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RESEARCH ARTICLE

Quick, incidental word learning in educational media: all contexts are not equal

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Abstract
Classic studies of educational media have demonstrated that children can engage in quick, incidental word learning on the basis of a single exposure of a program. Since most words are learned from context, a lingering question has been whether the kind of contextual support affects word learning. Using a within-subjects design this study examined 102 low-income preschoolers' word learning of digital episodes in three contextual settings: participatory, expository, and narrative contexts. Across three rounds, children's word knowledge was assessed through researcher-developed measures. Results indicated that target word learning occurred most frequently in the participatory followed by the expository context, with narrative being the most challenging for children. In all cases, however, children with lower receptive language scores acquired fewer words than their higher language peers, suggesting that without additional supports, educational media might exacerbate rather than close the word gap.

Keywords Vocabulary · Educational media · Preschoolers

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Introduction

Young children are extraordinary language learners. Although reports vary considerably, the average preschooler may know as many as 4000 to 6000 words (Biemiller and Slonim 2001; Kuperman et al. 2012). Most of these words will be learned incidentally in typical and frequent encounters in everyday contexts as children listen, interact, and play with language (Dickinson et al. 2012; Harris et al. 2011; Kuhl 2004; Weisberg et al. 2013). Children's ability to at least partially comprehend a new word's meaning by mapping a word to an underlying concept or "fast mapping," after limited exposures is now well-documented in the research (Carey and Bartlett 1978; Woodward and Markman 2003).

A more challenging task for children's initial comprehension of novel words, however, may be in contexts in which they have to match new words to their meanings with fewer representational cues or adult supports. Digital media may be such a context. With its fast-paced narration and quick cuts, young children will need to engage in rapid processing, noting the presence of a novel word and attributing its meaning almost simultaneously (Anderson and Kirkorian 2015; Kirkorian et al. 2016). Rice coined the term "quick incidental learning" (QUIL) to refer to children's ability to infer new word meanings without clearly identified ostensive cues or prompting from adults (Rice and Woodsmall 1988). In a series of studies using video clips from televised sources, Rice and her colleagues (Oetting et al. 1995) provided convincing evidence of word learning for preschoolers. In one study, for example, 5-year olds gained an average of 4.87 words in a 12-min program.

The potential of quick, incidental word learning from media without adult support is particularly compelling given children's interest and engagement in educational media. These online videos delivered from popular streaming platforms (e.g., Amazon; Netflix) have been systematically designed and marketed to enhance children's school readiness and academic development (Kabali et al. 2015; Rideout 2014, 2017). According to the most recent survey, over 72% of children age 8 and under are using mobile devices for watching videos and apps, up from 38% just two years before (Rideout 2017). In this same time frame, the average time spent on media activity has tripled, to more than an hour a day. Moreover, a recent study (Kabali et al. 2015) reported that a staggering 97% of US children under the age of four now have access to mobile devices regardless of family income, representing almost universal exposure. Therefore, digital media could represent an important context for learning new words rather effortlessly with limited exposure and a minimum of tutorial assistance.

In a recent meta-analysis, Takacs et al. (2014) provide additional support for this potential. Examining 29 studies with over 1200 children, these researchers found that multimedia were more beneficial for vocabulary learning ($g+ = 0.30$) and comprehension ($g+ = 0.40$) than encounters with traditional storybook materials that did not include the help of an adult, and that there were no discernable differences between learning outcomes with adult support. They argue that with optimal design (e.g., animated illustrations and music) multimedia materials might provide a similar type of support from an adult for word learning and comprehension.

Consequently, although adult support might be ideal for many reasons (Myers et al. 2017; Radesky and Christakis 2016; Strouse et al. 2018; Takeuchi and Stevens 2011), well-designed digital stories might serve as a language-enriching context to enhance children's word knowledge and meaning making processes. Given its near universal access, stories on mobile devices could enhance children's opportunities to engage in quick, incidental word learning as they attend to its engaging content. Such opportunities might be particularly

important for low-income children who have had less exposure to language in their earliest years than their middle-class peers. Studies have shown that the "word gap," (Hart and Risley 1995, 2003) the disparity in vocabulary size between low- and middle-income children has significant consequences over time that lead to large differentials in achievement (Anders et al. 2012; Bornstein et al. 2006; Bradley and Corwyn 2002; Reardon and Portilla 2016; Tamis-LeMonda et al. 2017; Valentino 2018). In a recent study, for example, Reardon and Portilla (2016) estimated that low-income children are likely to be two-thirds of a standard deviation below their higher SES counterparts *at the start* of kindergarten, the equivalent of about three years of learning in later grades (Valentino 2018).

Accelerating low-income children's vocabulary, therefore, is essential, and here, the special affordances of digital media might hold promise for those at risk (Shamir et al. 2012; Silverman and Hines 2009; Verhallen et al. 2006). The close proximity of words, sounds and images in digital media might help children build mental connections between auditory and visual representations. Studies have shown, for example, that digital stories with video supports enhanced low-income children's vocabulary compared to static, picture images (Smeets and Bus 2015; Verhallen and Bus 2010). These results provide support for Paivio's dual coding theory (Paivio 1986, 2008). According to the theory, humans process visual and auditory information in separate channels. When incoming sensory information can be processed by two channels rather than one, it is likely to be learned and retained more effectively. Consistent with the more recent cognitive theory of multimedia learning (Mayer 2008; Moreno and Mayer 2007), which include the roles of both auditory and visual input on information processing, studies have shown, for example, that young children are more likely to learn from presentations that include words with animated visual images (i.e., visual), and background music (i.e., auditory), especially when words in the narration are well-synchronized with this non-verbal information. Rather than "use up" the capacity for storing language in working or short-term memory, Bus et al. (2015) found that the information provided in dual channels (auditory and visual) enabled children to better figure out the meaning of unknown words and store them in long-term memory.

Furthermore, the theory of synergy in media presentations (Neuman 1995, 2009) suggests that video, music and sounds may expose children to an additional set of processing tools, which in combination, can add new dimensions to children's understanding. For example, in examining third graders recall and inferential abilities, a researcher found that the students who watched a multimedia story recalled more story elements than students exposed to only one medium (Neuman 1989). Similarly, in a more recent study, contrasting repeated exposure to words in a similar medium (e.g., book or video) versus different media (e.g., book and video), researchers reported significant gains in receptive language for the mixed media condition compared to single medium treatments (Neuman and Samudra, submitted for publication). Meringoff and her colleagues have shown that different media may support different aspects of children's recall in a story (Meringoff 1980). For example, studies of the formal features of video have found that animation, music, and other attention-directing cues may direct children's viewing and serve as markers of target words (Neuman et al. 2019), content and comprehension (Beentjes et al. 2001; Huston et al. 2009; Huston and Wright 1983). These theoretical perspectives suggest that information processed across multiple channels (e.g., visual and auditory), may benefit vocabulary learning.

This study was designed to examine children's word learning of digital episodes without adult support among low-income preschoolers. Conceivably, if educational media can provide supports for word learning and at least partial understanding of their meaning, digital stories might serve as a springboard for other language-promoting activities, and cascade

to other early learning experiences that affect children's achievement. Moreover, examining variability within a low-income group may be particularly important to better understand how specific pedagogical supports might promote word learning.

Word learning in digital stories

Although young viewers seem to be able to engage in quick, incidental word learning from digital stories, not all words are learned so effortlessly. For example, in several studies, Rice and her colleagues (Oetting et al. 1995; Rice and Woodsmall 1988) reported that there were differential effects by word class. Preschoolers demonstrated a greater ability to pick up and comprehend object and attribute words as compared to action and affective state words. Object words, such as *viola* and *gramophone* clearly showed an advantage over all other word types.

These findings are consistent with previous research indicating that nouns are generally easier to learn than action words. Some researchers have suggested that the preponderance of nouns in early vocabulary may result from an attentional focus (Ecols and Marti 2004; Kersten and Smith 2002): Children tend to preferentially attend to objects, which are more stable in time and space than action words. Nouns may also have the advantage of imageability (Ma et al. 2009; McDonough et al. 2011; Paivio 1986), the ease with which a concept may evoke a mental image. Correlating word imaginability ratings and form class (e.g. nouns, verbs) with age of acquisition, McDonough et al. (2011), for example, found that imageability predicted age of acquisition, suggesting that it might be a driving factor in word learning.

Concrete words or those that are high in imageability, such as *monkey* or *snake*, therefore, are thought to be easier to assess than abstract words (De Groot and Keijzer 2000; Kaushanskaya and Rechtzigel 2012; Schwanenflugel and Shoben 1983). Unlike abstract words (e.g. *truth*), words with high imageability have direct sensory referents to individual objects and categories, potentially building connections between the verbal and the image system. For low-income children, the high imageable noun-to-category linkage may serve as an anchor to access other essential grammatical forms (e.g. adjectives, verbs) and map them to their respective meanings. Concrete, high imageable words, therefore, might support rapid processing of words, and support the retrieval of information (see specific words in Table 1). However, as Waxman and Leddon (2010) caution, the acquisition of these nouns can only take the language learner so far. Language learners must ultimately come to understand the mapping between a wide range of grammatical forms and the meanings they convey.

