next, given that repetition may become a less helpful cue over time, we predict that fathers will use *less* repetition if their children have larger vocabularies. Specifically, we predict that variation in fathers' repetition will be negatively correlated with children's concurrent vocabulary knowledge. It is also possible, however, that variation in fathers' repetition will be positively correlated with children's concurrent vocabulary knowledge, given previous findings showing that repetitiveness in parents' speech to young infants predicts children's later vocabulary (Newman et al., 2016), and given the fact that researchers have not identified a threshold of language ability at which repetitiveness becomes less necessary for word learning in naturalistic interactions. Overall, this work will contribute to our knowledge regarding the extent to which repetition continues to be an important structural feature of CDS in different contexts and at different points in children's development.

Method

Participants. The present study used data from naturalistic interactions between low-income fathers and their 24-month-old children (n = 41). The data originally come from the Early Head Start Research and Evaluation Project (EHSREP), a randomized controlled evaluation of Early Head Start (EHS), which is a government-funded program in the United States designed to enhance children's health and development in families at or below the poverty level (Vogel, Xue, Moiduddin, Carlson, & Kisker, 2010). The sample used here comes specifically from the Father Involvement with Toddlers Substudy (FITS) (see Boller et al., 2006 for additional information on FITS), and includes English-speaking, African-American fathers and their 24-month-olds (22 girls,

19 boys). Fathers in this sample ranged from 18 to 52 years (*M* = 29 years, *SD* = 8.96). Fathers also varied in their years of educational attainment, but on average earned a high school degree (*M* = 12.5; Range = 10-16; *SD* = 1.47). As in Rowe et al. (2016), we will include years of education as a control variable in our analyses, because other studies within low-SES samples find that variation in parents' education level relates to differences in parents' use of CDS and children's vocabulary development (e.g., Pan, Rowe, Singer, & Snow, 2005; Rowe, Pan, & Ayoub, 2005; for an exception, see Weisleder & Fernald, 2013). See Rowe et al. (2016) for additional characteristics of the father/child pairs in our sample.

Procedure. Father-child pairs were videotaped at home for 10 minutes of semi-structured reading and play when children were 24 months of age. Each father was asked to play with their child using the contents of three bags, which contained: 1) a book, *The Very Busy Spider*, 2) a toy pizza and telephone, and 3) a toy barnyard with animals. The fathers were asked to play with the bags in this order, but they could divide the 10 minutes however they wanted. The experimenter also interviewed fathers and mothers to collect demographic information. Mothers completed the Words and Sentences short form of the MacArthur Bates Communicative Development Inventory (MCDI), a checklist of 100 lexical items where parents indicate whether their child has produced each word (see Fenson et al., 2000). According to maternal report, children's productive vocabularies within this sample ranged from 14 to 93 words (*M* = 61.0; *SD* = 18.22). One year later, when children were 36 months old, researchers visited the families in their homes and assessed children's receptive vocabulary using the Peabody Picture Vocabulary Test (PPVT), 4th edition (Dunn & Dunn, 2007), as well as their verbal

reasoning using the Mental Development Index (MDI) from the Bayley Scales of Infant Development, 2nd edition (Bayley, 1993). Note that analyses involving the PPVT and MDI used a reduced sample (n = 36 and n = 34, respectively) due to missing data from the latter visit. See Rowe et al. (2016) for more details on assessment methods.

Measures of Input Quantity and Quality. Fathers' 10-minute interactions with their 24-month-olds were transcribed by trained research assistants, using the CHAT conventions of the Child Language Data Exchange System (CHILDES; MacWhinney, 2000). To ensure accuracy, each transcript was verified by a separate research assistant. Each line codes for a different utterance, defined as a sequence of words that is preceded or followed by a change in conversational turn, intonation, or pause. Using the CLAN (Computerized Language Analysis) program (MacWhinney, 2000), we retrieved automated analyses of the total number of words (word tokens) spoken by fathers, our measure of overall quantity of speech. Our measure of input "quality" – repetition across utterances – was calculated in three distinct ways, as follows.

1. Type-token ratio (TTR): Using CLAN, we automatically calculated TTR, defined as the number of different word types in fathers' input divided by the total number of word tokens. Lower TTR signaled a greater amount of overall repetitiveness.
2. Repetition index: Using the CHIP framework (Sokolov & MacWhinney, 1990) within CLAN, we automatically calculated an average repetition index for each father, looking exclusively at fathers' self-repetition, not repetition across fathers' and children's utterances. CHIP computes a repetition index for the amount of overlap between one utterance (the "source" utterance) and

the utterance that follows (the "response" utterance). For example, if there are five total words in an utterance and two of those words overlap with the previous utterance, the repetition index would be 2 divided by 5, or 0.40. While CHIP's repetition index can be used to examine utterances across speakers, the father was always both the "source" and "response" in our analyses. Two contiguous father utterances still count as "source" and "response" utterances even if a child utterances occurred between the two.

3. Partial repetition: From the transcripts, trained research assistants identified and marked every instance of partial repetition of nouns, verbs, and adjectives. We defined partial repetition as instances where fathers repeated one or more nouns, verbs, and/or adjectives in three or fewer lines following the first instance of the word (children's own utterances were included in this line count). Note that the repetition of inflected forms was also counted (e.g., "cow" in one sentence and "cows" in another). Similar to other corpus analyses that have excluded words that do not fit into clean open-class categories (e.g., Brent & Siskind, 2001), we were interested specifically in partial repetition of open-class words. We also excluded repetitions of identical utterances (i.e., fathers repeating an entire sentence within three lines following the first instance of that sentence) to try to avoid instances where fathers simply thought their children failed to hear them. Additionally, our coding excluded proper nouns, pronouns, auxiliary verbs, and "to be" verbs. See Kaye (1980) for a similar method of coding parents' partial repetition, in which the researchers identified words that reoccurred within three utterances

and excluded exact immediate repetitions of identical utterances. Below is an example of one instance of partial repetition – taken from one of the 41 father/child transcripts – where a father repeats the noun "sheep" and the verb "go" within three lines following the first instance of the word (note that the child's utterance of "sheep" is counted in the line count, but would not be counted as an instance of partial repetition).

Father: How do **sheep go**?

Child: Sheep

Father: No

Father: **Sheep go** baah

To ensure reliability, 20% of transcripts were coded by two research assistants. Percent agreement, defined as the number of agreed-upon partial repetition coding markings divided by the total number of markings per subject, averaged 95.6%.

Measures of Input Quantity and Quality. In all analyses, we controlled for fathers' years of education, as prior work has shown that variation in parents' years of education relates to differences in the quantity and quality of parents' speech (e.g., Hoff, 2006; Malin, Cabrera, & Rowe, 2014; Rowe et al., 2005; Rowe, 2008). Using CLAN, we also obtained a measure of the total number of child word types used during the parent-child interaction at 24-month (i.e., the number of different word roots produced by the child), as a secondary measure of children's vocabulary knowledge.

Results

Variability in fathers' language input. There was substantial variability in our measures' of fathers' input, in line with previous research showing variability in quantity and quality of speech within low-SES samples (e.g., Pan et al., 2005; Weisleder & Fernald, 2013). Total number of words in fathers' speech (our measure of input quantity) ranged from 163 to 1,202 words per 10 minutes (M = 710.61, SE = 37.20), revealing a 7-fold difference in input between the least and most talkative fathers in our low-SES sample. In terms of repetition (our measures of input quality), fathers' TTR ranged from .18 to .42 (M = .26, SE = .01), fathers' average repetition index ranged from .43 to .74 (M = .58, SE = .02), and fathers' instances of partial repetition ranged from 8 to 85 (M = 40.51, SE = 2.84). Note that the highest TTR value (.42) was greater than 2.5 standard deviations above the mean, so we excluded it as an outlier in all subsequent analyses, and the adjusted range of fathers' TTR was .18 - .37 (M = .25, SE = .01). Correlations among these measures suggest that they captured overlapping but distinct aspects of fathers' language input. While TTR and partial repetition were significantly correlated (r = -.61, p < .001), there was no significant correlation between TTR and repetition index (r = -.03, p = .87), or between partial repetition and repetition index (r = .16, p = .30).

Father's repetition and children's language knowledge. To determine whether there were relations between children's MCDI scores and fathers' use of repetition, we first ran simple correlations between children's MCDI scores (i.e., their 24-month productive vocabulary) and our measures of repetition in fathers' input. Interestingly, in our sample, children's vocabulary at 24 months was not significantly related to fathers' total number of words (r = -.17, p = .29). However, children's vocabulary at 24-months

was significantly related to all three measures of fathers' repetition. Fathers' TTR was positively correlated with children's MCDI scores (r = .33, p = .04), suggesting that greater repetitiveness was negatively associated with children's vocabulary; fathers' repetition index was negatively correlated with children's MCDI scores (r = -.32, p = .04); and fathers' partial repetition was negatively correlated with children's MCDI scores (r = -.35, p = .03). Thus, across all three measures, children with larger vocabularies at 24 months (as reported by mothers on the MCDI) had fathers who used less repetition when speaking to them, suggesting the possibility that fathers are adjusting their speech to the language level of their children (see Figure 1.1).

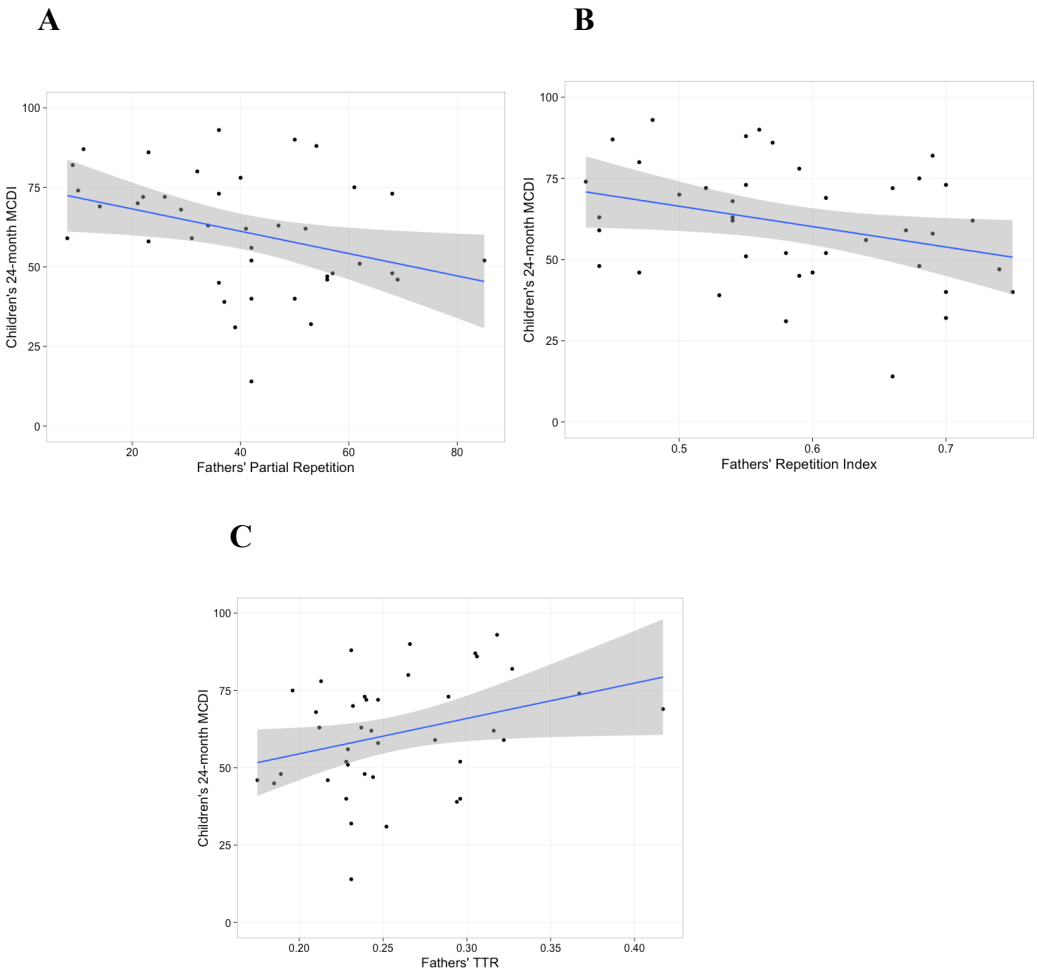


Figure 1.1. Correlations between children's 24-month MCDI and each measure of fathers' repetition: A) partial repetition, B) repetition index, and C) type-token ratio (TTR) (where lower TTR suggests more repetition). Blue lines show smoothed conditional means (linear), and error bands show confidence intervals around the mean.

To investigate potential child effects on fathers' input further we fit regression models to determine whether children's vocabulary at 24 months predicted each measure of repetition, controlling for total quantity of input and fathers' education. Results displayed in Table 1.1 show that children's 24-month vocabulary on the MCDI was a significant predictor of fathers' TTR ($p < .05$), controlling for fathers' education (*ns*) and total quantity of fathers' speech ($p < .001$) (Model 1). Similarly, children's 24-month vocabulary was a significant predictor of fathers' repetition index ($p < .05$), controlling for fathers' education (*ns*) and total quantity of fathers' speech (*ns*) (Model 2). Finally, children's 24-month vocabulary was a marginally significant predictor of fathers' partial repetition ($p = .051$), controlling for fathers' education (*ns*) and total quantity of fathers' speech ($p < .001$). Thus, across all three measures of repetition, children's vocabulary at 24 months was significantly associated with fathers' repetition at 24 months, such that children with larger (versus smaller) vocabularies had fathers who used less repetition, controlling for the total number of words spoken and fathers' level of education.

