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The temporal structure of parent talk to toddlers about objects

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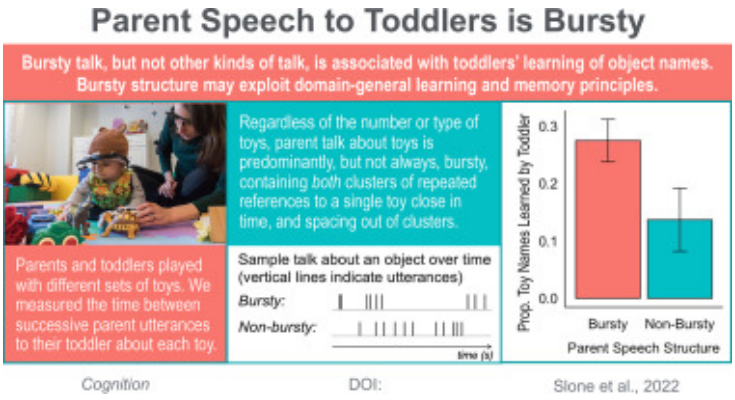
Highlights

- Parent talk about objects is predominantly clustered, containing both repetition and spacing.
- Clustered parent talk persists across different play contexts.
- Clustered parent talk is associated with better word learning by the toddler.
- Clustered talk may exploit domain-general learning and memory principles.

Abstract

Toddlers learn words in the context of speech from adult social partners. The present studies quantitatively describe the temporal context of parent speech to toddlers about objects in individual real-world interactions. We show that at the temporal scale of a single play episode, parent talk to toddlers about individual objects is predominantly, but not always, clustered. Clustered speech is characterized by repeated references to the same object close in time, interspersed with lulls in speech about the object. Clustered temporal speech patterns mirror temporal patterns observed at longer timescales, and persisted regardless of play context. Moreover, clustered speech about individual novel objects predicted toddlers' learning of those objects' novel names. Clustered talk may be optimal for toddlers' word learning because it exploits domain-general principles of human memory and attention, principles that may have evolved precisely because of the clustered structure of natural events important to humans, including human behavior.

Graphical abstract



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Introduction

Language is one of the most characteristic and influential aspects of human cognition, affecting human perception (Strange & Jenkins, 1978; Werker & Tees, 1984), attention (Carvalho, Vales, Fausey, & Smith, 2018), categorization (Lupyan, Rakison, & McClelland, 2007; Yoshida & Smith, 2005), encoding and remembering (Fausey & Boroditsky, 2010; Feist & Gentner, 2007), to name only a few. Unraveling the apparent ease and rapidity with which human toddlers learn language holds promise not only for advancing developmental science on early word learning, but also for

understanding mechanisms of learning more generally, with potential implications for fields such as artificial intelligence (Smith & Slone, 2017) and education (Vlach, 2014).

Toddlers learn words in the context of speech from adult social partners. Much research has shown, unsurprisingly, that both the quantity and quality of adults' speech to their children – as measured by aggregated statistics like word frequency and lexical diversity – are predictive of a child's language ability as well as later school achievement (Cartmill et al., 2013; Hart & Risley, 1995; Hoff, 2013; Hurtado, Marchman, & Fernald, 2008; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991). To more fully understand the processes by which these outcomes come about, however, we must consider how language is actually experienced and learned *in time*. Speech is not experienced en masse, but rather it is taken in dynamically as it unfolds in time, and the processes by which children learn language are likely intricately related to the temporal properties of their language input.