Genre features of digital stories

Although educational media might offer a potential for word learning, not all will have facilitative effects. Research with preschool and kindergarten children has revealed both positive and negative effects of digital stories, conditional upon whether materials are consistent with pedagogical supports for young children's learning (Bus et al. 2015; Chassiakos et al. 2016; Takacs et al. 2015). For example, studies by (DeJong and Bus 2004; Mayer 2005; Takacs et al. 2015; Verhallen et al. 2006) have shown that adding certain features, such as animated pictures, sometimes enriched with music and sound that match the simultaneously presented story text can facilitate vocabulary learning and comprehension for children at-risk for language and reading difficulties. These results suggest that certain program characteristics, integrating both

Table 1 Description of words and clips

Context	Vocabulary word	Definition	Repetitions	CHILDES	Video clip duration
Narrative (Martha Speaks)	Audience	An audience is people who listen to us play	7	0	1:50
	Lyrics	Lyrics are the words you sing	7	0	2:00
	Rubbish	Rubbish means garbage or junk	7	1	1:54
Participatory (Bubble Guppies)	Conductor	The conductor is head of the marching band and tells them where and when to march	7	1	1:56
	Materials	Materials are what you use to make things out of	7	0	1:52
	Actor	An actor is a person who pretends to be different things	7	1	2:01
Expository instruction (Sesame Street)	Sculpture	A sculpture is a piece of art that's made by shaping or carving something or by putting things together	7	0	1:49
	Author	An author is someone who writes books and stories	7	0	2:00
	Adventure	An adventure is an exciting activity or experience like a trip	7	1	1:54

nonverbal information and language, can consolidate the understanding of word meanings, and may be particularly well-suited to learning conditions for vulnerable children.

Less attention, however, has been paid to the context of the story in which these words may be learned. Words are embedded in contexts that may vary quite strikingly in digital media. For example, Clifford and his colleagues (Clifford et al. 1995) drew a broad distinction between "drama" and "factual" educational television programs, highlighting the differences in learning opportunities across these different genres. Extending this research, Linebarger and Piotrowski (2010) described these genre differences as macrostructures used to deliver content, with "drama" representing a narrative macrostructure (e.g., setting, character, goals, resolution), and "factual" an expository macrostructure, primarily intended to provide information (e.g., cause and effect). Evaluating the effects associated with watching content presented within each macrostructure, these researchers found differential gains in vocabulary and comprehension across programs among low-income elementary students. All favored the narrative macrostructure. Specifically, children's definitional vocabulary knowledge and literal comprehension were higher for narrative than expository programs. Consistent with Linebarger and Piotrowski (2009), they suggest that narrative macrostructures may reduce processing demands because they relate to children's narrative experiences in real-life (e.g., narrative dominance), thereby requiring less processing capacity than expository macrostructures in which prior background knowledge might be essential to children's comprehension.

At the same time, one could argue that word learning in narrative contexts where there are a series of actions with several characters in which the child must infer the referent from multiple cues in the ongoing scene might represent a more challenging task than in expository programs in which words are likely to be more topic-centered with visual referents to convey their meaning. For example, Fisch has posited, in his capacity model (2000), that due to limitations in working memory, children might pay attention to the narrative and characters in a story to the exclusion of educational content. In other words, as Beck et al. noted (1983), not all contexts are created equal. Some may facilitate word learning over others. Regardless of the particular macrostructure, children might be more likely to pick up partial word knowledge when it occurs in a more explicit, directive context followed by multiple encounters of the word (Frishkoff et al. 2008; Medina et al. 2011; Stahl 2003). For example, the 20 novel words in Rice and Woodsmall's study of quick, incidental word learning (1988) appeared a total of 114 times in a 12-min video, a dense rate of new information not likely to be encountered in more typical programming.

Therefore, it might be more beneficial to focus on the pedagogical supports within digital contexts for word learning instead of the broader macrostructures of programs. Given that both narrative and expository content can be intertwined in educational media (e.g., Sesame Street) (Nichols Linebarger et al. 2017), individual programs are likely to contain a variety of contextual supports for word learning. Focusing on the episode in which a novel word is conveyed might provide a more fine-grained analysis of the contextual supports for word learning. Consequently, in this study we examine word learning in three common educational media contexts: narrative, expository, and participatory described in greater detail below.

Contexts for word learning

Educational programs are frequently structured in episodes (Fenstermacher et al. 2010), a series of events that are distinctive and separate, occurring within a program. These episodes may act as contexts that surround a novel word, providing additional clues to its meaning or serving to direct children's attention to the word. Studies of word learning

suggest that some of these contexts may be more supportive than others for children who experience difficulty learning words (Elleman et al. 2017; Eller et al. 1988; Nagy 1995; Nagy et al. 1987). In a follow-up study of quick, incidental word learning, for example, Rice and her colleagues (Oetting et al. 1995) found differential effects for children who were typically developing language learners and those who had specific language impairments. Both groups of children demonstrated word-learning ability; however, those with language difficulties gained significantly less than their peers (4.67 compared to 2.29/out of 20). The pattern of word effects was revealing: For both groups of children the great gains were for words that entailed object properties, specifically, nouns that could be identified explicitly and visually represented (e.g., gramophone; viola) on the screen.

Our goal, therefore, was to shed greater light on the particular context(s) that might support word learning. Perhaps the most common context in educational programming is the narrative episode (Linebarger and Walker 2005; Vaala et al. 2010). In this case, media designers provide an ostensive cue, specifically the definition of a target word embedded within a narrative structure (e.g., setting, characters, plot, events, resolution). For example, the setting of an episode in *Martha Speaks* begins with children playing in a rock band together. One child says, "It looks like we might have a hit!"; "Maybe," says another, "but we need one more thing." "Vitamin B6?" "No, to be a hit, we need an audience. An audience is a group of people who listen to us play." The characters then go through a series of events to try to find an 'audience,' which is resolved when they find a baby play group to listen to them. The story conforms to the elements of a story grammar, representing a setting, an initiating event, attempts toward a goal, followed by a resolution (Mandler and Johnson 1977).

In contrast, there are episodes in which the target word is supported in an expository context. "The *Word on the Street*" episodes from Sesame Street best exemplify such an approach (Larson and Rahn 2015), targeting a specific word in each episode. Each word is first introduced by a Muppet who interviews people to ask for the meaning of the word and specific examples or synonyms of it. For example: "Hi I'm Murray (the Muppet) and I'm looking for a word on the street. What's the word on the street? "Sculpture." (Next scene) Little boy, "A sculpture is a piece of art that you shape." Little boy points to a sculpture as the word appears behind it. Two or more examples are likely to follow. Typical of an expository format, it includes an introduction to the topic, description of its attributes, examples, and category comparisons (Duke 2004; Pappas 1991; Saul and Dieckman 2005).

A third format to support word learning and vocabulary includes a direct-to-audience, participatory context (Anderson and Davidson 2019; Anderson et al. 2000; Claxton and Ponto 2013). In this case, the program attempts to intentionally engage viewers (e.g., through pauses) in the educational experience. Originating the approach, *Blue's Clues* use the process of delays, designed to allow audience members time to overtly or covertly provide answers, with feedback given a bit later. In this approach, the television character addresses the camera and appears to be directly speaking to the child viewer, asking questions and soliciting viewer participation. In *Bubble Guppies*, it might look like this: The children are pretending to act like the big bad wolf. Then some character comes on the screen, stares at the audience, and says: "I'm not a big bad wolf, I'm an actor." "What's that? (Pause, character looks at viewers for two-seconds, to encourage audience participation). A bubble appears with an actor in it. This is followed by feedback with the character saying, "An actor pretends to do different things. Let's think about actors." Additional examples are shown on the screen. See Appendix for a description of programs.

In all three contexts, media developers provide ostensive definitions of the target word with additional examples. At the same time, the context in which the word is presented and

repeated varies considerably throughout these episodes. Nevertheless, there is a dearth of evidence on how these different contexts might affect word learning. A recent small-scale study comparing the participatory model with a third-party joint attention model, for example (Krcmar and Cingel 2017), found that the use of participatory cues aided 2 to 3-year old children's ability to label an object called a *toma*, suggesting that the context may affect word learning. However, studies to date have not directly compared the extent to which particular contexts might better support word learning for children who might experience a word gap with fewer opportunities or more limited background knowledge. For example, it could be that certain contexts might better support vulnerable children's understanding of words better than others.