	Model 1: TTR	**Model 2: Rep Index**	**Model 3: Partial Rep**
Intercept	.06 (.09)	.04 (.15)	.01 (.11)
Father education	.11 (.10)	.19 (.15)	-.17 (.12)
# word tokens	-.78*** (.11)	.07 (.16)	.64*** (.12)
24-month MCDI	.20* (.10)	-.32* (.16)	-.24† (.12)
R squared (%)	66.59	14.34	52.95

***$p < .001$, ** $p < .01$, * $p < .05$, † $p < .1$

Table 1.1. Regression models predicting fathers' TTR (where lower TTR suggests more repetition) (Model 1), fathers' repetition index (Model 2), and fathers' partial repetition (Model 3) from fathers' education, fathers' total number of words, and children's MCDI vocabulary scores at 24 months. Table displays *β*-coefficients for each predictor (with significance symbols where applicable), with standard error in parentheses. The final line displays R-squared values for each model.

As a final step, we examined whether children's total number of word *types* (i.e., number of different word roots they produced) during the play interaction was related to fathers' repetition. That is, it is possible that to the extent they differ, both children's general vocabulary knowledge (MCDI) and their vocabulary use in the specific interaction (word types) may be associated with fathers' input. While number of child word types was not significantly related to fathers' TTR (r = .04, p = .81) or fathers' repetition index (r = -.14, p = .39), there was a significant negative relation between number of child word types and fathers' partial repetition (r = -.38, p = .01). To further explore this relationship, we added child word types to our regression models to determine whether child word types at 24 months predicted repetition in fathers' input, controlling for total quantity of input, fathers' years of education, as well as children's 24-month MCDI vocabulary scores. Children's MCDI scores and their number of word types used during the interaction were positively, but not significantly, correlated (r = .23, p = .16). Results displayed in Table 1.2 show that children's 24-month word types was significantly associated with fathers' partial repetition (p < .001), controlling for fathers' education (*ns*), total quantity of fathers' speech (p < .001), and children's 24-month vocabulary scores (p < .10) (Model 3). Children's word types at 24-months was not significantly associated with fathers' TTR (Model 1) or repetition index (Model 2), controlling for the same variables. Thus, children's language knowledge – as displayed

by the number of different word types they used within a conversational episode – was negatively related to fathers' use of partial repetition within that same conversational episode. That is, children who used *more* different word types had fathers who used *less* partial repetition across neighboring utterances.

	Model 1: TTR	**Model 2: Rep Index**	**Model 3: Partial Rep**
Intercept	.06 (.10)	.04 (.15)	.01 (.11)
Father education	.11 (.10)	.19 (.15)	-.17 (.12)
Fathers' # word tokens	-.78*** (.11)	.07 (.16)	.64*** (.12)
24-month MCDI	.20† (.10)	-.30† (.16)	-.14† (.10)
# child word types	-.02 (.10)	-.08 (.16)	-.40*** (.10)
R squared (%)	66.62	14.96	67.95

*** $p < .001$, ** $p < .01$, * $p < .05$, † $p < .1$

Table 1.2. Regression models predicting fathers' TTR (where lower TTR suggests more repetition) (Model 1), fathers' repetition index (Model 2), and fathers' partial repetition (Model 3) from fathers' education, fathers' total number of words, children's MCDI vocabulary scores at 24 months, and children's total number of word types spoken. Table displays β-coefficients for each predictor (with significance symbols where applicable), with standard error in parentheses. The final line displays R-squared values for each model.

Finally, because we found negative relations between children's language knowledge and fathers' use of repetition in general, we wanted to address the possibility that fathers' repetition at this age might be negatively associated with children's later language outcomes. To do so, we examined whether repetition in fathers' speech to their 24-month-olds related to language outcomes at 36 months, as measured by PPVT vocabulary scores and MDI verbal reasoning scores. While we cannot definitively determine who is influencing whom from our correlational study, there are two

competing possible outcomes of this analysis that can enable us to make cautious inferences about directionality. First, if fathers' repetition is driving variation in children's vocabulary levels, then fathers' repetition at 24 months should also be negatively related to children's language outcomes at 36 months. On the other hand, if children's vocabulary levels contributed to variations in fathers' repetition – that is, if fathers tailored their input to the language level of the child – then fathers' repetition at 24 months should be unrelated to children's language outcomes at 36 months. In the latter case, fathers with low-vocabulary children at 24-months are likely to be helping those children "catch up" to their high-vocabulary counterparts, whereas fathers with high-vocabulary children might not need to use as much repetition to promote their children's vocabulary growth. Thus, there might be no clear overall relationship between fathers' use of repetition and children's later vocabulary.

To examine these two possible alternatives, we ran partial correlations between each measure of fathers' repetition at 24 months (TTR, repetition index, and partial repetition) and children's language outcomes at 36 months (PPVT vocabulary scores and MDI verbal reasoning scores), controlling for fathers' education, fathers' total number of word tokens at 24 months, and children's MCDI vocabulary scores at 24 months. None of the relations were statistically significant (see Table 1.3).

	36-month PPVT	**36-month MDI**
TTR	.07	-.24
Repetition Index	-.28	-.19
Partial Repetition	.20	-.27

*** $p < .001$, ** $p < .01$, * $p < .05$, † $p < .1$

Table 1.3. Partial correlations between children's language outcomes at 36 months (PPVT vocabulary scores and MDI verbal reasoning scores) and each measure of fathers' repetition at 24 months (TTR, Repetition Index, and Partial Repetition), controlling for fathers' education, fathers' total number of word tokens at 24 months, and children's MCDI vocabulary scores at 24 months.

General Discussion

The present study examined variability in low-SES fathers' repetition and partial repetition in speech to their 2-year-old children. In particular, we asked whether differences in fathers' repetition were related to children's vocabulary knowledge. Our results expand upon existing literature in several ways. First, to our knowledge, this is the first study to examine repetition in low-SES families, and our results show wide variability in the extent to which fathers repeat words to their toddlers. Second, while repetition in parents' language input to 7-month-old infants has been shown to positively predict children's vocabulary size in toddlerhood (Newman et al., 2016), our results reveal that at 24 months, repetition in fathers' language input was negatively related to children's concurrent vocabulary size. That is, fathers of children with larger vocabularies used less repetition. Moreover, repetition in fathers' input at 24 months was not predictive of children's subsequent receptive vocabulary or verbal reasoning abilities at 36 months, suggesting that – controlling for concurrent vocabulary – more repetitiveness in fathers' speech to toddlers is not directly implicated in children's later learning outcomes. Together, these findings add support to research showing that specific features of input are more or less helpful in promoting vocabulary at different stages in early language development (Rowe, 2012; Rowe & Zuckerman, 2016), while extending research on repetition and accommodation to a sample of low-income fathers. Importantly, future longitudinal research is needed to further explore changes in fathers'

use of repetition in child-directed speech over time. Moreover, in order to better understand the unique role played by fathers in children's language learning, future research should compare the present findings directly to mothers' speech, as well as parents' speech across the SES spectrum.

Interestingly, while children's 24-month vocabulary predicted all three indices of fathers' repetition, the strongest relation was between children's vocabulary and fathers' partial repetition in particular. Although we cannot conclusively determine the causal nature of these variables, the fact that child word types at 24 months only predicted fathers' partial repetition suggests that this variable might best capture relevant individual differences in fathers' repetition. This finding – that partial repetition seems to be a particularly promising construct for investigating the relation between fathers' repetition and children's vocabulary development – suggests that the partial repetition of open-class words in particular may be important for promoting children's learning of those words (Schwab & Lew-Williams, 2016a).

One possible interpretation of our findings that 24-month-olds with larger vocabularies had fathers who used less repetition – and that children who produced more word types had fathers who used less partial repetition in particular – is that parents are sensitive to children's language knowledge and tailor their language input to their own child's developmental level. This interpretation is supported by previous research (Huttenlocher et al., 2010; Rowe et al., 2005; Snow & Ferguson, 1977; Vygotsky, 1978). In a study examining caregivers' speech over time with 14- to 36-month-old children, mothers from low-income families increased both their number of word tokens and types as their children became more proficient (Pan et al., 2005). But young children are not

just passive listeners. Their social feedback to caregivers – such as moment-to-moment attentiveness and vocalizations – shapes caregiver's future language input (e.g., Nicely et al., 1999; Ko et al., 2016), and in turn, parental responsiveness promotes children's language development (e.g., Tamis-LeMonda et al., 2014). This active responsiveness to caregivers facilitates increasingly useful and informative interactions with caregivers.

Another possible interpretation of our findings is that fathers' use of more repetition at 24 months "caused" their children to have smaller vocabularies. If this was the case, it is likely that fathers' repetition at 24 months would also negatively relate to children's later vocabulary at 36 months. Yet our research revealed that repetitiveness in fathers' input to children at 24 months was not associated with either of our measures of language knowledge at 36 months (children's PPVT scores or MDI scores) while controlling for concurrent vocabulary, suggesting that fathers' use of repetition did not seem to hinder children's language development. This finding also converges with research showing that although infant-directed speech seems to promote word learning early on in development (e.g., Ramírez-Esparza et al., 2014), this may not be the case for older toddlers (Ma, Golinkoff, Houston, & Hirsh-Pasek, 2011). Similarly, young children's ability to capitalize on parents' repetition of words over time might decline during the third year of life, as observed here. Importantly, however, it does not seem to be the case that hearing more repetition at 24 months is negatively related to children's vocabulary growth; rather, it may simply no longer be beneficial.

Although repetitiveness in fathers' speech to their 24-month-olds was not related to children's 36-month vocabulary or verbal reasoning in our sample, repetition could still be beneficial for this age group under certain circumstances. In particular,

experimental evidence has shown that partial repetition of words in successive sentences is important for two-year-olds' initial encoding of new words (Schwab & Lew-Williams, 2016a). Thus, it is possible that when 24-month-olds are learning new object labels, hearing a word in immediate succession is initially beneficial, but it might not be as necessary with subsequent exposures to words over protracted time scales. Moreover, the recordings of fathers took place in a constrained setting: all children participated in a 10-minute play session with familiar objects, such as a toy pizza, toy telephone, and toy animals. Increased repetition may not be helpful in this laboratory context, but in natural settings where two-year-olds are engaging with many new words, parents' repetition over time may in fact positively predict language outcomes.

Our findings also contribute to a growing field of research examining the relations between fathers' interactions with their children and children's developmental outcomes. While most prior research showing the influence of parents' speech on children's language outcomes has focused on mothers' speech and mother/infant interactions, particularly in middle-income households (e.g., Newport et al., 1977; Hoff, 2003), more recent research has shown that high-quality interactions with fathers also promote children's language and cognitive development (e.g., Cabrera, Shannon, & Tamis-LeMonda, 2007; Shannon, Tamis-LeMonda, London, & Cabrera, 2002). In particular, fathers' responsiveness to their young children predicts language development in a similar way to mothers' responsiveness (e.g., Tamis-LeMonda et al., 2004). Our findings go further to suggest that fathers in a low-SES sample vary the amount of repetition in their speech based on their children's vocabulary knowledge. Thus, similar to mothers

(e.g., Rowe et al., 2005), fathers seem to engage in a highly sensitive form of audience design, tailoring their speech to the language level of their child.

To help alleviate the 'vocabulary gap' between low- and high-SES toddlers, as well as to better serve children with language delays or disorders, researchers need to determine the particular ways in which caregivers can promote children's language learning. Future work is needed to compare the use of specific features of language input (such as repetition) in the speech of mothers and fathers from both high- and low-SES families. This would facilitate a more complete understanding of how variation in these features interacts with different children's learning trajectories. However, our results are suggestive of two possible steps for parent-aimed interventions and early childhood programs. First, suggestions for enhancing parent-child interactions should be targeted to children's specific age and level of language knowledge. A one-size-fits-all strategy for supporting language learning is not likely to be beneficial for all young children, and we currently know little about when and why certain types of input are more or less helpful for different children's language development. This is a prime opportunity for collaboration between basic cognitive scientists and, for example, speech-language pathologists. Notably, several speech therapy techniques already incorporate the use of repetition, such as auditory bombardment, in which specific sounds are repeated (Bowen & Cupples, 1998), and focused stimulation, in which a child is exposed to multiple exemplars of a specific linguistic target (Ellis Weismer & Robertson, 2006). Second, the present study extends previous research showing the importance of fathers for promoting children's language development. Specifically, we show for the first time that repetition in low-income fathers' speech is related to children's language knowledge, providing

further support for the idea that policies and programs should aim to include fathers as an important centerpiece of parenting.