Words unfolding over time are not random. People talk about what they see and what they are doing, which change with context (Montag, Jones, & Smith, 2018). Children may hear “socks” mentioned repeatedly when getting dressed in the morning, then not hear “socks” again until socks are taken off in the evening. Instead, they may hear talk about “swings” when at the park, talk about “flamingos” when at the zoo, and talk about “fossils” when at the museum, with none of these words likely mentioned again until that particular context is revisited. This clustered or “bursty,” context-dependent property of language has been demonstrated at multiple time-scales, from conversations to whole texts (Abney, Warlaumont, Oller, Wallot, & Kello, 2017; Altmann, Cristadoro, & Esposti, 2012; Altmann, Pierrehumbert, & Motter, 2009). Burstiness has been quantified and modeled in large corpora of spoken and written language (Altmann, Cristadoro and Esposti, 2012, Altmann, Pierrehumbert and Motter, 2009; Church & Gale, 1995; Katz, 1996), in which words are shown to have a much higher probability of being encountered if they were just mentioned compared to their probabilities in the corpus of words as a whole. It is nearly inevitable that individual words would be bursty in corpora that span long time scales and therefore multiple contexts for talk. But the growth in children's vocabularies that can be observed over days, weeks, and months, is grounded in in-the-moment experiences of words that unfold on much shorter time scales. To the best that we can determine, the temporal properties of speech to young word learners has not been precisely quantified, despite considerable evidence that the repetitive structure of parent speech is relevant to early word learning (Brodsky, Waterfall, & Edelman, 2007; Hoff-Ginsberg, 1985, Hoff-Ginsberg, 1986, Hoff-Ginsberg, 1990).

Research examining the temporal structure of parent speech to children at shorter timescales (i.e., individual parent-child interactions) finds that parent speech is highly repetitive, with individual

words and phrases often repeated across successive utterances (Brodsky et al., 2007; Broen, 1972; Frank, Tenenbaum, & Fernald, 2013; Messer, 1980; Rohde & Frank, 2014; Snow, 1972; Suanda, Smith, & Yu, 2016b). These parental self-repetitions correlate with children's language ability (Brodsky et al., 2007; Hoff-Ginsberg, 1985, Hoff-Ginsberg, 1986, Hoff-Ginsberg, 1990), and can even predict young children's learning of novel object labels when implemented in an experimental context (Schwab and Lew-Williams, 2016, Schwab and Lew-Williams, 2017). However, despite the seeming importance of repeated talk on short timescales, research in this area remains largely qualitative because we lack clear quantitative descriptions of the timing properties of parent speech to young children in a single context and how this relates to the clustered temporal patterns we see at longer timescales. On short timescales, do parents mention an object in only one cluster of repeated talk and then move on, or do they intersperse multiple clusters of talk about an object over time?

The first aim of the present paper was to quantify temporal speech structure during a natural context for parent talk to their children: free-flowing play with toys. Because the timing of parent talk about individual toys might be influenced by the specific play context, we quantified parent speech in two contexts: play with a large set of real toys on the floor (Study 1), and play with three novel toys at a table (Study 2). The design of Study 2 also lends itself to our second aim: examining relations between the temporal structure of parent speech about individual novel objects and toddlers' learning of those objects' novel names.

Experimental studies of presentation timing have pitted the effects of massed (i.e., a single cluster) learning opportunities against spaced learning opportunities (Childers & Tomasello, 2002; Vlach, Ankowski, & Sandhofer, 2012; Vlach & Johnson, 2013; Vlach, Sandhofer, & Kornell, 2008). Counterintuitively, research demonstrates that spacing out repetitions of the same novel word in time can promote young children's learning and longer-term retention (Vlach, Ankowski and Sandhofer, 2012, Vlach, Sandhofer and Kornell, 2008). Nevertheless, this spacing effect is limited if the information spaced out in time has not yet been encoded strongly enough in memory so as not to be completely forgotten during the spacing interval (Appleton-Knapp, Bjork, & Wickens, 2005; Gagné, 1950; Vlach & Johnson, 2013). This may be particularly important to keep in mind for young children, whose working memory, attention, knowledge base, and metamemory are still developing and may affect the ideal timing of presentations to support learning (Knabe & Vlach, 2020; Slone & Sandhofer, 2017). For instance, Vlach and Johnson (2013) found that 20-month-olds learned novel words via a spaced schedule, but 16-month-olds required a massed schedule with item presentations closer together to support learning.