Therefore, our study raised the following questions: (i) To what extent does the context in digital episodes influence low-income preschoolers' word learning, including word identification in context, learning of word meanings, and word identification in a new context? (ii) Are there differences across contexts? and (iii) How is this relationship influenced by child characteristics (i.e., general vocabulary knowledge)?

Methods

Sample

A total of 108 children from two Head Start Centers between the ages 42 and 61 months (M = 4.39, SD = 0.38) participated in the study. All qualified for free and reduced lunch. Children were randomly selected from 10 classrooms. Consent was received from parents and assent was received from all participating children. The sample was diverse: 80% were African-American; 12%, Hispanic, and 8% Haitian, Middle Eastern, Dominican, and multiethnic groups; 52% of the sample was female. Children's average Peabody Picture Vocabulary Test (PPVT) was approximately one standard deviation below the norm at 88.3 (SD = 0.38).

Research design

To examine the effects of context on word learning, we used a within-subject design. In a within-subject design, each child is exposed to all conditions and all 9 words in a counter-balanced approach. In our case, the within-subject factor was context (e.g., narrative, expository, and participatory episodes). The design allowed us to control for between-subject variability because all participants viewed words in all contexts. It also reduced error and increased our power to detect the potential differences between contexts, minimizing a threat to internal validity since all participants serve as their own controls. Knowledge of words from one context was compared with knowledge of words from the other two contexts for each individual participant.

Video episode conditions

We selected three program series that included episodes representing different word learning contexts: *Martha Speaks*, broadly structured as a traditional narrative; *Word on the Street (Sesame Street)*, structured as an expository context; and *Bubble Guppies*, an

interactive context which included participatory episodes. All three programs are targeted to preschoolers (e.g., www.commonsensemedia.org/reviews; www.pbskids.org). According to the Flesch-Kincaid readability formula (https://www.readabilityformulas.com) (e.g., a measure typically used to determine text difficulty), episodes should be easy to understand by preschoolers. Three clips from these episodes which included an ostensive definition of a novel word were selected from each program series for a total of nine clips. In each clip, the word was labelled, followed by an ostensive definition. Each novel word was repeated seven times throughout the episode. The average length of each episode was 108.6 s (SD = 13.7).

Target words in each clip were nouns identified by three independent reviews as high utility, or Tier 2, based on the heuristic developed by Beck and McKeown (2007). Nouns were selected because children seem to be able to engage in quick, incidental word learning and their higher imageability than action words (McDonough et al. 2011). We also used the CHILDES database which consists of transcriptions of adult–child spoken interactions in different home and laboratory settings around the word to calibrate word difficulty: each of these words occurred less than five times in the utterances of 48-month old children (MacWhinney 2000). Similarly, five of our words were not included in the Dale-Chall list of words that pre-school age children should recognize (Chall and Dale 1995) indicating that these words were likely to be challenging but achievable. See Table 1 for a description of words and clips.

Procedure

Two weeks prior to the start of the study, children were individually administered a 20-item screening measure (e.g., 9 of which were the target words, 11 equally difficult foils, all nouns) to determine their potential familiarity with any of the novel words. Foils included: balloons, binoculars, jump rope, elbow, hive, forehead, strawberry, mustache, tricycle, athlete. Children were shown a picture and prompted to identify the word, by answering "What is this?" Six children identified one of the target words, and were subsequently eliminated from the study. A total of 102 children completed all phases of the study.

The study was conducted in three rounds to avoid fatigue and/or inattention. All activity took place in the library in each Center. We developed a protocol with an explicit script, using a Latin Squares design to counterbalance the order of rounds. Two graduate research assistants in educational psychology were trained in administering the treatments and assessments. In Round 1, for example, a child would individually view three short videos (e.g., narrative, expository, and participatory) counterbalanced by genre to account for an order effect, followed by three brief assessments (described below). After a 1–3 min break, the child would participate in Round 2 following a similar routine with three different episodes and assessments. After another short break, the child participated in a final Round 3, viewing three episodes and subsequent assessments. After completing all assessments, children were given a brief interest survey. Altogether, the protocol and assessments, including the breaks took approximately 35-min per child.

Measures

Participating children were individually administered the following measures:

Peabody picture vocabulary test (PPVT-4) (Dunn and Dunn 2007)

Before the study began, we individually administered the PPVT-4 to children. This standardized measure examines children's overall receptive vocabulary. Reliability of the measure ranges from 0.91 to 0.94.

Vocabulary measures Previous studies investigating incidental word learning have reported small but reliable gains in word knowledge from context (Nagy and Herman 1987; Nagy et al. 1987). To detect these gains, Nagy et al. have examined the incremental nature of word learning, from simple labeling to greater understanding of words. Based on this research, we developed and piloted measures that could tap word learning from initial identification to understanding. We used receptive measures since we believed that they might be more sensitive to partial word knowledge, particularly for low-income children who might have more limited language than their middle-class peers (Oetting et al. 1995). Furthermore, previous research on children's quick, incidental learning from educational media had used receptive measures, allowing us to examine how our research might compare with general patterns of word effects in educational media (Rice et al. 1992).

Word identification in context This assessment was designed to measure children's ability to label the target word. Modeled on the PPVT, children were asked to point to an image of a vocabulary word in the context in which it was viewed. All four quadrants were taken from the same video clip and focused on a key object in the scene. The child was asked to point to the correct word. Each word was assessed two different times for a total of 18 items. Responses were summed to yield an overall accuracy score, which was then converted into a proportion score. Cronbach's $\alpha = 0.609$.

Word meaning This assessment was designed to capture a developing understanding of the meaning of the word. Children were shown three pictures specifically designed for the task, and asked to point to one of three images that best represented the word's meaning. For example, children were asked to point to the picture that 'tells musicians what to do' (conductor) or something 'that is old and unwanted' (rubbish). Each word was assessed two times for a total of 18 items. Responses were summed to yield an overall accuracy score, which was then converted into a proportion score (Cronbach's $\alpha = 0.59$).

Words in new context This assessment was an adaptation of a Yes/No measure used in previous research (Neuman et al. 2011). The format was based on the research by Beck and McKeown as a method to judge whether a word in a new contextual setting had meaning (2007). We designed an 18-item task to assess children's knowledge of the target words in each episode. Two items per word were developed. Assessment questions were devised to include the target word in a sentence that was related to its definition or not. For example, "do you put *rubbish* in a trash can?" Or later in the sequence, "do you put *rubbish* in bed?" These questions were designed to examine words in a new context, a form of transfer for very young children. Each target word was tested using both an appropriate context and an inappropriate context to measure their ability to apply the word to a new context. Children heard an equal number of yes and no questions across the assessment, and the order of these questions was fully randomized. Children responded either 'yes' or 'no' to each question. In order to be judged "correct" children had to respond correctly to both questions. Kearns and Biemiller (2010/2011), for example,

have shown that scoring correctly on two questions rather than one increases the likelihood that a child might know the word and be able to use it. Using this approach, the total number of correct responses was recorded, which was then converted to a proportion score. Given that we asked two different kinds of questions, we calculated Cronbach's alpha separately to account for these differences (Cronbach's α for yes items = 0.755; α for no items = 0.871.)

Consequently, although the internal consistency for our word identification in context and word meaning measures was below desirable levels, these assessments were considered within the acceptable range for researcher-developed measures (Shadish et al. 2002). Furthermore, Gersten et al. (2005) have asserted that lower reliabilities can be considered acceptable for newly created measures and can indicate that a coherent construct is being assessed. Previous studies using similar brief researcher-designed measures have found meaningful resources with alphas lower than 0.6 (e.g., Loftus et al. 2010).

Enjoyment and interest in clip

Children were given an enjoyment/interest measure after the final round of vocabulary assessments. Specifically, our purpose was to examine the likeability of the episodes which could potentially affect children's engagement and attention to words. Children were given an example of a 5-point happy face Likert scale ranging from "strongly dislike" to "strongly like" with a neutral face as the midpoint. The administrator first presented the child with a picture from each show, and asked, "How much did you like this show?" The researcher explained each of the faces. Following the general questions, the research assistant presented the child with different characters from each show, and asked, "Show me the face that best tells me if you like this character or not?" There were 18-items on the measure (Cronbach's α = 0.815). A likeability score for each show was calculated.

Prior to the analysis of results, we examined the differences in the likeability of the programs (e.g., Bubble Guppies; Word on the Street; Martha Speaks). Children reported to enjoy watching all three programs (M = 3.89; 3.96; 4.07, out of 5), with no significant differences between them. Given the lack of variance in ratings of show enjoyment, therefore, we believed that we could confidently say that the context of the episode, not the program itself, might account for differences in word learning.