Conclusions. Although repetition of words over time may be beneficial for children's language learning at early developmental time points, as well as for the initial encoding of new words slightly later in development, the present study suggests that repetition in fathers' language to their children does not broadly promote children's language learning in the third year of life. Instead, within our low-SES sample, fathers seem to tailor their speech – and in particular, their use of repetition – to the language level of the child. This research highlights a key idea for future research on the influence of language input on children's learning: that specific features of language input are beneficial to children at different time points of development and across different contexts. In designing interventions that target early language learning, simple messages to parents such as "more repetition is good" or "more repetition is bad" are not accurate or beneficial. Instead, it is important for caregivers to cater their language to children's maturing vocabulary knowledge. In support of efforts to improve the effectiveness of policies, interventions, and early childhood programs, our findings indicate that fathers provide responsive and valuable support for children's language growth over time.

Chapter III: How does the use of isolated words interact with repetition to influence word learning?[3]

While previous research suggests that isolated words are (1) present in CDS and (2) promote early language learning (e.g., Brent & Siskind, 2001; Lew-Williams et al., 2011), it is unclear the extent to which isolated words are helpful on their own, or whether their power in facilitating language learning comes from *also* being repeated in nearby sentences. Notably, repetition has been built into the operationalization of isolated words in much of the literature. For instance, in Lew-Williams et al. (2011), isolated words always occurred in immediate repetition with neighboring sentences (where the same word occurred within the sentence). Brent & Siskind (2001) *only* looked at words that occurred both in isolation and in combination with other words in the corpus (86 words that occurred in isolation but never occurred in combination with other words were excluded from the word count). Moreover, results revealed that of the 63.1 isolated word types children heard on average, 17.2 of those were repeated within 30 seconds. These findings suggest that caregivers not only tend to use a variety of word types in isolation, but they also tend to repeat a number of those word types in close temporal proximity. Together, these findings suggest that the definition of isolated words (as words that only occur in "isolation") might be too narrow. Given that many previous isolated word studies involve repetition, it is possible that there is an important interaction between isolation and partial repetition in the context of child-directed speech and children's word

[3] This chapter was conducted in collaboration with Rose M. Hartman, Caitlin M. Fausey, and Casey Lew-Williams. The results of Experiment 2 were presented at the 2016 International Conference on Infant Studies, New Orleans, LA. The results of Experiment 3 were presented at the 2017 Interdisciplinary Advances in Statistical Learning conference, Bilbao, Spain.

learning.

Additionally, while previous research has focused on isolated words being beneficial in helping young children identify word boundaries in a stream of speech (Lew-Williams et al., 2011) and in promoting word learning over time (Brent & Siskind, 2001; Swingley & Humphrey, 2017), it is not yet clear whether the use of isolated words directly facilitates children's learning of word-object pairings. The present set of studies aims to address this question. Moreover, these studies are the first – to our knowledge – to delve into the extent to which these two cues of CDS (isolated words and partial repetition) contribute independently to learning or whether the effect is additive, as well as whether or not these cues co-occur in natural CDS. In doing so, we aim to determine whether the established definition of "isolated words" is in fact too narrow.

First, we present an experiment following up on Schwab & Lew-Williams (2016a) examining the extent to which isolated words influence toddlers' word learning, in combination with either "structured" or "unstructured" input (i.e., input that does or does not contain partial repetition across successive sentences). Second, we reveal an extensive corpus analysis looking at whether partial repetition and isolated words tend to occur together in CDS, particularly focusing on nouns. That is, if a noun occurs in isolation, does it occur more often in structured input (i.e., with partial repetition), or less often? Finally, we replicate our initial experiment and discuss implications of our findings.

Experiment 2: The relationship between isolated words and partial repetition on children's language learning

Schwab & Lew-Williams (2016a) found that two-year-olds could only successfully learn novel words in a fast-paced word-learning paradigm if toddlers received back-to-back exposures to novel word labels ("Structured" condition) and not if exposures were interleaved ("Unstructured" condition). Here we asked whether the use of isolated words in the input boosts children's word learning – both on its own and in combination with structured input. That is, can toddlers successfully learn novel words in an "Unstructured" condition if half of utterances are isolated object labels? Additionally, is children's learning significantly better when isolated words and clusters of "Structured" repetition are combined (i.e., are there additive effects of isolated words and repetition clusters on word learning)?

Method

Participants. 40 monolingual English-learning two-year-olds (*M*=29.18, *SD*=3.62, range=24.3-36.2 months) took part in this study. Nineteen participants were female, and all participants lived in monolingual English-speaking homes. Children had no history of developmental delays or disorders. Twenty children were randomly assigned to each of two experimental conditions: an *Isolated* + *Structured* condition and an *Isolated* + *Unstructured* condition, described in detail below. Nineteen additional participants were tested but not included due to fussiness (*n*=9), instrument error (*n*=2), or inattentiveness (i.e., looking away from the screen throughout more than 50% of trials in the learning or test phase, *n*=8).

Stimuli & Design. The stimuli and design nearly identical to Schwab & Lew-Williams (2016a). Three novel words – *fep, dax,* and *coro* – corresponded to one of three pictures of novel objects, each characterized by a different color, texture, and shape (adapted from Horst, 2009). Half of participants saw one set of word/object pairings, and half saw a second, counterbalanced set of pairings. All participants heard each word one time in each of three sentence frames ("Do you know what a ___ is?/ Wow, this ____ looks neat./ Can you find the ____ there?"), as well as three times in isolation. All words and sentences were recorded in a child-directed manner by a female native English speaker in a soundproof booth, edited in Praat, and set to a 65 dB intensity level. During the experiment, visual stimuli were displayed on a 55-inch television, and audio was projected from laterally placed speakers.

The *Structured + Isolated* condition consisted of blocked exposure to each novel object – as in the Structured condition of Schwab & Lew-Williams (2016a) – but half of the exposures were sentences and half were isolated words (e.g., "Wow, this *fep* looks neat. *Fep*! Do you see the *fep* here?"). There were two blocks of labeling sentences for each novel word/object pair, and sentences and isolated word utterances always alternated within each block (i.e., Sentence–Isolated Word–Sentence or Isolated Word–Sentence–Isolated Word). In the *Unstructured + Isolated* condition, participants heard the same sentences and isolated object labels, but ordered such that no two adjacent utterances had overlapping words (e.g., "Wow, this *dax* looks neat. *Fep*! Do you see the *coro* here?"). Total number of exposures to each word and total time each object appeared on the screen was controlled across conditions.

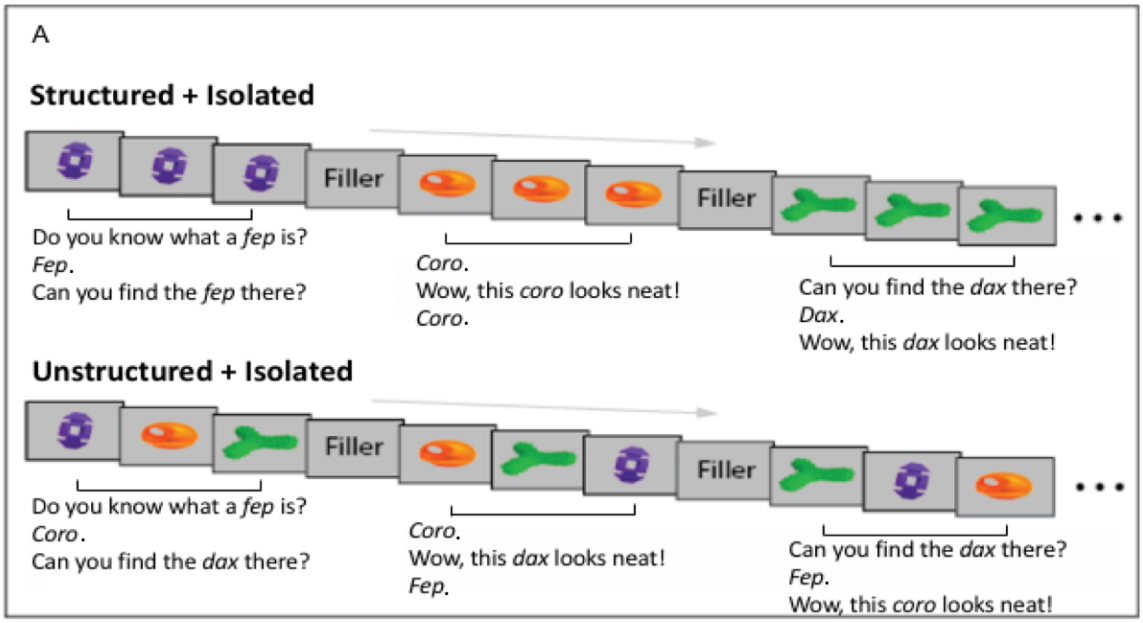
Procedure. Participants were seated on a parent's lap, approximately 36 inches from the monitor. Parents wore opaque sunglasses and were instructed not to interfere during the experiment. Participants were randomly assigned to either the *Structured + Isolated* or *Unstructured + Isolated* condition.

In the *learning phase* (see Figure 3a), each novel object picture was shown by itself for 3 s, with a blank screen displayed for 300 ms between pictures. Each utterance began 200 ms after picture onset. There were 18 labeling trials in the learning phase (six per object), plus five attention-getting filler trials, which occurred between sets of three labeling episodes. Filler trials consisted of pictures and videos with accompanying sounds or child-directed utterances (e.g., a train animation with a voice saying "Choo-choo!" or a picture of puppies and a voice saying "Look at the puppies!"). Two counterbalanced trial orders were used across participants.

The *test phase* (see Figure 3b) was presented immediately after the learning phase, following a 4-s attention-getting filler trial, and was identical for both conditions. The test phase followed a looking-while-listening design (see Fernald, Zangl, Portillo, & Marchman, 2008). On each test trial, participants saw a pair of two of the novel object pictures positioned on the left and right sides of the screen. Test sentences asked participants to identify one of the objects (e.g., "Where is the fep? Do you see it?"). Each test trial was 5.7 s total. Pictures were shown in silence for 2 s, followed by the test sentences or isolated words, which lasted 2.7 seconds. There were 18 test trials, with each novel word/object pair tested six times. Similar to the learning phase, the test phase also included five attention-getting filler trials, which occurred after every three test trials. Two counterbalanced test orders were used across participants.

Patterns of eye gaze were coded offline, frame by frame, at 33 ms intervals. Each child's eye gaze was coded as 'left' if looking at the left picture, 'right' if looking at the right picture, 'off' if shifting between pictures, or 'away' if not looking at either picture. Trials where the child looked away at noun onset or looked away for more than 15 consecutive frames were excluded from analyses. To assess reliability, 25% of videos were coded by a second researcher. The overall proportion of frames on which coders agreed on gaze location averaged 98.3%. A more conservative reliability estimate measuring the mean proportion of frame agreement during shifts in gaze averaged 96.3%.

Additionally, children's vocabulary was assessed using the MacArthur-Bates Communicative Development Inventory: Words and Sentences (Fenson et al., 2007). The MCDI is a standardized measure of children's expressive vocabulary based on parental report, using a checklist of 680 words. Between conditions, there were no significant difference in mean MCDI vocabulary scores (Isolated + Structured*: M*=439.75*, SE* =39.01*;* Isolated + Unstructured*: M*=452.0*, SE*=39.86*; t(38)*= -.24, *p*=.81, *d*=-.08).



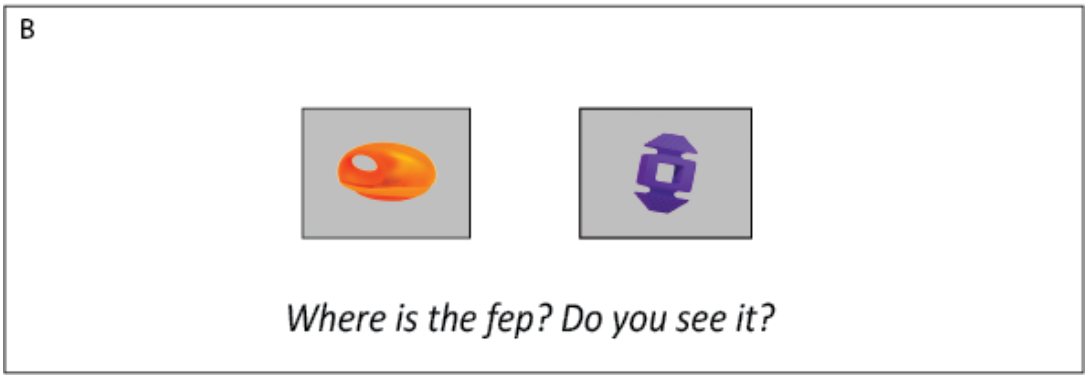


Figure 2.1. Experimental procedure. (A) Example trial orders showing objects labeled over time in the learning phase for participants in the *Structured* + *Isolated* and *Unstructured* + *Isolated* conditions. (B) Example test trial, where two of the novel objects appeared side-by-side, and participants heard sentences referring to one of them (e.g., "Where is the fep?").