Study 2 models toddlers' word learning outcomes, examining how different speech structures used by a parent to talk to their child about different objects relates to the child's learning of those

objects' novel names. Specifically, we were interested in whether parent speech that intersperses multiple clusters of talk about an object over time in a single interaction may constitute a particularly effective training schedule. Such a training schedule provides close clustered repetitions of words in time, which may help learners resolve ambiguity of reference in the moment and help support initial encoding and short-term retention of word-object mappings (Kachergis, Yu, & Shiffrin, 2009; Suanda et al., 2016b; Vlach & Johnson, 2013; Weisleder & Fernald, 2014). Such a schedule also provides delays between clustered repetitions, which may support longer-term retention of those mappings (Atkinson & Shiffrin, 1968; Benjamin & Tullis, 2010; Brainerd & Reyna, 2002; Glenberg, 1979; Haebig et al., 2019; Landauer, 1969; Melton, 1970; Vlach et al., 2012; Wickelgren, 1970).

Section snippets

Participants

Thirty-three parent-toddler dyads (n = 16 female toddlers) participated in this study when the child was between approximately 1 and 2 years of age (M = 19.0 months, SD = 3.2, *range*: 12.3–25.3). Families were recruited from a working and middle-class population of a Midwestern college town and given a small gift (e.g., a toddler book or t-shirt) for participating. Participants were treated in accordance with University IRB #0906000439. Informed parental consent was obtained for all dyads prior …

Participants

Analyses were conducted on a corpus of audio-visual recordings of 30 parent-toddler dyads engaged in unscripted, free-flowing play with six novel objects. Toddler (n = 14 females) participants were between approximately 1 and 2 years of age (M = 21.6 months, SD = 2.9, *range*: 15.6–26.0). Analyses on a portion of the recordings in Study 2 have been reported previously

(Bambach, Crandall, & Yu, 2013; Lee, Bambach, Crandall, Franchak, & Yu, 2014; Suanda et al., 2016a; Suanda et al., 2016b; Suanda, …

General discussion

Burstiness is a pervasive property of the complex systems that generate many natural events including human behavior (Eckmann, Moses, & Sergi, 2004; Goh & Barabási, 2008; Vázquez et al., 2006), and thus provides the evolutionary and developmental context for human learning. The present studies demonstrate that even on the timescale of a single play episode, regardless of the number of potential referents, parent talk to toddlers is predominantly bursty, containing not only repeated references …

CRediT authorship contribution statement

Lauren K. Slone: Conceptualization, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Drew H. Abney:** Conceptualization, Methodology, Writing – review & editing. **Linda B. Smith:** Funding acquisition, Writing – review & editing. **Chen Yu:** Funding acquisition, Writing – review & editing. …

Declaration of Competing Interest

None. …

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Recommended articles

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L.K. Slone *et al.*

Consider the category: The effect of spacing depends on individual learning histories
Journal of Experimental Child Psychology (2017)

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Within arms reach: Physical proximity shapes mother-infant language exchanges in real-time

2023, Developmental Cognitive Neuroscience

> *Citation Excerpt :*
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> …Temporal parameters are as critical as other features of experience that are typically studied (i.e., frequencies and durations of events, the proportion of time taken up by an event), and they promise to reveal key insights into mechanisms of learning and development (e.g., Mendoza and Fausey, 2022). The temporal signature of proximity observed here in 100 dyads resembled the bursty temporal structure that characterizes spoken and written human language (Altmann et al., 2012; Altmann et al., 2009; Church and Gale, 1995; Katz, 1996) and infant-directed caregiver speech during play (Slone et al., 2023). This temporal structure may provide infants with ideal levels of uncertainty required for learning (Kidd et al., 2012)….

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