Results

The following results first describe the role that context plays in children's ability to identify, define, and apply word meanings. All analyses were conducted using SPSS statistical software package version 25. Initial analyses of children's receptive language scores indicated a significant negative skew to the data. We therefore used a median split to divide children into groups based on their PPVT scores, with half of the children in the sample performing about two standard deviations below norm, (M = 73.47, SD 15.41) while the other half, had average receptive language scores (M = 103.61, SD 7.98). Therefore, for each analysis, we used a 3 × 2 repeated measures ANCOVA, with context (narrative, expository, participatory) as a three-level within-subjects' variable,

and receptive language scores (higher or lower) as a 2-level between subjects' variable. We also include children's age in months as a covariate in all analyses due to the age ranges of children in our sample. As a mixed design with one within-subjects factor, we centered the covariate prior to any analyses to prevent distortion of effects (Schneider et al. 2015).

As shown in Table 2, our researcher-designed measures of word learning were correlated with the PPVT. These results indicated that our measures were reflecting a receptive language factor, and therefore, could be assumed to be adequately accessing children's word learning from educational media.

Context and word learning

As shown in Table 3, children learned words from digital media. In order to test this, we tested children's learning against what could be expected if they were merely guessing at the correct answer. In our word-identification measure there were 4 options – the target and three distractor items. If children were guessing at the correct answer, we would expect answers to be random, and therefore each child has a ¼ or 25% chance of guessing correctly. Therefore, if children's overall average accuracy is greater than a proportion of 0.25, we can conclude that their responses were not guesses, but at least partially informed responses. In this analysis, for word identification, we found that children performed significantly above chance levels on these in-context questions in the narrative context, $t\ (101) = 5.16$, $p < 0.001$ level, the expository context, $t\ (101) = 11.76$, $p < 0.001$, and the participatory context, $t\ (101) = 14.62$, $p < 0.001$.

For our word meaning measure, there were three potential options—the target word and two distractors—therefore the average score that we would expect children to earn if they were guessing randomly would be 0.33. We found that children scored significantly above chance levels on word meaning in all three contexts: narrative, $t\ (101) = 3.38$, $p = 0.001$; expository, $t\ (101) = 5.99$, $p < 0.001$, and participatory $t\ (101) = 4.89$, $p < 0.001$. Finally, for our measure of understanding words in context, there were again four options, and therefore the expected score if children are guessing randomly would be 0.25. In this measure, children did not score above chance levels on understanding the words in new contexts: narrative, $t\ (101) = 1.09$, $p = 0.280$, expository, $t\ (101) = 0.99$, $p = 0.322$, and the participatory context, $t\ (101) = 0.60$, $p = 0.552$. Together, these results suggest that although quick, incidental word learning seemed to occur across all contexts, some of these contexts were more supportive than others.

Table 2 Correlations of word measures

Measure	1	2	3	4
1. PPVT	–			
2. Words in context	0.35**	–		
3. Word meaning	0.38**	0.33**	–	
4. Words in new context	0.35**	0.37**	0.18	–

**p < 0.01

Table 3 Mean proportion correct (and standard deviations) of children's responses by age, condition, and measure

	Participatory condition			Expository condition			Narrative condition		
	Total children	Ages 3.5–4.4	Ages 4.5–5.0	Total	Ages 3.5–4.4	Ages 4.5–5.0	Total	Ages 3.5–4.4	Ages 4.5–50
Word*** identification	0.61 (0.25)	0.55 (0.26)	0.68 (0.23)	0.52 (0.23)	0.50 (0.24)	0.53 (0.22)	0.37 (0.23)	0.33 (0.21)	0.42 (0.25)
Word*** meaning	0.50 (0.32)	0.45 (0.36)	0.55 (0.25)	0.53 (0.32)	0.45 (0.31)	0.62 (0.31)	0.44 (0.29)	0.38 (0.27)	0.50 (0.31)
Words in new context	0.27 (0.30)	0.19 (0.28)	0.36 (0.31)	0.23 (0.25)	0.20 (0.22)	0.26 (0.28)	0.22 (0.26)	0.21 (0.25)	0.24 (0.26)

*** $p < 0.001$

Differences by context and receptive language proficiency

Word identification

Our first question focused on whether certain contexts might be more supportive for children's word learning, especially for those who might have lower proficiency in receptive language. Conceivably, if certain contexts in digital media might better support those children with a significantly lower receptive language, it might serve as a useful medium to potentially accelerate word knowledge for these children (Fig. 1).

We first examined children's ability to identify the words presented in the episodes. We found a significant effect of our covariate, $F(1, 99) = 7.21$, $p = 0.009$, partial $\eta^2 = 0.068$, indicating that children's age was a factor in word identification. We also found a significant main effect of context, $F(2, 98) = 39.35$, $p < 0.001$, partial $\eta^2 = 0.284$, a significant main effect of receptive language, $F(1, 99) = 14.30$, $p < 0.001$, partial $\eta^2 = 0.126$, and a significant context by vocabulary interaction, $F(2, 98) = 4.57$, $p = 0.011$, partial $\eta^2 = 0.044$. For word identification, therefore, older children who were more proficient in receptive language were more likely to identify novel words in episodes than others. Furthermore, children's ability to identify words appeared to be influenced by the context in which it was presented.

To follow up on the interaction between context and vocabulary, we conducted a series of paired samples t-tests. In order to account for family-wise error rate, we included a Bonferroni correction, which put the threshold for significance at 0.008. These analyses

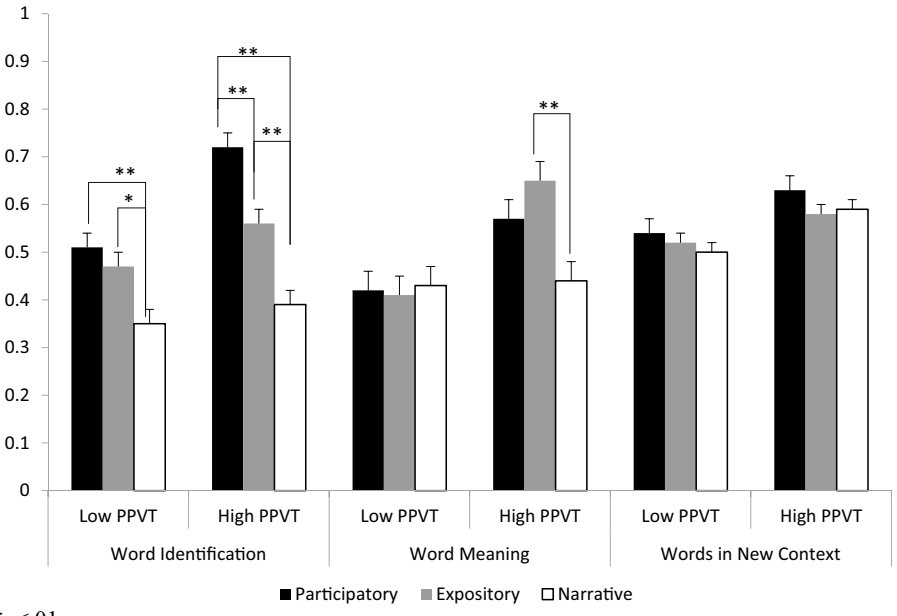

Fig. 1 Children's mean proportion correct on vocabulary measures by context for lower and higher PPVT scores. *p < .01. **p < .001

indicated that the effects of context were not universal across students. Children with higher receptive language scores recalled more words from the participatory context than the expository, t (50) = 4.02, $p < 0.001$, $d = 0.69$, and both of these contexts were higher than the narrative context (t (50) = 9.14, $p < 0.001$, $d = 1.37$ for participatory; t (50) = 4.20, $p < 0.001$, $d = 0.74$ for expository). For children with lower language skills, although the narrative context continued to be significantly less helpful for learning than either the participatory, t (50) = 4.87, $p < 0.001$, $d = 0.50$ or expository contexts, t (50) = 2.80, $p = 0.007$, $d = 0.53$, there were no significant differences in word learning between participatory and expository contexts, t (50) = 0.93, $p = 0.355$, $d = 0.18$.

Taken together, these results suggest that the participatory and expository contexts were more beneficial for word identification than the narrative context. Furthermore, for children with already higher receptive language, the participatory context was the most promising overall context. Children at both levels of receptive language, however, seemed to struggle to identify words when the episodes were in a narrative context.

Word meaning

We next examined whether children developed an understanding of the words. In this analysis, we found a significant effect of the covariate (age), F (1, 99) = 14.99, $p < 0.001$, partial $\eta^2 = 0.131$, a significant main effect of receptive language, F(1, 99) = 14.96, $p < 0.001$, partial $\eta^2 = 0.131$, and a significant context by language interaction, F(2, 98) = 3.87, $p = 0.023$, partial $\eta^2 = 0.038$. However, there was no significant main effect of context, F(2, 98) = 2.61, $p = 0.076$, partial $\eta^2 = 0.026$.