Results

Children's accuracy in looking to target pictures during the test phase was the primary measure of word learning, as in other studies of novel word processing (e.g., Bion, Borovsky, & Fernald, 2013). Accuracy was calculated as participants' total time looking to the target picture divided by their total time looking to either picture on each test trial, within a time window of 300 to 2000 ms after noun onset, in accordance with previous research on young children's language processing (Fernald et al., 2008). Trials were included in analyses if children were looking at either the target or the distracter object at noun onset. Figure 2.2 displays children's accuracy in looking to the target referent over time in the Structured + Isolated condition and Unstructured + Isolated condition. Figure 2.3 displays children's average accuracy in the Structured + Isolated condition (M=.59, SE=.02) versus the Unstructured + Isolated condition (M=.57, SE=.03) within the analysis window. A two-tailed independent samples t-test (one-tailed) revealed no significant difference in accuracy between the Structured and Unstructured conditions, $t(36.59)$=.50, p=.62, d=.16. However, accuracy was significantly greater than chance

(with chance defined as 50% looking to the target) in both the Structured + Isolated condition ($t(19)=4.12$, $p<.001$)), and the Unstructured + Isolated condition ($t(19)=2.72$, $p=.01$), suggesting that participants learned the novel words successfully in both conditions.

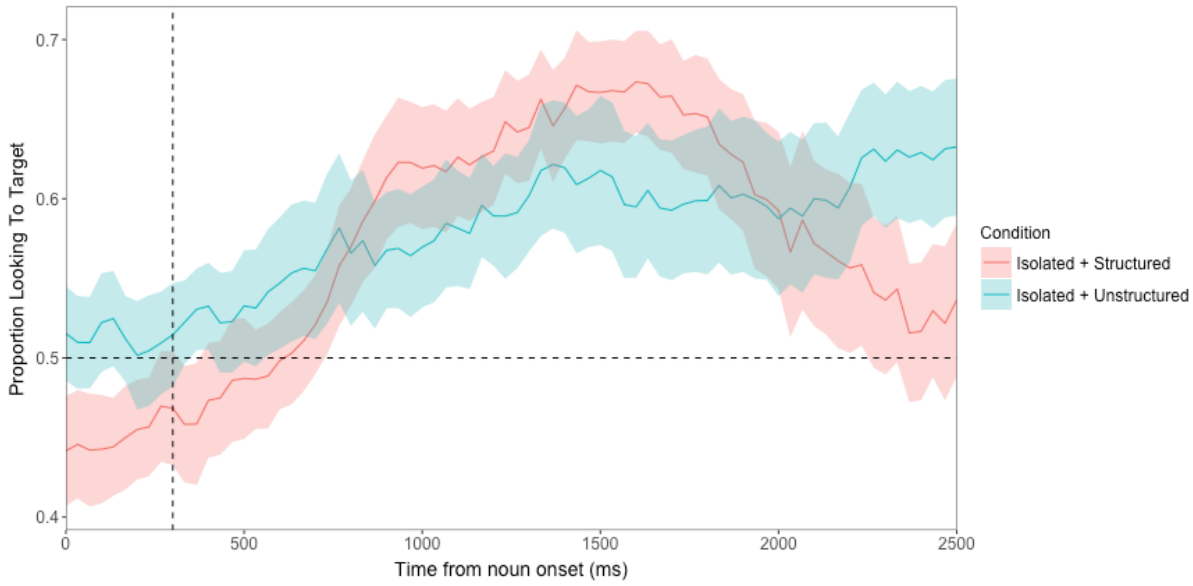


Figure 2.2. Change over time in mean proportion of looks to the target beginning at noun onset for the Isolated+Structured and Isolated+Unstructured conditions. Accuracy looking to the target was measured starting at 300 ms (as noted by the dashed vertical line) to account for the amount of time (in milliseconds) it takes to program an eye movement. The horizontal dashed line shows chance levels of looking to the target object. Error bands show standard errors across participants.

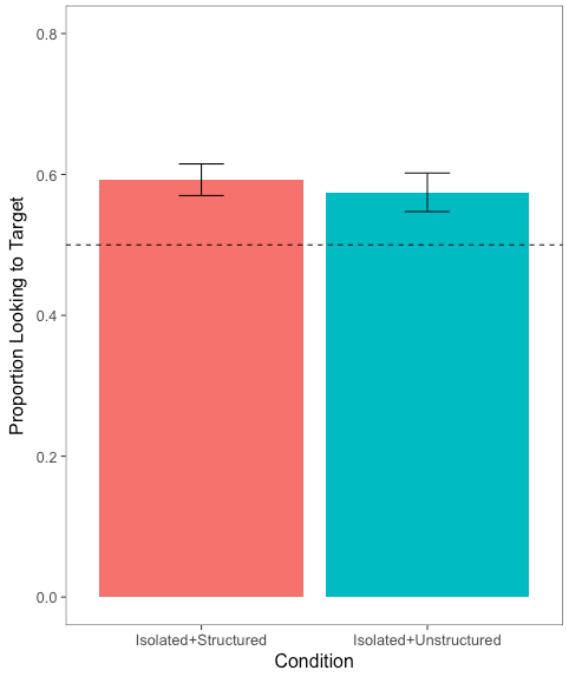


Figure 2.3. Mean proportion of looks to the target picture (i.e., accuracy) following noun onset for the Structured + Isolated and Unstructured + Isolated conditions. The dotted line shows chance levels of looking. Error bars show standard errors across participants.

Given that our participants spanned the full range of the third year of life (24 to 36 months), we examined effects of age on children' novel word learning (as in Schwab & Lew-Williams, 2016a). Note, however, that there was no significant difference in mean age across conditions (Isolated + Structured: M=28.75, SE=39.01; Isolated + Unstructured: M=29.61, SE=.90; t(38)=-.74, p=.46, d=-.23). A 2x2 factorial analysis of variance (ANOVA) revealed no significant main effect of age (F(1, 36)=0.773, p=.25, η^2_p=.01) and no significant age x condition interaction, (F(1, 36)=0.17, p=.68, η^2_p=.005). Thus, there seemed to be no influence of age on two-year-olds' ability to utilize isolated words in learning new object labels.

Discussion

Thus, unlike in Schwab & Lew-Williams (2016a), participants were able to successfully learn new word/object pairs in an "Unstructured" condition when half of utterances were isolated object labels, suggesting that isolated words may help promote word learning in 2-year-olds, at least in the absence of partial repetition. Yet these results also suggest that there may not be an additive effect of having both structural features – isolated words and partial repetition – on children's word learning. Although the experiment suggests that isolated words and partial repetition together in child-directed speech provide no additive benefit, this result may have been due to the nature of the testing design. In particular, given the fast-paced nature of the task, there may have been ceiling effects. Additionally, there was a non-significant baseline difference in proportion

looking to the target (from 0-300 ms) between the Isolated+Structured (*M*=.51, *SE*=.03) and the Isolated+Unstructured condition (*M*=.45, *SE*=.03), *t*(38)=-1.43, *p*=0.16, *d*=-.45 (see Figure 2.2). Finally, the two conditions may not have varied enough in their "structure" to capture a difference in learning (e.g., note that the unstructured condition was still marked by repetition of nouns over the course of the learning phase). Given these constraints, Experiment 3 sought to examine the profile of isolated nouns and partial repetition in *naturalistic* child-directed speech, as well as determine whether the combination of isolated words and repetition in this type of input tend to predict children's acquisition of those nouns, over and above the use of isolation or repetition alone.

Experiment 3: The profile of isolated nouns and repetition in child-directed speech

In order to help clarify the results of Experiment 2 and further answer the question of whether isolated words and partial repetition might work together to promote word learning, Experiment 3 examined corpora of parent-child interactions to determine whether or not these two cues do in fact tend to travel together in naturalistic child-directed speech. Specifically, if a noun often occurs in isolation, does it also often occur in clusters of repetition (or are nouns that occur in isolation repeated sooner than nouns that do not occur in isolation)? Additionally, we tested the extent to which repetition, isolated words, and the two features together are predictive of vocabulary age-of-acquisition norms, in order to determine the extent to which these features might be related to children's learning of new nouns.

Method

To examine the profile of caregivers' use of isolated nouns and partial repetition of nouns in child-directed speech, we used dense at-home recordings of caregiver-child interactions, including all available CHILDES transcripts from the North American and UK English language collection that were at least an hour in length and taken when children were between 0 and 3 years of age (MacWhinney, 2000), along with the Brent & Siskind (2001) corpus. There were 54 unique caregivers in this set of corpora. We identified the nouns in caregiver utterances using the part-of-speech tagging provided by the MOR grammar (MacWhinney, 2000). All subcategories of nouns were included in the analysis, except proper nouns (such as the child's name). Thus, we analyzed 698,623 noun tokens distributed across 1,135,211 caregiver utterances.

Within this set of corpora, we then defined three patterns of noun use: *isolated nouns* (single-noun utterances), *repetition clusters* (nouns used at least three times within six utterances), and *isolation clusters* (a repetition cluster including at least one isolated noun). Additionally, for each word, the *repetition distance* was calculated: the number of utterances between that word and its closest repetition (excluding repetitions within the same utterance). All measures were calculated within individual conversation transcripts.

Additionally, in order to estimate age of acquisition (AoA) for nouns in our corpus, we used the wordbankr package in R to access MacArthur-Bates Communicative Development Inventory (MCDI) data from 5,846 Words and Sentences administrations, downloaded from WordBank (Frank, Braginsky, Yurovsky, & Marchman, 2016). To estimate AoA, we fit a logistic linear model to find the age at which each word crosses the threshold to at least 50% of children producing it.

Results

First, we analyzed the extent to which repetition and isolation travel together in naturalistic CDS, and we found that nouns that occur in isolation in our corpus are also more likely to be repeated close by. For one, a noun that occurs in isolation at least once is more likely to also occur in a repetition cluster at least once, $X^2(1, N=11351)=3092.7$, $p<.001$, Cramer's $V=.522$ (see Figure 3.1). Note, however, that this result is confounded by frequency, since higher frequency nouns are both more likely to occur in clusters and more likely to occur in isolation. We also found that nouns in isolation have closer repetitions that nouns not in isolation. A mixed effects model predicting the log-transformed repetition distance for noun tokens based on whether or not they are in isolation, with child as a random effect, showed that nouns in isolation are repeated sooner, $b=-.358$, $SE=.022$, $t(46.17)=-16.01$, $p<.001$ (see Figure 3.2). Finally, a paired t-test on the log-transformed repetition distance for all nouns observed both in isolation and not in isolation revealed that when a given noun occurs in isolation, its closest repetition is on average nearer than when that same noun occurs not in isolation, $t(1900)=16.40$, $p<.001$ (see Figure 3.3).

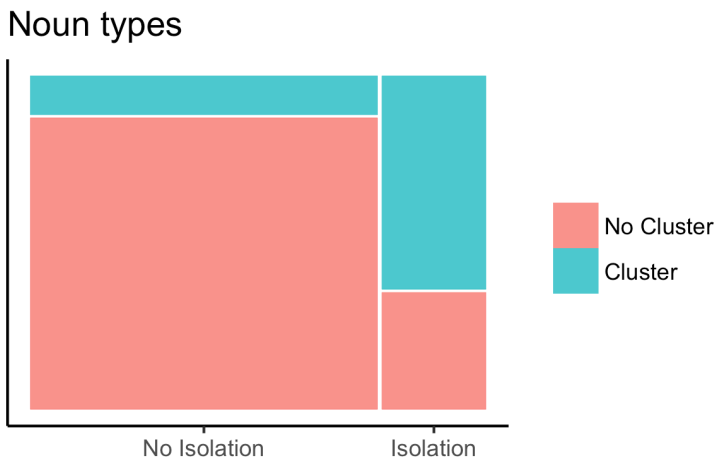


Figure 3.1. Mosaic plot showing relationship between nouns being in isolation (or not in isolation) and in a repetition cluster (or not in a cluster).

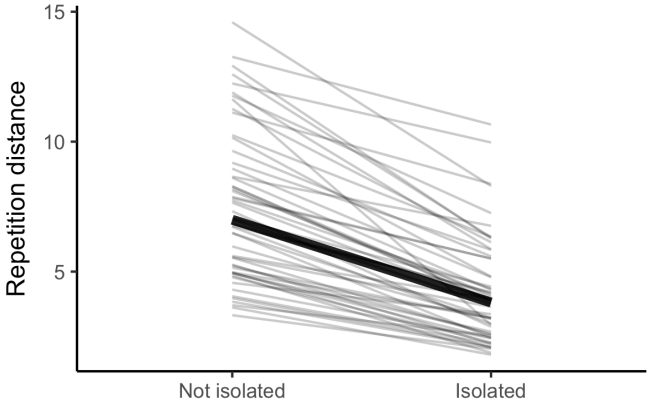


Figure 3.2. Average repetition distance (per child) between nouns that occur in isolation and nouns that never occur in isolation. The dark line displays the overall effect, showing that nouns in isolation tend to be repeated sooner.