We then examined whether the effect of context differed for children with higher or lower receptive language scores, again, with a correction that put the threshold of significance at 0.008. These analyses indicated that for the higher PPVT group, learning word meanings were less likely to occur in a narrative than in an expository context (t(50) = 3.83, $p < 0.001$ $d = 0.70$). There were also differences between the participatory and narrative context, (t(50) = 1.94, $p = 0.059$, $d = 0.43$), though these effects were non-significant. Similar to our previous analysis, we found no significant differences in word meaning between the expository and participatory contexts (t (50) = 1.55, $p = 0.129$, $d = 0.26$).

For the lower PPVT group, however, once again, there were no context effects in word meaning (t(50) = 1.33, $p = 0.742$, $d = 0.07$; t(50) = 0.11, $p = 0.914$, $d = 0.03$; t(50) = 0.24, $p = 0.814$; $d = 0.03$). Rather, children with lower PPVT scores seemed to struggle with word meanings in any digital context. In contrast, those with higher PPVT scores seemed to benefit from the participatory and expository contexts, suggesting context effects for those with better overall receptive language skills.

New context

In our final analysis, we examined whether children were able to apply the novel word to a new context, one that did not relate to the digital episode. In this analysis we found a significant effect of the covariate (age), F(1, 99) = 9.42, $p = 0.003$, partial $\eta^2 = 0.087$, along with a significant main effect of receptive language, F(1, 99) = 29.25, $p < 0.001$, partial $\eta^2 = 0.228$, such that children with higher PPVT scores outperformed their peers with lower scores. However, there was no significant main effect of context, F(2, 98) = 0.13, $p = 0.881$, partial $\eta^2 = 0.001$ or context by language interaction, F(2, 98) = 0.23, $p = 0.798$,

partial $\eta^2 = 0.002$. Rather, the context of the episode did not appear to support children's ability to transfer their knowledge of novel words.

Overall, these results suggest that children are more likely to learn words in participatory and expository contexts than in a narrative setting. However, it also suggests that neither context sufficiently supported word learning for those who have lower receptive language skills. These children are likely to require additional supports in learning new words and in understanding, and applying their meaning to other contexts.

Discussion

Children are known to learn words from digital sources. Classic studies by Rice and her colleagues (Oetting et al. 1995; Rice and Woodsmall 1988), for example, have shown that preschoolers' can show appreciable learning about a word from a single exposure to a video episode, and that such rapid processing of words, or quick, incidental learning in media can occur even when adult supports are minimal. Nevertheless, the strength and information available to the young viewer after a single exposure is presumed to vary according to both word and context factors (Schwanenflugel et al. 1997). For example, young children acquire nouns earlier than verbs, which are, in turn, acquired before other open class parts of speech such as adjectives and adverbs (Golinkoff and Hirsh-Pasek 1999). Studies suggest that the early acquisition of word knowledge is a powerful predictor of later achievement (Cunningham and Stanovich 1997).

A lingering question, however, has been whether 'text' or genre features, such as the kind of contextual support can enhance (or potentially hinder) word learning. Previous studies (Linebarger and Piotrowski 2009, 2010) have suggested that program macrostructures (e.g., narrative; expository) affect children's learning from media, with narrative reportedly superior to other program structures such as expository in story retellings and retention. However, contexts embedded within these larger program structures may vary considerably, ranging from pedagogical contexts specifically designed to teach designated target words to more natural contexts in which the word is set in a surrounding that supports the word's meaning. Given that most words are learned from context (through oral communication, print, and digital resources), our goal was to better understand how such learning takes place for young children.

We also sought to examine the extent of low-income children's partial word knowledge. Similar to the research by Rice et al., we assumed that children might be able to pick up at least a partial understanding of a new word in context. Recognizing that there may be varying degrees of partial knowledge, however, we constructed a task that required children only to identify the word in the same context as it was just viewed (Nagy and Townsend 2012). Representing a somewhat greater degree of partial knowledge, we constructed a task that measured word meaning, knowing that children may have more explicit, though still limited understanding of the target word. And finally, we tapped their ability to use the word in a new context, extending their understanding in a near transfer task. Together, these tasks were designed to better elucidate the initial phases of word learning in digital contexts, and the incidental nature of such word learning encounters.

The results of our study indicated that target word learning occurred most frequently at all partial learning phases in the participatory condition. These episodes engaged low-income children by pausing, asking questions, and soliciting viewer participation. Previous studies have proposed that it might be the role of social contingency in children's

learning of novel words (Roseberry et al. 2014). Specifically, participatory cues might simulate the types of conversational activity and joint focus that has shown to be associated with children's language acquisition (Krcmar and Cingel 2017). Although much of the research on social contingency has explored children's learning in live, day-to-day interactions (Shonkoff and Phillips 2000), recent studies have shown that video, and skype among other in vivo sources may support language interactions and word learning (Kirkorian et al. 2016; Krcmar et al. 2007). Results of a recent study suggest that participatory episodes which mimicked social contingency enhanced young children's (2-to 3-year's old) word learning (Krcmar and Cingel 2017). Furthermore, such participatory contexts may engage children in processing words more interactively, an essential feature in oral language development (Rowe 2018) and vocabulary learning (Beck et al. 1983). Consequently, program features which engage children in participating while viewing may serve as a potential proxy (though certainly not an ideal substitute) for the type of socially contingent interactions that support language learning.

At the same time, low-income children also learned words in the expository context, though not quite as well as in the prior context. Like the other contexts, these episodes included an ostensive definition, followed by several repetitions of the word. However, in contrast to the narrative context, in particular, expository episodes provided specific, concrete examples and declarative information about the word, seeming to support the word learning process. In addition, the visual representations of the words seemed to bolster children's word learning, providing further evidence of Paivio's theoretical principles of dual coding (1986, 2008). Studies have shown that such explicitness which includes identification of the word to be learned and concrete examples of the targeted words and their meanings in other contexts can be more effective than more implicit language learning opportunities (Bowne et al. 2016; Kame'enui and Baumann 2012).

Understanding the benefits of social contingency in participatory contexts and the explicit, concrete examples in the expository contexts might help to explain the more modest words identified in the narrative contexts. Although the narrative contexts included an ostensive definition of the target word, subsequent exposures to the word were more implicit, running throughout the story. The more extensive information about the word seemed to rely on children's ability to infer the relevant meaning, potentially requiring more than partial knowledge. Similar to studies of vocabulary learning in print, these results suggest that words may be more effectively learned when explicitly identified with examples that explore different uses of the word than implicit language learning opportunities (Coyne et al. 2007).

Fisch's capacity model (Fisch 2000) might also help to explain the more limited word learning in these narrative contexts. According to his model, children tend to prioritize narrative over educational content, a principle he describes as narrative dominance. Given children's limited capacity to store information, he argues that the allocation of working memory will compete for attention. For this reason, when the processing of narrative and educational content is in competition with each other, a greater proportion of working memory resources will be devoted to the narrative than to education. To overcome these challenges, media designers would have to either reduce the demands of processing the narrative or integrate the educational content and narrative so seamlessly as to create two parallel processes that complement rather than compete with one another. Clearly, however, it is possible to create narrative stories that support more explicit contexts for vocabulary learning.

Quick, incidental word learning was more difficult for low-income children with lower PPVT scores than their higher scoring peers. Although they were able to demonstrate

partial word learning of approximately 4 of the 9 words, none of the contexts was sufficiently powerful to keep up with their higher language peers who averaged 5 of the 9 words. Furthermore, the narrative context seemed more challenging than either of the participatory or expository contexts. These findings indicate important differences among low-income children, highlighting the within group variability that is often overlooked in previous studies (Verhallen and Bus 2010).

Consistent with previous studies, these findings suggest that higher language skills beget more rapid processing of words. Given the novelty of the words, however, what remains unclear is the reason for these findings. Rice and Woodsmall (1988), for example, suggest that these differences could be due to limitations of working memory, which is probably critical for picking new words in an ongoing video. Others have argued for processing speed, indicating that the differences in processing of words characterized as phonological in nature are central, acting as a microcosm of the processes involved in later fluent reading (Norton and Wolf 2012). Still others suggest that it might relate to differences in background knowledge and children's ability to make associative connections between a novel word and a known word (e.g., It has something to do with…) (Stahl 2003). Clearly a good deal of research is needed to understand the mechanisms for word learning in digital contexts in order to disentangle these relationships.

At the same time, it does suggest that without additional supports, children who are lower in overall language are likely to acquire fewer words than their higher language peers through these informal learning opportunities, a discrepancy that may accelerate over time. In our case, there was an average 20% differential in the number of words learned between the two groups. This was based on viewing a total of about 16-min of video. Given the rapid growth in screen media use by children eight years old and under, averaging 48-min a day, it could potentially exacerbate the word gap rather than narrow it. In previous studies, Neuman et al. (2019) report that attention-directing cues within programs, such as visual pop-ups; humor, and strategically-based sound alerts can support attention to and identification of targeted vocabulary words. In our subsequent studies, we are exploring additional strategies such as slowing the pacing of episodes, repeated practice, and reducing the density of language in attempts to accelerate word learning for low-income children with lower language skills.

Limitations and future directions

There are several limitations in our study. Clips in our study were short (about 1 ½ minutes), with multiple repetitions of target words. Given their brevity, children were likely to watch with great attention. At the same time, we cannot argue that this represents the typical viewing pattern for preschoolers in a more informal setting. In addition, each clip, regardless of the context in which it was seen, included an ostensive definition across all contexts to eliminate this as a potential confound. In this respect, our study was not fully comparable to Rice and Woodsmall's notion of quick, incidental learning (1988), which did not include ostensive references. However, like Rice's research, there was no prompting in any case from an adult; children viewed the episodes with an experimenter who was nearby but nonresponsive. Therefore, we are uncertain how children might learn in a more natural setting in which adult mediation or parent presence might affect word learning, particularly when there may be variation across children's backgrounds and cultural norms. Furthermore, the reliability for some of our measures was relatively low, likely due to our effort to avoid fatigue by reducing the number of items in these assessments (Tavakol and

Dennick 2011). Although item difficulty can also be a factor in reliability (e.g. Gulliksen 1945), participants' performance was neither at floor, nor ceiling, suggesting that difficulty was unlikely to be the issue. Also due to preschoolers' attention span, our research was limited in the number of words assessed in each condition. At the same time, it allowed us to examine more words than previous studies in digital contexts (e.g. Krcmar and Cingel 2017; Linebarger et al. 2013). Lastly, we limited our analysis of word learning to nouns rather than other parts of speech. Based on previous research (Harris et al. 2011) however, we know that concrete nouns have an advantage in children's quick, incidental learning in digital media and therefore, might have inflated our results; whether or not our findings are confirmed with other word types remains to be seen. Future research is needed to determine if contextual effects vary according to word type or other aspects of language acquisition essential for literacy development.

In conclusion, this study contributes to our understanding of children's quick, incidental word learning across different digital learning contexts. It provides evidence to suggest that participatory episodes which engage low-income children actively in learning are most optimal for word learning. Furthermore, to our knowledge, it is the first to examine partial learning of words in greater detail, suggesting how such exposure to words may help children identify, define, and apply these words in new contexts. Partially known words can be used as a strategy to identify words for later instruction (Biemiller 2005). At the same time, our study suggests that while children are learning words in these contexts, none of them are informative enough to accelerate learning for children with lower receptive language skills. Different supports both through media design and adult mediation may be necessary to enhance their ability to take advantage of quick, incidental word learning.

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Compliance with ethical standards

Conflict of interest There are no conflicts of interest.

Appendix

Description of programs

Martha Speaks: An animated series on PBS KIDS aimed at viewers between the ages of 4–7. Martha's educational goal is to teach kids new words. With two stories in each program, children get to know Martha as an outspoken, confident dog who gets her friends into exciting adventures.

In **T.D. and the band,** for example, T.D. sets out to recruit the gang to join his band. He writes a hit song. But to have a 'hit,' the band needs to find an audience (key word). They find a group of babies in child care. They become the audience for the band!

Excerpt: (Rock Band in place)

"Ready, let's try to play" (they play a song)

"It looks like we might have hit"

"Except there is one thing missing if we want the song to be a hit"

"Oh, I know. Maybe our name should be Vitamin B6"

"No, if we want something to be a hit, we need an audience. An audience is when people listen to us play"

"True, something can't be a hit without an audience"

"But where do we find an audience?"

[events]

[Clip is resolved when they find a child care audience]

Word on the Street (Sesame Street): Built into specific parts of Sesame Street episodes, Word on the Street is designed to introduce viewers to a target word. Each target word is first introduced by a Muppet, Murray. At the beginning of each episode, Murray interviews people to ask for the meaning of the word and examples of the word.

Excerpt

In **Word on the Street, Sculpture:**

Hi, I'm Murray from Sesame Street, and I'm looking for a word on the street."

"What's the word on the street?"

"Sculpture"

"What is a sculpture?"

"It's a type of art."

"It can be made out of metal and rock"

"How would you make it into a sculpture?

"Carve it."

"What is another way to make a sculpture?

[The clip continues with more examples].

Bubble Guppies: A preschool series, produced for Nickelodeon, Bubble Guppies is a combination comedy, educational and musical program revolving around fish-tailed preschoolers who attend school in an underwater classroom. Children learn about topics such as science, math and literacy through original music.

Excerpt

"It's time to build Bubble Guppies doghouse"

"Ok, construction team. Here's the blueprint for Bubble Guppies doghouse."

"Everybody, have your tools."

"Wait a minute. Mmm, Mr. Grouper, what should we use to build our doghouse?"

[Pause, pause] [Picture pops up]

"Materials. Materials are what you use to make things out of."

"Let's think about what kind of materials you can use to build things out of."

[pause, pause]

Construction workers build a house out of….[pause, pause]

"Wood"

"Wow that a great kind of material"

[clip continues]

References

Anders, Y., Rossbach, H.-G., Weinert, S., Ebert, S., Kuger, S., Lehrl, S., et al. (2012). Home and preschool learning environments and their relations to the development of early numeracy skills. *Early Childhood Research Quarterly, 27*(2), 231–244. https://doi.org/10.1016/j.ecresq.2011.08.003.

Anderson, D., Bryant, J., Wilder, A., Santomero, A., Williams, M., & Crawley, A. (2000). Researching Blue's Clues: Viewing behavior and impact. *Media Psychology, 2*, 179–194. https://doi.org/10.1207/S1532785XMEP0202_4.

Anderson, D. R., & Davidson, M. C. (2019). Receptive versus interactive video screens: A role for the brain's default mode network in learning from media. *Computers in Human Behavior*. https://doi.org/10.1016/j.chb.2019.05.008.

Anderson, D. R., & Kirkorian, H. L. (2015). Media and cognitive development. *Handbook of Child Psychology and Developmental Science*. https://doi.org/10.1002/9781118963418.childpsy222.

Beck, I., & McKeown, M. (2007). Increasing young low-income children's oral vocabulary repertoires through rich and focused instruction. *Elementary School Journal, 107*, 251–271. https://doi.org/10.1086/511706.

Beck, I., McKeown, M., & McCaslin, E. (1983). Vocabulary development: All contexts are not created equal. *Elementary School Journal, 83*, 177–181. https://doi.org/10.1086/461307.

Beentjes, J. W., de Koning, E., & Huysmans, F. (2001). Children's comprehension of visual formal features in television programs. *Journal of Applied Developmental Psychology, 22*(6), 623–638. https://doi.org/10.1016/S0193-3973(01)00097-1.

Biemiller, A., & Slonim, N. (2001). Estimating root word vocabulary growth in normative and advantaged populations: Evidence for a common sequence of vocabulary acquisition. *Journal of Educational Psychology, 93*, 498–520. https://doi.org/10.1037//0022-0663.93.3.498.

Biemiller, A. (2005). Size and sequence in vocabulary development: Implications for choosing words for primary grade vocabulary instruction. In E. H. Hiebert & M. Kamil (Eds.), *Teaching and learning vocabulary: Bringing research to practice* (pp. 223–242). Mahwah, NJ: Erlbaum.

Bornstein, M., Hahn, C., Bell, C., Haynes, O., Slater, A., Golding, J., et al. (2006). Stability in cognition across early childhood: A developmental cascade. *Psychological Science, 17*(2), 151–158. https://doi.org/10.1111/j.1467-9280.2006.01678.x.

Bowne, J., Yoshikawa, H., & Snow, C. (2016). Experimental impacts of a teacher professional development program in early childhood on explicit vocabulary instruction across the curriculum. *Early Childhood Research Quarterly, 34*, 27–39. https://doi.org/10.1016/j.ecresq.2015.08.002.

Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic status and child development. *Annual Review of Psychology, 53*(1), 371–399. https://doi.org/10.1146/annurev.psych.53.100901.135233.

Bus, A., Takacs, Z., & Kegel, C. (2015). Affordances and limitations of electronic storybooks for young children's emergent literacy. *Developmental Review, 35*, 79–97. https://doi.org/10.1016/j.dr.2014.12.004.

Carey, S., & Bartlett, E. (1978). Acquiring a single new word. *Papers and Reports on Child Language Development, 15*, 17–29.

Chall, J. S., & Dale, E. (1995). *Readability revisited: The new Dale-Chall readability formula*. New York: Brookline Books.

Chassiakos, Y. L. R., Radesky, J., Christakis, D., Moreno, M. A., & Cross, C. (2016). Children and adolescents and digital media. *Pediatrics, 138*(5), e20162593. https://doi.org/10.1542/peds.2016-2593.