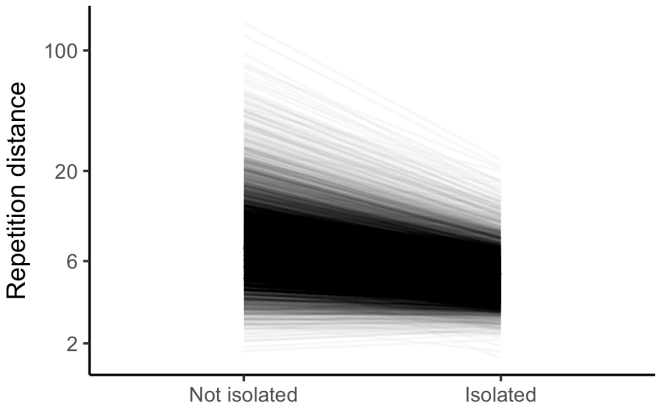


Figure 3.3. For nouns that children hear both in isolation and not, occurrences in isolation are repeated sooner than occurrences of the same noun not in isolation. Each line represents mixed effects model estimates for a different noun. Note that the y-axis is stretched to a log scale to make differences at lower values easier to discern.

Next, we examined the relationship between caregivers' use of each of these three CDS features (isolated nouns, repetition clusters, and isolation clusters) and children's average AoA for nouns (note that this analysis was restricted to the 2.7% of noun types in our available data that also occur on the MCDI) (see Figure 3.4). To avoid multicollinearity, we used measures of isolation, repetition clusters, and isolation clusters after adjusting for frequency. We did this by first running three models predicting 1)

isolation count from frequency, 2) repetition cluster count from frequency, and 3) isolation cluster count from frequency, isolation count, and repetition cluster count. We then used those residuals as variables to predict AoA, so that any shared variance was attributed to the overall frequency effect rather than to any of the usage pattern predictors. Each residual represents the variance in that usage pattern (isolation, repetition clusters, and isolation clusters) beyond what can be explained by frequency – and in the case of isolation clusters, by frequency, isolation count, and repetition cluster count. Thus, we used a conservative analytic approach to evaluate whether isolation clusters per se matter for noun age of acquisition.

A model including log frequency, residualized isolation frequency, residualized repetition cluster frequency, and residualized isolation cluster frequency explained about 47% of the variance in noun AoA, $R^2 = .469$, $F(4,315) = 69.44$, $p < .001$. Noun frequency ($\beta = .612$, $t(315) = 14.09$, $p < .001$) and residualized isolation frequency ($\beta = -.219$, $t(315) = -4.859$, $p < .001$) are associated with earlier AoA. The effect for residualized repetition cluster frequency was not significantly different from zero ($\beta = -.067$, $t(315) = -1.485$, $p = .139$). Note that both residualized isolation frequency and residualized repetition cluster frequency are significantly correlated with of AoA (isolation: $r = -.247$, $p < .001$, repetition clusters: $r = -.158$, $p = .005$), suggesting that the lack of a significant effect for repetition clusters in the combined model is due to multicollinearity between residualized isolation frequency and residualized repetition cluster frequency (tolerance = .829), rather than a lack of a relationship with AoA (Figure 3.4). The residualized frequency of isolation clusters, however, was significantly associated with earlier AoA ($\beta = .171$, $t(315) = 4.173$, $p < .001$). The key result from this analysis is that the residualized frequency of

a noun occurring in isolation clusters predicted AoA for nouns, after controlling for noun frequency, repetition cluster frequency, and isolation frequency.

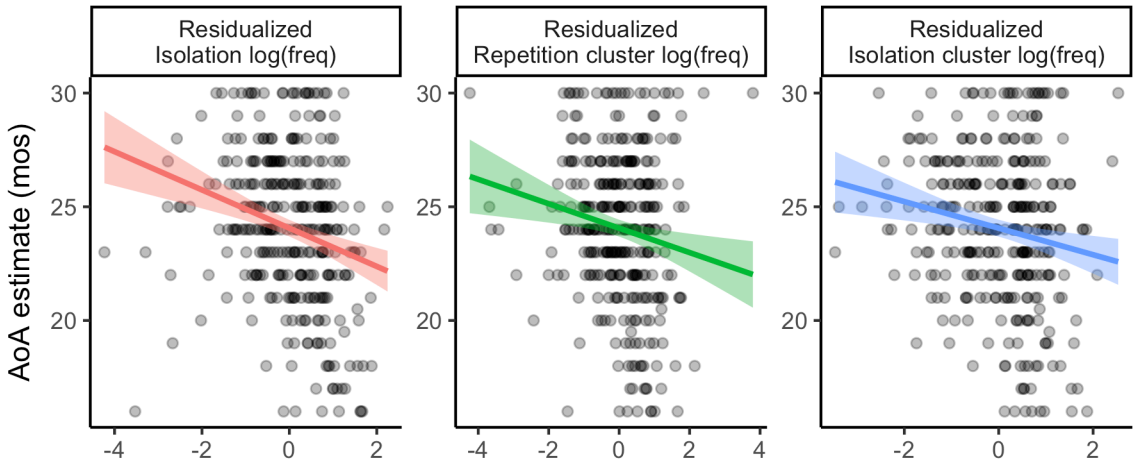


Figure 3.4. Repetition, isolation, and their joint occurrence in child-available speech matter for nouns' age of acquisition. Scatterplots show the relationship between age of acquisition and each of three residualized predictors, standardized (see text). Note that all predictors are residualized on log frequency, and the predictor for isolation clusters is additionally residualized on both isolation frequency and repetition cluster frequency. Lines show the linear best fit, with +-1 SE.

Discussion

Overall, results of the corpus analysis suggest that isolation and partial repetition (or "repetition clusters") travel together in CDS: Nouns occurring in isolation are more likely to be repeated in a nearby utterance compared to nouns not occurring in isolation. Additionally, even after controlling for raw frequency, as well as the frequency of both isolated nouns and repetition clusters, isolation clusters significantly predict children's vocabulary development (i.e., average AoA for nouns on the MCDI). These results suggest that even though the overall frequency of isolated clusters in caregivers' input is low, these two features in combination – isolated words and partial repetition – may have some unique relevance for promoting children's language learning.

Experiment 4: Experiment 2 Replication

While Experiment 2 suggested that repetition and isolated words together (i.e., isolation clusters) may not provide an additional word learning boost over and above the use of isolated words on their own, Experiment 3 (corpus analysis) revealed that isolated words and partial repetition tend to co-occur in natural child-directed speech. Moreover, isolation clusters were found to be uniquely related to children's age-of-acquisition vocabulary norms, suggesting that this feature may be particularly relevant for early word learning. Given this discrepancy in findings between Experiment 2 and Experiment 3, Experiment 4 aims to replicate Experiment 2. We did this in order to be more confident in the results of our first experiment and be sure there was no inherent flaw in our experiment design (given the baseline difference in looking to the target we observed in Experiment 2).

If isolated words and partial repetition together in caregiver's input (e.g., "isolation clusters") do in fact promote children's word learning, it is likely that two-year-olds will show increased learning in the Structured + Isolated compared to the Unstructured + Isolated condition in Experiment 4. However, given that we saw no difference in learning between the two conditions in Experiment 2, it is possible that learning in the Structured + Isolated condition in Experiment 4 will be no different than in the Unstructured + Isolated condition. While the non-significant baseline difference in Experiment 2 may have dampened our ability to capture learning differences among children, it is also possible that the timescale of language exposure within this five-minute experiment does not show enough resemblance to the complexity of children's

naturalistic language environments to reveal any sort of relationship between isolation clusters and word learning. Despite the difficulty in designing experiments to capture naturalistic language learning environments, the aim of this experiment was to clarify the extent to which isolated words and partial repetition do – or do not – work together to promote children's word learning.

Method

Participants. 40 new monolingual English-learning two-year-olds (*M*=29.94 *SD*=3.59, range=24.2-35.9 months) took part in this study. Twenty participants were female, and all participants lived in monolingual English-speaking homes. Children had no history of developmental delays or disorders. Twenty children were randomly assigned to each of two experimental conditions: an *Isolated* + *Structured* condition and an *Isolated* + *Unstructured* condition, described in detail below. Between conditions, there were no significant differences in mean age (Structured: *M*=29.72, *SE*=.86; Unstructured: *M*=30.16, *SE*=.76; *t*(38)=-.38, *p*=.70, *d*=-.23) or mean MCDI vocabulary scores (Structured: *M*=455.25, *SE*=40.91; Unstructured: *M*=469.10, *SE*=27.88; *t*(38)=-.28, *p*=.78, *d*=-.09). Thirty-seven additional participants were tested but not included due to fussiness (*n*=13), instrument error (*n*=9), inattentiveness (i.e., looking away from the screen throughout more than 50% of trials in the learning or test phase, *n*=13), or experimenter error (*n*=2).

Stimuli & Design. The stimuli and design were identical to Experiment 2.

Procedure. The procedure was identical to Experiment 2. To assess reliability, 25% of videos were again coded by a second researcher. The overall proportion of frames

on which coders agreed on gaze location averaged 98.8%. A more conservative reliability estimate measuring the mean proportion of frame agreement during shifts in gaze averaged 97.5%.

Results

As in Experiment 2, children's accuracy in looking to target pictures was calculated as participants' total time looking to the target picture divided by their total time looking to either picture on each test trial, within a time window of 300 to 2000 ms after noun onset. Trials were included in analyses if children were looking at either the target or the distracter object at noun onset. Figure 4.1 displays children's accuracy in looking to the target referent over time in the Structured + Isolated condition (*M*=.61, *SE*=.03) versus the Unstructured + Isolated condition (*M*=.56, *SE*=.03). Note that there is no baseline difference in looking to the target in the pre-analysis time window (0-300 ms; *t*(38)=-1.43, *p*=.16, *d*=-.02).

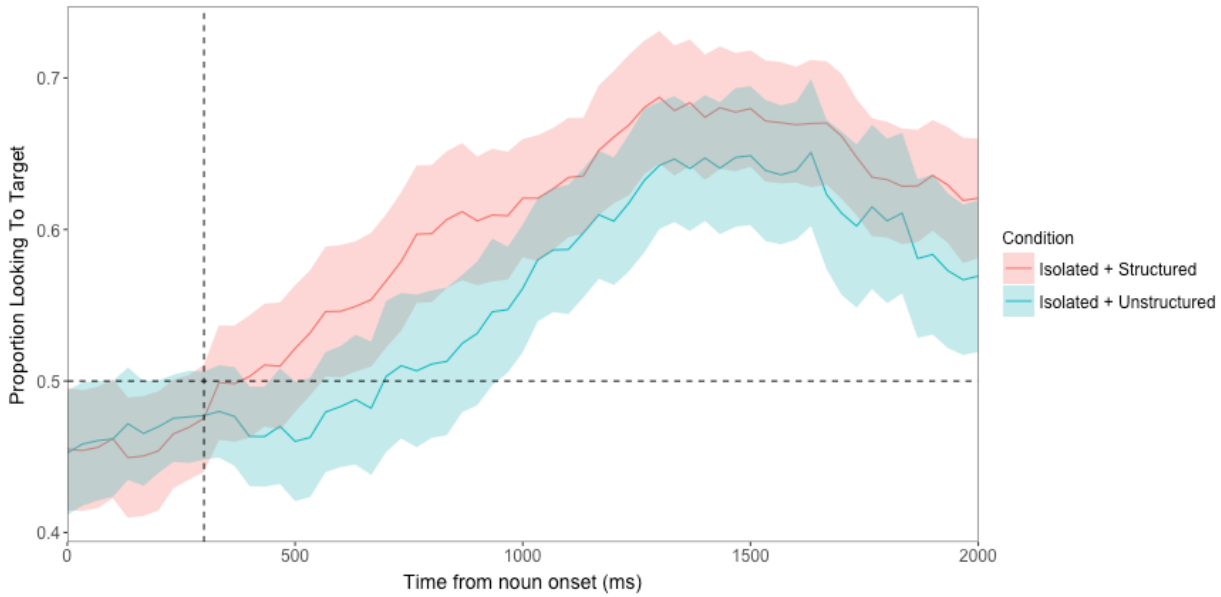


Figure 4.1. Change over time in mean proportion of looks to the target beginning at noun onset for the Isolated+Structured and Isolated+Unstructured conditions.

Accuracy looking to the target was measured starting at 300 ms (as noted by the dashed vertical line) to account for the amount of time (in milliseconds) it takes to program an eye movement. The horizontal dashed line shows chance levels of looking to the target object. Error bands show standard errors across participants.

A two-tailed independent samples *t*-test (one-tailed) revealed no significant difference in accuracy between the Isolated+Structured and Isolated+Unstructured conditions, $t(36.59)=1.24$, $p=.11$, $d=.39$. However, accuracy was significantly greater than chance (with chance defined as 50% looking to the target) in both the Structured + Isolated condition ($t(19)=3.92$, $p<.001$), and the Unstructured + Isolated condition ($t(19)=1.83$, $p=.04$), suggesting that participants learned the novel words successfully in both conditions.

Given that Experiment 4 replicated the same pattern of results as Experiment 2, it seems that at least within the context of this experiment, there may be no combined or additive effect of isolated words and repetition on children's word learning. However, we decided to further examine this idea by directly comparing the conditions of Experiment 4 (Isolated + Structured and Isolated + Unstructured) with a condition from a previously published manuscript (Unstructured [+ No Isolation], from Schwab & Lew-Williams, 2016a). The Unstructured + No Isolation condition was identical to the Isolated + Unstructured condition, but all labeling instances were sentences, so this input was lacking *both* isolated words and partial repetition. Thus, we aimed to examine the effect of number of CDS cues on children's learning of new words. That is, the Unstructured + No Isolation condition contained 0 CDS cues (no isolated words and no partial repetition), the Isolated + Unstructured condition contained 1 CDS cue (isolated words), and the Isolated + Structured condition contained 2 CDS cues (isolated words and partial repetition). A one-way ANOVA looking at the effect of cue number (0, 1, 2) on

children's accuracy looking to the target revealed a significant main effect of cue number, $F(1, 58)=5.23$, $p=.022$, $\eta^2_p=.09$ (see Figure 4.2). Follow-up t-tests revealed no significant difference in accuracy between the Isolated + Unstructured condition and the Unstructured + No Isolation condition ($t(38)=-.99$, $p=.16$, $d=.31$), but a significant difference in accuracy between the Isolated + Structured and the Unstructured + No Isolation condition, $t(38)=2.54$, $p=.008$, $d=.80$. These results point to a possible (though tentative) additive benefit of the combination of these cues – repetition and isolation – on children's word learning.

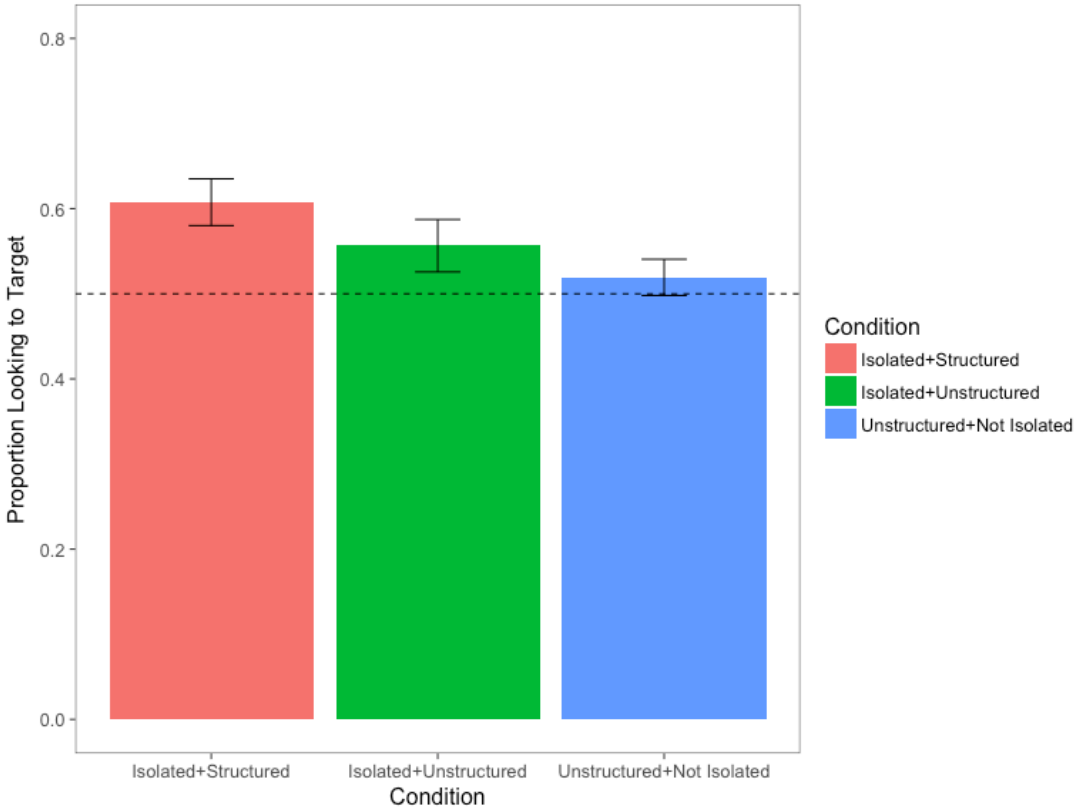


Figure 4.2. Mean proportion of looks to the target picture (i.e., accuracy) following noun onset for the Structured + Isolated condition, Unstructured + Isolated condition, and Unstructured + No Isolation condition (from Schwab & Lew-Williams, 2016a). The dotted line shows chance levels of looking. Error bars show standard errors across participants.

Finally, we examined age effects in learning across these three conditions. A 2x3 factorial ANOVA revealed no significant main effect of age, $F(1, 56)=0.18$, $p=.68$, $\eta^2_p =.003$, and no significant age x cue number interaction, $F(1, 56)=2.03$, $p=.16$, $\eta^2_p=.03$, but the main effect of cue number remained significant, $F(1, 56)=5.54$, $p=.022$, $\eta^2_p=.09$.

Discussion

Overall, the results of Experiment 4 replicated the results of Experiment 2, in that there was no significant difference in children's accuracy looking to the target object at test in the Isolated + Structured condition compared to the Isolated + Unstructured condition, but looking time in both conditions was greater than chance. However, when comparing accuracy in these conditions with the Unstructured + No Isolated condition of a previous experiment (Schwab & Lew-Williams, 2016a), results point to a possible additive effect of multiple cues (isolated words and clusters of repetition) on children's word learning, in line with the corpus analysis findings from Experiment 3.

General Discussion

Together, Experiments 2, 3, and 4 explored 1) whether isolated words promote two-year-olds' learning of new object labels and 2) the extent to which the combination of two child-directed speech (CDS) cues – isolated words and partial repetition of words across utterances – matters for children's word learning. In a looking-while-listening lab task (Experiment 2), we found that isolated words promoted two-year-old's word learning (in a similar manner to hearing repetition across utterances), but there was no clear additive effect of isolated words in combination with repetition in promoting children's learning. Next, in a large-scale corpus analysis of naturalistic parent-child

conversation transcripts (Experiment 3), we found that isolated nouns and repetition of nouns tend to travel together in natural CDS. If a noun occurs in isolation, it is also more likely to occur in a nearby sentence. Moreover, instances of these "isolation clusters" predict children's vocabulary acquisition norms, even when controlling for repetition alone, isolated words alone, or word frequency. Finally, we replicated the results of Experiment 2 in Experiment 4, finding that within this experimental context, the combined features of isolated words and repetition clusters promote children's word learning, but not clearly over and above the feature of isolated words alone. However, in comparing against a group of children who heard the same labeling episodes without *either* isolated words or partial repetition (from Schwab & Lew-Williams, 2016a), we found some evidence that the combination of cues (i.e., isolated words and partial repetition together) may enhance children's word learning, even within this restricted experimental context.

Interestingly, previous studies looking at the use of isolated words in CDS have had repetition built into the operationalization of isolated words (e.g., Brent & Siskind, 2001; Fernald & Morikawa, 1993; Lew-Williams, Pelucchi, & Saffran, 2011). Moreover, we know from previous research that temporally proximal instances of repetition (i.e., clusters of repetition occurring in child-directed speech) influence learning (e.g., Onnis et al., 2008; Schwab & Lew-Williams, 2016a). However, the combination of these two cues – isolated words and clusters of repetition – has not been explicitly examined previously. Our experiments suggest that isolated words tend to occur in a repeated context, and also, the combination of these two cues is perhaps more powerful in influencing children's learning than hearing isolated words on their own. Thus, it is possible that the previous

definition of isolated words (as words that only occur in "isolation") is in fact too narrow. Future researchers studying isolated words should therefore consider the interaction of this CDS feature with another important, correlated feature of CDS: repetition of words across successive sentences.

The idea that multiple cues in CDS might work together to enhance children's learning is in line with previous research showing that cue combination can support learning in a variety of domains, including perception, category learning, and language (e.g., Kirkham, Slemmer, & Johnson, 2002; Wu, Mareschal, & Rakison, 2011; Yoshida & Smith, 2005). Interestingly, using multiple cues to learning and being able to integrate those cues may be an ability that develops over the course of childhood (Wu et al., 2001). Thus, it is possible that younger infants would show a decreased ability to use both repetition and isolated words as cues to language learning in the laboratory, and it is possible that older children would show an enhanced ability to do so. Future research should therefore examine the influence of these CDS cues on different language learning processes across a wider span of development.

The present study is the first – to our knowledge – to examine whether these two important cues of CDS (isolated words and partial repetition) can work together to support children's word learning, as well as whether or not these cues travel together in natural CDS. Our findings show that the use of isolated words and repetition clusters do in fact travel together in naturalistic child-directed speech, suggesting that the definition of isolated words as clearly "isolated" may be too simplistic. Instead, researchers should be careful to consider the influence of these two cues in combination. To that end, we also provide the first evidence suggesting that the combination of isolated words and

repetition clusters promotes children's acquisition of new nouns in naturalistic settings and (possibly) children's word learning in the laboratory, above and beyond the effect of either cue on its own.

Chapter IV: How does continuity of reference influence children's learning of new words?[4]

Children are adept at finding structure in the complexities of language input, but there is substantial variability in their learning. In order to better understand these differences, researchers have examined various features of caregivers' input shown 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 et al., 2011; Schwab & Lew-Williams, 2016a), visual cues (e.g., the size and perceptual salience of objects in the visual field; Pereira et al., 2014; Pruden, Hirsh-Pasek, Golinkoff, & Hennon, 2006), and auditory cues (e.g., intonation and pitch; Ma et al., 2011; Singh et al., 2009). Recent research suggests that another contextual cue in caregivers' speech may also facilitate 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 & Shieffelin, 1983), and this discourse continuity seems to help children learn new words (Horowitz & Frank, 2015; Sullivan & Barner, 2016). The present study aims to clarify the mechanisms behind *how* discourse continuity facilitates children's word learning. First, do clusters of verbal references to the same object promote children's learning, or does interleaving verbal references inhibit children's learning? Second, does the semantic content of the discourse matter for learning (i.e., do surrounding utterances need to be semantically meaningful)?

[4] A version of this chapter is currently under review. Schwab, J. F. & Lew-Williams, C. (under review). How continuity of reference promotes children's learning of new words.

Research has shown that discourse continuity supports children's abilities to learn new words (Horowitz & Frank, 2015; Sullivan & Barner, 2016), but what are the mechanisms behind this word-learning boost? It is possible that providing context for each labeling episode through topic continuity helps children successfully encode and remember multiple new object labels (see Schwab & Lew-Williams, 2017). More specifically, structured information – i.e., clusters of repetition – may promote children's learning through enhanced attention or processing abilities (e.g., Schwab & Lew-Williams, 2016; Vlach & Johnson, 2013). Yet, it is also possible that discontinuous discourse might be *harmful* to word learning, given children's developing working memory capacities and slow rehearsal speeds (see Baddeley, 1992). More specifically, interleaved references might serve as a distraction or increase cognitive load (in a similar manner to background speech, e.g., McMillan & Saffran, 2016). Thus, the present study aims to determine whether continuity of discourse actually promotes children's learning, or if discontinuity of discourse interferes with children's encoding of new words.

In addition to clarifying whether continuity helps or discontinuity hurts in a discourse context, the present study aims to clarify whether the content of the 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 and vivid 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, 2014). 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.

Thus, the present study adds to the existing literature by trying to understand the mechanisms behind children's word learning from discourse continuity. 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 5 aimed to confirm that discourse continuity promotes children's word learning in a context where the discourse provides descriptive featural information about the objects. Experiment 6 examined whether discourse continuity is helpful regardless of content by examining children's word learning when the surrounding discourse is neutral and uninformative. Finally, Experiment 7 aimed to determine whether or not discourse continuity is only beneficial insofar as discontinuous references *hurt* children's learning.

In this experiment, children were exposed to object references surrounded by visual and gestural continuity or discontinuity, but with no surrounding discourse. By examining whether continuity helps or discontinuity hurts within a discourse context, as well as whether the visual informativity of the discourse influences learning, we aim to shed light on the mechanisms behind children's increased learning from continuous discourse in caregiver interactions.

Experiment 5: Continuity of object-related discourse influences word learning

In Experiment 5, we tested the extent to which discourse continuity influences children's learning of new object/label pairs when the discourse contains vivid and 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 promote children's word-learning abilities, children should show more successful learning of correct object/label mappings in the Continuous-Informative compared to the Discontinuous-Informative condition.

Method

Participants. Participants were 40 4-year-old children (*M*=46.41 months, *SD*=3.71, range=42.1-53.6). Twenty-three participants were male, and all participants lived in monolingual English-speaking homes. 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 below. 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 & 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 5.1). 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 5.1). There were two blocks of trials for each novel object/label pair. Each object was referred to six times total (2x per object label).

	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

Table 5.1. Sentences used in informative and uninformative reference trials. Label/object pairs were randomized, but reference sentences always corresponded to the same object. Informative reference trials were repeated twice each in Experiment 5, and uninformative reference trials were repeated twice each in Experiment 6.

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 5.1). 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.



Figure 5.1. Schematic depicting sample trials in the learning phase for the Continuous and Discontinuous conditions in Experiment 5. Between each trial, the speaker rested both hands in her lap and smiled at the participant.

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 1) smiled at the participant, 2) looked down at an object, 3) grabbed the object, raised it slightly, and tilted it up, 4) looked back at the participant and said a labeling or object-directed sentence about the object, 5) looked back at the object and set it back down, and 6) 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, e.g., "*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.

Results

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=.65; see Figure 5.2). 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.