Claxton, L. J., & Ponto, K. C. (2013). Understanding the properties of interactive televised characters. *Journal of Applied Developmental Psychology, 34*(2), 57–62. https://doi.org/10.1016/j.appdev.2012.11.007.

Clifford, B., Gunter, B., & McAleer, J. (1995). *Television and children: Program evaluation, comprehension, and impact*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Coyne, M., McCoach, B., & Kapp, S. (2007). Vocabulary intervention for kindergarten students: Comparing extended instruction and incidental exposure. *Learning Disability Quarterly, 30*, 74–88. https://doi.org/10.2307/30035543.

Cunningham, A. E., & Stanovich, K. (1997). Early reading acquisition and its relation to reading experience and ability 10 years later. *Developmental Psychology, 33*, 934–945.

De Groot, A. M., & Keijzer, R. (2000). What is hard to learn is easy to forget: The roles of word concreteness, cognate status, and word frequency in foreign-language vocabulary learning and forgetting. *Language Learning, 50*(1), 1–56. https://doi.org/10.1111/0023-8333.00110.

DeJong, M., & Bus, A. (2004). The efficacy of electronic books in fostering kindergarten children's emergent story understanding. *Reading Research Quarterly, 39*, 378–393. https://doi.org/10.1598/rrq.39.4.2.

Dickinson, D. K., Griffith, J. A., Golinkoff, R. M., & Hirsh-Pasek, K. (2012). How reading books fosters language development around the world. *Child Development Research*. https://doi.org/10.1155/2012/602807.

Duke, N. K. (2004). The case for informational text. *Educational Leadership, 61*(6), 40–45.

Dunn, L., & Dunn, D. (2007). *Peabody picture vocabulary test-4th edition*. Bloomington, MN: Pearson Education Inc.

Ecols, C., & Marti, C. (2004). The identification of words and their meanings: From conceptual biases to language-specific cues. In D. G. Hall & S. R. Waxman (Eds.), *Weaving a lexicon* (pp. 41–78). Cambridge MS: MIT Press.

Elleman, A. M., Steacy, L. M., Olinghouse, N. G., & Compton, D. L. (2017). Examining child and word characteristics in vocabulary learning of struggling readers. *Scientific Studies of Reading, 21*(2), 133–145. https://doi.org/10.1080/10888438.2016.1265970.

Eller, R. G., Pappas, C. C., & Brown, E. (1988). The lexical development of kindergarteners: Learning from written context. *Journal of Reading Behavior, 20*(1), 5–24. https://doi.org/10.1080/10862968809547621.

Fenstermacher, S., Barr, R., Salerno, K., Garcia, A., Shwery, C., Calvert, S., et al. (2010). Infant-directed media: An analysis of product information and claims. *Infant and Child Development, 19*, 557–576. https://doi.org/10.1002/icd.718.

Fisch, S. (2000). A capacity model of children's comprehension of educational content on television. *Media Psychology, 2*, 63–91.

Frishkoff, G. A., Collins-Thompson, K., Perfetti, C. A., & Callan, J. (2008). Measuring incremental changes in word knowledge: Experimental validation and implications for learning and assessment. *Behavior Research Methods, 40*(4), 907–925. https://doi.org/10.3758/BRM.40.4.907.

Gersten, R., Fuchs, L., Compton, D., Coyne, M., Greenwood, C., & Innocenti, M. (2005). Quality indicators for group experimental and quasi experimental indicators in special education. *Exceptional Children, 71*, 149–164. https://doi.org/10.1177/001440290507100202.

Golinkoff, R., & Hirsh-Pasek, K. (1999). *How babies talk: The magic and mystery of language in the first three years of life*. New York: Dutton.

Harris, J., Golinkoff, R., & Hirsh-Pasek, K. (2011). Lessons from the crib for the classroom: How children really learn vocabulary. In S. B. Neuman & D. Dickinson (Eds.), *Handbook of early literacy research* (Vol. 3, pp. 49–65). New York: Guilford.

Hart, B., & Risley, T. (1995). *Meaningful differences*. Baltimore, MD: Brookes.

Hart, B., & Risley, T. R. (2003). The early catastrophe: The 30 million word gap by age 3. *American Educator, 27*(1), 4–9.

Huston, A. C., Bickham, D. S., Lee, J. H., & Wright, J. C. (2009). From attention to comprehension: How children watch and learn from television. In B. Gunter & J. Gunter (Eds.), *Children and television* (pp. 63–86). New York: Routledge.

Huston, A., & Wright, J. (1983). Children's processing of television: The informative functions of formal features. In J. Bryant & D. R. Anderson (Eds.), *Children's understanding of television: Research on attention and comprehension* (pp. 35–68). New York: Academic Press.

Kabali, H., Irigoyen, M., Nunez-Davis, R., Budacki, J., Sweta, D. S., Leister, K., et al. (2015). Exposure and use of mobile media devices by young children. *Pediatrics, 136*, 1–9. https://doi.org/10.1542/peds.2015-2151.

Kuhl, P. K. (2004). Early language acquisition: Cracking the speech code. *Nature Reviews Neuroscience, 5*, 831–843.

Kame'enui, E., & Baumann, J. (2012). *Vocabulary instruction: Research to practice*. New York: Guilford.

Kaushanskaya, M., & Rechtzigel, K. (2012). Concreteness effects in bilingual and monolingual word learning. *Psychonomic Bulletin & Review, 19*(5), 935–941. https://doi.org/10.3758/s13423-012-0271-5.

Kearns, G., & Biemiller, A. (2010/2011). Two-questions vocabulary assessment: Developing a new method for group testing in kindergarten through second grade. *Journal of Education, 190*, 31–42. https://doi.org/10.1177/002205741019000l-206.

Kersten, A., & Smith, L. (2002). Attention to novel objects during verb learning. *Child Development, 73*, 93–109. https://doi.org/10.1111/1467-8624.00394.

Kirkorian, H., Choi, K., & Pempek, T. (2016). Toddlers' word learning from contingent and noncontingent video on touch screens. *Child Development, 87*, 405–413. https://doi.org/10.1111/cdev.12508.

Krcmar, M., & Cingel, D. (2017). Do young children really learn best from the use of direct address in children's television? *Media Psychology*. https://doi.org/10.1080/15213269.2017.1361841.

Krcmar, M., Grela, B., & Lin, K. (2007). Can toddlers learn vocabulary from television? An experimental approach. *Media Psychology, 10*, 41–63.

Kuperman, V., Stadthagen-Gonzalez, H., & Brysbaert, M. (2012). Age-of-acquisition ratings for 30,000 English words. *Behavior Research Methods, 44*(4), 978–990. https://doi.org/10.3758/s13428-012-0210-4.

Larson, A., & Rahn, N. (2015). Vocabulary instruction on Sesame Street: A content analysis of the Word on the Street initiative. *Language, Speech, and Hearing Services in Schools, 46*, 207–221. https://doi.org/10.1044/2015_Ishss-14-0079.

Linebarger, D., Moses, A., Liebeskind, K., & McMenamin, K. (2013). Learning vocabulary from television: Does onscreen print have a role? *Journal of Educational Psychology, 105*, 609–621. https://doi.org/10.1037/a0032582.

Linebarger, D., & Piotrowski, J. (2009). TV as storyteller: How exposure to television narratives impacts at-risk preschoolers' story knowledge and narrative skills. *British Journal of Developmental Psychology, 27*, 47–69. https://doi.org/10.1348/026151008x400445.

Linebarger, D., & Piotrowski, J. (2010). Structure and strategies in children's educational television: The roles of program type and learning strategies in children's learning. *Child Development, 81*, 1582–1597.

Linebarger, D. L., & Walker, D. (2005). Infants' and toddlers' television viewing and language outcomes. *American Behavioral Scientist, 48*(5), 624–645. https://doi.org/10.1177/0002764204271505.

Loftus, S., Coyne, M., McCoach, D. B., Zipoli, R., & Pullen, P. (2010). Effects of a supplemental vocabulary intervention on the word knowledge of kindergarten students at risk for language and literacy difficulties. *Learning Disabilities Research and Practice, 25*, 124–136. https://doi.org/10.1111/j.1540-5826.2010.00310.x.

Gulliksen, H. (1945). The relation of item difficulty and inter-item correlation to test variance and reliability. *Psychometrika, 10*(2), 79–91.

Ma, W., Golinkoff, R. M., Hirsh-Pasek, K., McDonough, C., & Tardif, T. (2009). Imageability predicts the age of acquisition of verbs in Chinese children. *Journal of Child Language, 36*(2), 405–423. https://doi.org/10.1017/S0305000908009008.

MacWhinney, B. (2000). *The CHILDES project: Tools for analyzing talk* (3rd ed.). Mahwah, NJ: Erlbaum.

Mandler, J., & Johnson, N. (1977). Remembrance of things parsed: Story structure and recall. *Cognitive Psychology, 9*, 111–151. https://doi.org/10.1016/0010-0285(77)90006-8.