Between conditions, there was no significant difference in children's mean age (Continuous-Informative: M=46.96 months, SD=4.13; Discontinuous-Informative: M=45.86 months, SD=3.26; $t(38)=.94$, p=.35, d=.30) or mean standardized PPVT score (Continuous: M=118.63, SD=11.96; Discontinuous: M=114.21, SD=15.05; $t(36)=1.0$,

p=.32, d=.33). Because we tested children ranging from 3.5 to 4.5 years of age, we examined a possible interaction between age and discourse continuity on children's word learning. A 2x2 factorial Analysis of Variance (ANOVA) with age and condition (Continuous-Informative or Discontinuous-Informative) as between-subjects factors revealed a significant main effect of condition (F(1, 36)=4.31, p=.045, η^2_p=.09), but no significant main effect of age (F(1, 36)=2.04, p=.16, η^2_p=.05) and no significant condition x age interaction (F(1, 36)=.80, p=.38, η^2_p=.02). Thus, across the 3.5- to 4.5-year range, discourse continuity supported children's word learning equivalently.

Discussion

These results confirm that discourse continuity promotes word learning for 3.5- to 4.5-year-old children when the discourse provides descriptive information about the features of each object, such as its color or texture (in a similar manner to Horowitz & Frank, 2015). However, are the benefits of discourse continuity defined by the presence of informative content, or is any form of verbal continuity sufficient to enhance children's learning about new objects? In Experiment 6, we aimed to determine whether continuity of *neutral* discourse – i.e., discourse that provided no identifying visual information about the objects (e.g., "*This is really great*") – would promote children's word learning in a comparable manner. To do so, we replicated Experiment 5, except that the adult provided neutral instead of vivid and informative discourse (see Table 5.1).

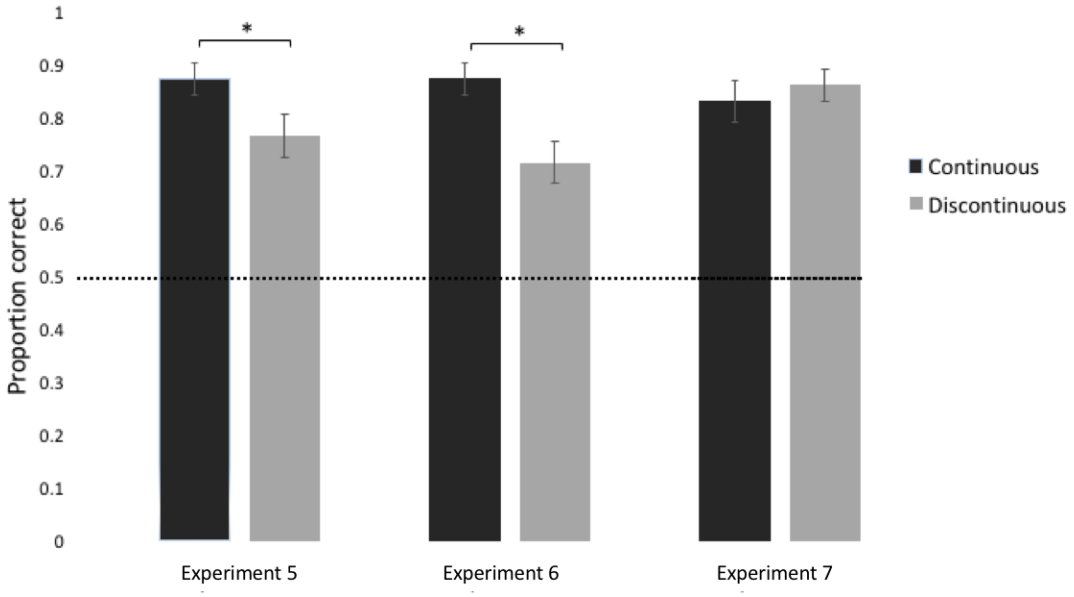


Figure 5.2. Mean proportion correct for children in Experiment 5 (Continuous-Informative vs. Discontinuous-Informative conditions), Experiment 6 (Continuous-Neutral vs. Discontinuous-Neutral conditions), and Experiment 7 (Continuous-No-Discourse vs. Discontinuous-No-Discourse conditions). Error bars show standard error across participants; the dotted line shows chance proportion correct. Asterisks indicate statistical significance (at the $p<.05$ level).

Experiment 6: Does the content of the discourse matter for learning?

Experiment 6 sought to determine whether or not the benefits of continuity vs. discontinuity for children's learning are exclusive to discourse that contains vivid and meaningful content. Object labels were the same as in Experiment 5, but accompanying discourse provided no relevant descriptive information about each object. If the relevant contextual cue boosting children's performance in this task is continuity of reference more generally – and not the pairing of object labels with accompanying featural information – we again expected that children would show more successful learning of object/label mappings when discourse was continuous as opposed to discontinuous. However, if discourse continuity only promotes word learning when utterances cue

children's attention to salient information about the objects, then learning should be equivalent regardless of continuity.

Method

Participants. Participants were 40 4-year-old children (*M*=46.37 months, *SD*=3.36, Range=42.27-53.13). Sixteen participants were male, and all participants came from monolingual English-speaking homes. Children had no history of pervasive developmental delays. Twenty children were randomly assigned to one of two experimental conditions: a *Continuous-Neutral* or *Discontinuous-Neutral* condition, described in detail below. Two additional participants were tested but not included due to experimenter error (*n*=1) or being bilingual (less than 85% English exposure) (*n*=1).

Stimuli & Design. Words and objects were identical to Experiment 5. The *Continuous-Neutral* condition was identical to the *Continuous-Informative* condition from Experiment 5, 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 5.1). 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 5 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 6 were identical to the procedures in Experiment 5.

Results

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=.92; see Figure 5.2). Similar to Experiment 5, 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.

Between conditions, there was no significant difference in children's average age (Continuous: M=46.27 months, SD= 3.20; Discontinuous: M=46.47 months, SD=3.60; $t(38)=-.18$, p=.86, d=-.06) or average standardized vocabulary score (Continuous-Neutral: M=119.5, SD=13.13; Discontinuous-Neutral: M=114.72, SD=12.62; $t(36)=1.14$, p=.26, d=.37). Because we tested children ranging from 3.5 to 4.5 years of age, however, we again examined a possible interaction between age and discourse continuity on children's word learning. A 2x2 factorial Analysis of Variance (ANOVA) with age and condition (Continuous-Neutral or Discontinuous-Neutral) as between-subjects factors

revealed a significant main effect of condition ($F(1, 36)=8.27$, $p=.007$, $\eta^2_p=.19$), but no significant main effect of age ($F(1, 36)=.01$, $p=.92$, $\eta^2_p<.01$) and no significant condition x age interaction ($F(1, 36)=.62$, $p=.44$, $\eta^2_p=.02$). Similar to Experiment 5, effects of continuity and discontinuity did not change across the 3.5- to 4.5-year range.

Next, we compared children's learning across Experiments 5 and 6. A 2x2 mixed analysis of variance (ANOVA) with experiment (5 or 6) as a between-subjects factor and condition (Continuous or Discontinuous) as a within-subjects factor revealed a significant main effect of condition ($F(1, 76)=12.47$, $p<.001$, $\eta^2_p=.14$), but no significant main effect of Experiment ($F(1, 76)=.44$, $p=.51$, $\eta^2_p<.01$), and no significant condition x experiment interaction ($F(1, 76)=.44$, $p=.51$, $\eta^2_p<.01$).

Discussion

Thus, Experiment 6 replicated the results of Experiment 5 using an uninformative discourse context with neutral object-focused sentences. Together, findings from Experiments 5 and 6 suggest that continuity of reference in general – and not continuity of vivid or informative discourse – promotes children's word learning.

Experiment 7: Does continuity help or does verbal interference hurt learning?

Experiments 5 and 6 demonstrated that clustered verbal references to objects promote 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 – even in the absence of discourse – helps children learn new words. Thus, Experiment 7 examined continuity and discontinuity of object reference with no verbal discourse surrounding object labels. In addition to labeling objects, the experimenter performed identical reference actions as in Experiments 5 and 6, but instead of producing speech, she drew children's attention to each object in silence. If continuity of reference helps learning in general, 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 learning, we would expect that in the absence of surrounding discourse, there would be less successful learning in both conditions (compared to the continuous conditions of Experiments 5 and 6). Finally, if discontinuity in verbal discourse *hurts* children's learning, we would expect that in the absence of surrounding discourse, there would be equally successful learning in both conditions.

Method

Participants. Participants were 40 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. 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 below. 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 & Design. Words and objects were identical to Experiments 5 and 6. The *Continuous-No-Discourse* condition was identical to the *Continuous* conditions from Experiments 5 and 6 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 5 and 6, 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 7 was identical to the procedure in Experiments 5 and 6, except that 12 of the 18 learning trials occurred in silence. On silent trials, the experimenter: 1) smiled at the participant, 2) looked down at an object, 3) grabbed the object, raised it slightly, and tilted it up, 4) looked back at the participant and smiled in silence for approximately two seconds, 5) looked back at the object and set it back down, and 6) 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 7 were identical to the procedures in Experiments 5 and 6.

Results

As in Experiments 5 and 6, 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)=-.61, *p*=.54, *d*=.19 see Figure 5.2).

Again, between conditions, there was no significant difference in children's average age (Continuous-No-Discourse: *M*=45.31 months, *SD*=2.87; Discontinuous-No-Discourse: *M*=45.85 months, *SD*=3.48; *t*(38)=-.54, *p*=.59, *d*=-.17) or average standardized vocabulary score (Continuous-No-Discourse: *M*=118.32, *SD*=8.32; Discontinuous-No-Discourse: *M*=117.63, *SD*=12.24; *t*(36)=.20, *p*=.84, *d*=.07). A 2x2 factorial Analysis of Variance (ANOVA) with age and condition (Continuous-No-Discourse or Discontinuous-No-Discourse) as between-subjects factors revealed no significant main effect of condition ($F(1, 36)=.38$, $p=.54$, $\eta^2_p<.01$), age ($F(1, 36)=2.37$, $p=.13$, $\eta^2_p=.06$), and no significant condition x age interaction ($F(1, 36)=.26$, $p=.61$, $\eta^2_p<.01$).

To compare results across Experiments 5, 6, and 7, accuracy scores were analyzed using a 3x2 mixed ANOVA with experiment (5, 6, 7) as a between-subjects factor and condition (Continuous or Discontinuous) as a within-subjects factor. There was no significant main effect of experiment, $F(2,114)=1.02$, $p=.36$, $\eta^2_p=.02$, but there was a

significant main effect of condition ($F(1, 114)=7.07$, $p<.01$, $\eta^2_p=.06$) and a significant experiment x condition interaction ($F(2, 114)=3.55$, $p=.03$, $\eta^2_p=.06$). 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 5 ($t(38)=-.87$, $p=.39$, $d=-.28$) or the Continuous-Neutral condition from Experiment 6, $t(38)=-.86$, $p=.40$, $d=-.27$. However, accuracy was higher in the Discontinuous-No-Discourse condition (in Experiment 7) compared to the other Discontinuous conditions (in Experiments 5 and 6). There was a marginally significant difference in proportion correct between the Discontinuous-No-Discourse condition and the Discontinuous-Informative condition from Experiment 5 ($t(38)=1.82$, $p=.08$, $d=.58$), and a significant difference in proportion correct between the Discontinuous-No-Discourse condition and the Discontinuous-Neutral condition from Experiment 6, $t(38)=2.74$, $p<.01$, $d=.87$.

The absence of a significant difference between conditions in Experiment 7 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 5 and 6, 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, i.e., children's overall proportion looking either to the target object (M=.51, SD=.13), the experimenter (M=.31, SD=.12), or away (M=.18, SD=.08). Results of one-way Analyses of Variance (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 ($F(5, 24)=0.42$, $p=.83$, $\eta^2_p=.08$), as well as no significant main effect of condition on children's proportion time spent looking at the experimenter, $F(5, 24)=0.02$, $p>.99$, $\eta^2_p<.01$. 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 ps>.1) or children's proportion looking time to experimenter (all ps>.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: 5 labeling trials for each of the six conditions (30 total) and 5 reference trials for each of the four conditions in Experiments 5 and 6 (20 total). We chose not to include reference trials for the No-Discourse conditions from Experiment 7 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 3x2 factorial ANOVA with experiment (5, 6, 7) and continuity (Continuous vs. Discontinuous) as between-subjects variables. Results revealed a significant main effect of experiment ($F(2, 354)=7.0$, $p< .01$, $\eta^2_p=.04$), but no significant main effect of continuity ($F(1, 354)=.44$, $p=.51$, $\eta^2_p<.01$) and no significant experiment x continuity interaction ($F(2, 354)=.44$, $p=.12$, $\eta^2_p=.01$). Second, we examined whether or not there were differences in enthusiasm ratings across conditions for *reference* trials (although note, as described above, that we did not include reference trials for Experiment 7). A 2x2 factorial ANOVA was performed to determine the effect of experiment (5, 6) and continuity on enthusiasm ratings for reference trials. Results showed no significant main effect of experiment ($F(1, 236)=.32$, $p=.57$, $\eta^2_p<.01$), no significant main effect of continuity ($F(1, 236)=.004$, $p=.95$, $\eta^2_p<.01$), and no significant experiment x continuity interaction ($F(1, 236)=1.42$, $p=.23$, $\eta^2_p<.01$).

Discussion

Overall, Experiment 7 suggests that continuity of visual and manual information alone cannot explain the benefits of discourse continuity for children's learning of multiple new object/label pairs. These findings also point to the idea that clusters of verbal references to a particular object may be beneficial for children's learning because parents are *not* rapidly switching reference between objects. Additionally, 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 x 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. First, we confirmed that children learn new words better from continuous – as opposed to discontinuous – discourse references, but found that there was no added benefit when the discourse provided informative visual content. Additionally, 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 fact that informativity (in the form of vivid descriptions of target objects) did not influence learning in the present experiments is likely to have been context-dependent. Unlike in previous experiments looking at children's learning of new words from the surrounding discourse (e.g., Horowitz & Frank, 2015; Sullivan & Barner, 2016), here we were testing word learning in an *unambiguous* context (that is, there were additional referential cues to learning, such as eye gaze and pointing). While informative visual content is undoubtedly important in helping children determine which object is being talked about in an ambiguous context, it does not seem to promote children's learning and encoding of new words in an unambiguous context. However, we do know that causal information is helpful for children's word learning (Booth, 2009; Booth & Alvarez, 2014), so future research should continue to examine which type of elaborative content might be important for children's word learning and under what circumstances.

The present results regarding discourse continuity are convergent with studies showing that repetition of words across neighboring utterances is helpful for learning (Onnis, Waterfall, & Edelman, 2008; Schwab & Lew-Williams, 2016). Yet interestingly, while previous research has suggested that repetition might be beneficial because it enhances attention or enables participants to align and compare across utterances (e.g., Schwab & Lew-Williams, 2016), the present study suggests another possible explanation for the positive effects of repetition: that verbal interference *disrupts* learning, perhaps because it serves as a distraction or increases cognitive load (e.g., McMillan & Saffran, 2016). Thus, future studies looking at the benefits of repetition should delve further into a possible interference mechanism (i.e., discontinuity disrupting children's learning) in order to see the extent to which this mechanism generalizes across learning contexts.

Additionally, while previous research has shown that repetition of object labels in blocks of successive utterances promotes toddlers' word learning (Schwab & Lew-Williams, 2016; Vlach & Johnson, 2013), here, with older preschool-age children, simply referencing an object for several sentences in a row – without repeating the label itself – enabled better word learning (relative to references that were distributed 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? Previous work has shown that the need for caregivers to repeat object labels in neighboring sentences decreases over time as children become more proficient in language (Schwab, Rowe, Cabrera, & Lew-Williams, 2018). In parallel, children's ability to exploit discourse continuity in ambiguous word learning contexts has been shown to increase with age, particularly during the preschool years (Horowitz & Frank, 2015). Following from this, the usefulness of repeated labels may decline as children's ability to better understand the discourse context comes online. Future research should therefore also examine individual differences in caregivers' naturalistic use of discourse cues in the home, and young children's evolving abilities to exploit repetition and continuity of reference as they learn new information from the environment.

Importantly, the present experiments focused on the mechanisms behind caregivers' unidirectional discourse continuity and children's learning, but in naturalistic parent-child interactions, there is a social feedback loop, whereby 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 attention in a word-learning episode do seem to influence learnability of object labels (Trueswell et al., 2016). 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 a few months later. Therefore, examining how children's own attention, interests, and speech interact with parents' discourse continuity or discontinuity in shaping their word learning is another important research direction.

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), in some contexts these kinds of discourse cues may not be needed for word learning. More likely, however, discourse cues, in combination with socio-pragmatic cues, help children encode information about object/label co-occurrences over time, presumably by increasing their salience in the moment. Relatedly, Pereira et al. (2014) 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 the 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 what defines 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 object functions, or 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 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 word learning at moments when adults provide clusters of verbal and nonverbal referential cues to particular objects. 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 uncovers how the structure and content of caregivers' discourse can directly influence children's encoding of new words.

Chapter V: Conclusions[5]

This dissertation shows that multiple features of child-directed speech (CDS) – word repetition, isolated words, and discourse continuity – promote word learning in young children. While each of these cues is helpful on its own, isolated words and repetition tend to occur together in naturalistic child-directed speech, and the two cues combined may be even more powerful for promoting early learning. Additionally, children's level of language knowledge seems to influence their ability to utilize these cues in learning new words. Repetition of words in successive sentences may be particularly helpful for young children learning new words, but as their vocabularies increase, repetition may become a less helpful cue. Concurrently, over the course of early childhood, children become better at understanding discourse cues, and discourse continuity (or more accurately, the absence of discontinuity) may replace repetition as being a helpful cue. Overall, the present dissertation helps illuminate the complex relations between structural features of CDS and children's word learning. However, the underlying mechanism(s) behind the influence of these structural cues on learning remains unclear. One possibility is that these cues are directly driving children's learning, perhaps by increasing attention to, processing of, or encoding of the word-object pairs. However, it is also possible that these cues promote children's learning by revealing to children the speakers' interest in the objects, or their intentions in trying to communicate new information to the child.

One possible explanation for children's increased learning from structural features

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[5] Portions of this chapter come from published work. Schwab, J. F. & Lew-Williams, C. (2016). Repetition across successive sentences facilitates young children's word learning. *Developmental Psychology, 52*(6), 879-886.

of language input is attention-based. In terms of repetition, repeated elements might become more salient and easily learnable simply by being presented in close proximity. Recent research has shown that human attention is spontaneously biased toward input that contains regularities (Zhao, Al-Aidroos, Turk-Browne, 2013). Relatedly, infants have been shown to pay more attention to visual and auditory stimuli when information is neither too simple nor too complex (Kidd, Piantadosi, & Aslin, 2012; Kidd, Piantadosi, & Aslin, 2014). Given that the present experiments were short, fast-paced word-learning studies, repeated structure or isolated object labels might simply engage children's attention by enabling them to detect the most relevant content from the input more easily. However, the influence of repeated elements on attention and learning is complex and may also change over the course of development (see Emberson, Cannon, Palmeri, Richards, & Aslin, 2017 for an examination of the effects of stimulus repetition on the infant brain as compared to adults). Additionally, although discontinuous discourse inhibited children's word learning in Chapter IV, there was no significant difference in children's attention to continuous vs. discontinuous referential episodes. This suggests that attention to repetitive content alone did not drive learning differences. Thus, attentional mechanisms are unlikely to fully explain children's increased learning from structural features of CDS across childhood.

A related second possible explanation is that these structural features of language input promote children's processing of novel word-object pairs in-the-moment, as well as subsequent processing of those words in new sentential contexts. For one, these structural features may provide what Linda Smith and colleagues have called an "optimal moment" of word learning (Pereira et al., 2014), or a clear period of focus on one novel object or

word/object pair, which allows children to process this new information more easily. Isolated words likely provide this kind of optimal moment by presenting young children with a neatly packaged object label; repetition of object labels in immediate succession might lead to perceptual pop out of the target word, highlighting it in a similar manner; and finally, a word and object being clearly linked within the discourse over a short burst of utterances may present an ideal moment to process information for older children. Thus, it is possible that repetition, isolated words, and discourse continuity each enable a clear packaging of information, allowing children to process and learn new words more easily. Additionally, hearing novel words or topics repeated in successive sentences might strengthen subsequent processing of those words. Weisleder and Fernald (2014) proposed that hearing words multiple times in a variety of sentence constructs gives children more opportunities to practice processing familiar words, and in doing so, enables them to learn new lexical and sentential information. In this vein, hearing a novel word repeated in a subsequent sentence may provide young children with an immediate opportunity to practice processing that word in a new context, and this may enhance their ability to process novel information that comes moments later. Speed of processing has been shown to predict later vocabulary outcomes (e.g., Fernald, Perfors, & Marchman, 2006; Hurtado, Marchman, & Fernald, 2008; Marchman & Fernald, 2008; Weisleder & Fernald, 2013), suggesting that early differences in children's ability to process new words can have cascading effects on continued vocabulary growth.

Third, structural features in children's language input may not just engage attention or enhance processing, but also enable children to more successfully bind together similar learning events and form memories of word/object pairings. Indeed,

Smith and Yu (2013) found that moment-to-moment attention to objects in a cross-situational word learning task was not sufficient for forming word/object mappings, suggesting that successful learning requires binding word/object pairs into memory as opposed to simply forming transient representations. In related work, Vlach and Johnson (2013) proposed that massed – as opposed to distributed – exposures to word/object pairings in a cross-situational statistical learning task facilitate more successful learning by allowing children to aggregate statistical information across trials in order to form stable memory representations of those pairings (see Kachergis, Yu, & Shiffrin, 2009, for comparable results on the importance of temporal contiguity with adult participants). Similarly, in our research, immediate repetition of words or topics across successive sentences – in some cases, in combination with isolated words – may have enabled stronger binding of labeling instances to their referents and helped children form more stable memories of word/object pairs. Our research has also shown that within discourse, discontinuous object references interfere with learning, perhaps because they serve as a distraction or disrupt children's memory formation of those new label/object pairs. Interestingly, while interleaving instances of labels across lengths of time may facilitate better long-term memory for new words (e.g., Childers & Tomasello, 2002; Vlach et al., 2008), immediate repetition of words and topics over shorter timescales (coinciding with a lack of disruption or interference) may be important for helping children form successful memories of word/object pairs in the first place.

It is clearly possible that structural features of language directly influence children's learning by promoting some combination of increased attention, ease of processing, or encoding abilities. However, is also possible that these cues promote

children's learning indirectly by suggesting to children that these new word/object pairs *should* be of interest because the speaker is trying to communicate with them. If this is the case, children may be deciding intentionally to pay more attention or to encode more effectively.

According to Michael Tomasello's social-pragmatic theory of word learning, children's word learning is driven by their social-cognitive skills, which allow them to interpret other people's communicative *intentions* in a variety of situations (Tomasello, 2000). To this end, there is a large body of evidence showing that children can utilize social cues to learn new words (see Baldwin & Tomasello, 1998 for a review). For example, 19-month-old children have been shown to only successfully attach a new label to an object if a speaker appears to be referring to the object (Baldwin, 1993). In these experiments, children would not attach the new label to an object if the speaker was not directly referring to it, even if the object appeared at the same time as the object label, the speaker was touching the object in a non-referential manner, or the object was especially interesting (Baldwin, 1993). In a similar vein, it is possible that structural features of child-directed speech could suggest social interest or intentionality of labeling to young children. That is, children could interpret continuity across sentences or hearing a word in isolation as a parent's explicit attempt to teach them that word.

Relatedly, according to theories of natural pedagogy, ostensive communicative cues, including infant-directed speech, drive young children to interpret adults' object-directed behavior as indicating relevant information (e.g., Csibra & Gergely, 2009; Csibra, 2010; Gergely, Egyed, & Király, 2007). Thus, caregivers' use of structural cue may serve as a communicative cue that highlights the importance of a word/object pair.

Because these structural cues are common in CDS, children may infer that the speaker is trying to provide contextually or culturally important information, and therefore learn better from this type of structured input. Yet overall, it is still an open question whether children's improved learning from structural cues is due to bottom-up mechanisms – such as improved attention, processing, or encoding abilities – or whether instead, these structural cues lead children to interpret a speaker's intentions as indicating increased relevance or importance of the word/object pairs, thus driving children to learn them better.

The present results also suggest that over the course of children's development, repeating words in successive sentences may become less helpful, and instead, having continuity of reference may become more helpful. It is possible that this finding is related to the "repeated-name penalty" found in adults (e.g., Gordon, Grosz, Gilliom, 1993). In this line of research, explicitly repeating a name – rather than substituting a name with a pronoun in subsequent sentences – has been shown to lead to longer reading times (Gordon et al., 1993), as well as increased brain activity (Almor, Smith, Bonilha, Fridriksson, & Rorden, 2007), suggesting more difficult or intensive processing. The present findings suggest that over the course of development, repetition of nouns in successive sentence might go from being initially *helpful* for children's learning to no longer having a positive learning benefit, perhaps because these sentences become more difficult to process. Instead, continuity of reference – or continuing to focus on the same noun for multiple sentence in a row, but using pronouns – seems to be more beneficial for children's learning at an older age.

While hearing more CDS overall has been shown to be important for children's vocabulary development (Ramírez-Esparza et al., 2014; Weisleder & Fernald, 2013), the present research shows the extent to which particular structural features within CDS directly influence children's learning of new words. Recent findings also suggest that the use of structural features differs across the socioeconomic status (SES) spectrum, with high-SES caregivers using more repetition in successive utterances compared to low-SES caregivers (Tal & Arnon, 2018). Thus, the current line of research may ultimately help explain how differences in quality of language input within and across the SES spectrum lead to gaps in vocabulary development (see Schwab & Lew-Williams, 2016b). At present, it is unclear to what extent each of the proposed mechanisms – attention, processing, memory, or the understanding of speakers' intentions – underlies the finding that structural features of CDS enhance children's learning of new referents. Yet these studies provide an important step in characterizing the specific features of CDS that promote vocabulary development, and highlight the importance of understanding how input gives rise to language learning at multiple timescales and at different levels of language knowledge.

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