Mayer, R. (2005). Cognitive theory of multimedia learning. In R. Mayer (Ed.), *The Cambridge handbook of multimedia learing* (pp. 31–48). Cambridge, UK: Cambridge University Press.

Mayer, R. E. (2008). Applying the science of learning: Evidence-based principles for the design of multimedia instruction. *American Psychologist, 63*(8), 760–769. https://doi.org/10.1037/0003-066X.63.8.760.

McDonough, C., Song, L., Hirsh-Pasek, K., Golinkoff, R., & Lannon, R. (2011). An image is worth a thousand words: Why nouns tend to dominate verbs in early word learning. *Developmental Science, 14*, 181–189. https://doi.org/10.1111/j.1467-7687.2010.00968.

Medina, T. N., Snedeker, J., Trueswell, J. C., & Gleitman, L. R. (2011). How words can and cannot be learned by observation. *Proceedings of the National Academy of Sciences, 108*(22), 9014–9019. https://doi.org/10.1073/pnas.1105040108.

Meringoff, L. (1980). A story a story: The influence of the medium on children's comprehension of stories. *Journal of Educational Psychology, 72*, 240–244. https://doi.org/10.1037/0022-0663.72.2.240.

Moreno, R., & Mayer, R. (2007). Interactive multimodal learning environments. *Educational Psychology Review, 19*(3), 309–326. https://doi.org/10.1007/s10648-007-9047-2.

Myers, L. J., LeWitt, R. B., Gallo, R. E., & Maselli, N. M. (2017). Baby FaceTime: Can toddlers learn from online video chat? *Developmental Science, 20*(4), 1–15. https://doi.org/10.1111/desc.12430.

Nagy, W. E. (1995). *On the role of context in first-and second-language vocabulary learning*. Champaign, Ill.: University of Illinois at Urbana-Champaign, Center for the Study of Reading.

Nagy, W., Anderson, R. C., & Herman, P. (1987). Learning word meanings from context during normal reading. *American Educational Research Journal, 24*, 237–270. https://doi.org/10.2307/1162893.

Nagy, W., & Herman, P. (1987). Breadth and depth of vocabulary knowledge: Implications for acquisition and instruction. In M. G. McKeown & M. E. Curtis (Eds.), *The nature of vocabulary acquisition* (pp. 19–35). Hillsdale, NJ: Erlbaum.

Nagy, W., & Townsend, D. (2012). Words as tools: Learning academic vocabulary as language acquisition. *Reading Research Quarterly, 47*, 91–108. https://doi.org/10.1002/rrq.011.

Neuman, S. B. (1989). The impact of different media on children's story comprehension. *Reading Research and Instruction, 28*, 38–47. https://doi.org/10.1080/19388078909557985.

Neuman, S. B. (1995). *Literacy in the television age: The myth of the TV effect* (2nd ed.). Norwood, NJ: Ablex.

Neuman, S. B. (2009). The case for multimedia presentations in learning: A theory of synergy. In A. Bus & S. B. Neuman (Eds.), *Multimedia and literacy development: Improving achievement for young learners* (pp. 44–56). New York: Taylor & Francis.

Neuman, S. B., Newman, E., & Dwyer, J. (2011a). Educational effects of a vocabulary intervention on preschoolers' word knowledge and conceptual development: A cluster randomized trial. *Reading Research Quarterly, 46*(3), 249–272. https://doi.org/10.1598/RRQ.46.3.3.

Neuman, S. B., Wong, K., Flynn, R., & Kaefer, T. (2019). Learning vocabulary from educational media: The role of pedagogical supports for low-income preschoolers. *Journal of Educational Psychology, 111*, 32–44. https://doi.org/10.1037/edu0000278.

Nichols Linebarger, D., Brey, E., Fenstermacher, S., & Barr, R. (2017). *What makes preschool educational television educational? A content analysis of literacy, language-promoting, and prosocial*

preschool programming Media exposure during infancy and early childhood (pp. 97–133). Switzerland: Springer.
Norton, E., & Wolf, M. (2012). Rapid automized naming (RAN) and reading fluency: Implications for understanding and treatment of reading disabilities. *Annual Review in Psychology, 63*, 427–452. https://doi.org/10.1146/annurev-psych-120710-100431.
Oetting, J., Rice, M., & Swank, L. (1995). Quick Incidental Learning (QUIL) of words by school-age children with and without SLI. *Journal of Speech and Hearing Research, 38*, 434–445. https://doi.org/10.1044/jshr.3802.434.
Paivio, A. (2008). The dual coding theory. In S. B. Neuman (Ed.), *Educating the other America* (pp. 227–242). Baltimore, MD: Brookes.
Paivio, A. (1986). *Mental representations: A dual coding approach*. Oxford, England: Oxford University Press.
Pappas, C. (1991). Young children's strategies in learning the "book language" of information books. *Discourse Processes, 14*, 203–225. https://doi.org/10.1080/01638539109544782.
Radesky, J. S., & Christakis, D. A. (2016). Increased screen time: Implications for early childhood development and behavior. *Pediatric Clinics, 63*(5), 827–839. https://doi.org/10.1016/j.pcl.2016.06.006.
Reardon, S., & Portilla, X. (2016). Recent trends in income, racial, and ethnic school readiness gaps at school entry. *AERA Open, 2*, 1–18. https://doi.org/10.1177/2332858416657343.
Rice, M., & Woodsmall, L. (1988). Lessons from television: Children's word learning when viewing. *Child Development, 59*, 420–429. https://doi.org/10.2307/1130321.
Rice, M., Buhr, J., & Oetting, J. (1992). Specific language impaired children's quick incidental word learning (QUIL) of words: The effect of a pause. *Journal of Speech and Hearing Research, 35*, 1040–1048. https://doi.org/10.1044/jshr.3505.1040.
Rideout, V. (2014). *Learning at home: Families educational media use in America*. NY: Joan Ganz Cooney Center.
Rideout, V. (2017). *The Common Sense census: Media use by kids age zero to eight*. San Francisco, CA: Common Sense Media.
Roseberry, S., Hirsh-Pasek, K., & Golinkoff, R. (2014). Skype me! Socially contingent interactions help toddlers learning language. *Child Development, 85*, 956–970. https://doi.org/10.1111/cdev.12166.
Rowe, M. (2018). Understanding socioeconomic differences in parents' speech to children. *Child Development Perspectives, 12*, 122–127. https://doi.org/10.1111/cdep.12271.
Schneider, B., Avivi-Reich, M., & Mozuraitis, M. (2015). A cautionary note on the use of the Analysis of Covariance (ANCOVA) in classification designs with and without within-subject factors. *Frontiers in Psychology, 6*, 474–490. https://doi.org/10.3389/fpsyg.2015.00474.
Saul, E. W., & Dieckman, D. (2005). Choosing and using information trade books. *Reading Research Quarterly, 40*(4), 502–513. https://doi.org/10.1598/RRQ.40.4.6.
Schwanenflugel, P., & Shoben, E. (1983). Differential context effects in the comprehension of abstract and concrete verbal materials. *Journal of Experimental Psychology: Learning, Memory & Cognition, 9*, 82–102. https://doi.org/10.1037//0278-7393.9.1.82.
Schwanenflugel, P., Stahl, S., & McFalls, E. (1997). Partial word knowledge and vocabulary growth during reading comprehension. *Journal of Literacy Research*. https://doi.org/10.1080/10862969709547973.
Shadish, W. R., Cook, T., & Campbell, D. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Boston: Houghton-Mifflin Company.
Shamir, A., Korat, O., & Fellah, R. (2012). Promoting vocabulary, phonological awareness and concept about print among children at risk for learning disability: Can e-books help? *Reading and Writing, 25*(1), 45–69. https://doi.org/10.1007/s11145-010-9247-x.
Shonkoff, J., & Phillips, D. (Eds.). (2000). *From neurons to neighborhoods*. Washington, D.C.: National Academy Press.
Silverman, R., & Hines, S. (2009). The effects of multimedia-enhanced instruction on the vocabulary of English-language learners and non-English-language learners in pre-kindergarten through second grade. *Journal of Educational Psychology, 101*(2), 305. https://doi.org/10.1037/a0014217.
Smeets, D. J., & Bus, A. G. (2015). The interactive animated e-book as a word learning device for kindergartners. *Applied Psycholinguistics, 36*(4), 899–920. https://doi.org/10.1017/S0142716413000556.
Stahl, S. (2003). How words are learned incrementally over multiple exposures. *American Educator, Spring, 18–19*, 44.
Strouse, G. A., Troseth, G. L., O'Doherty, K. D., & Saylor, M. M. (2018). Co-viewing supports toddlers' word learning from contingent and noncontingent video. *Journal of Experimental Child Psychology, 166*, 310–326. https://doi.org/10.1016/j.jecp.2017.09.005.

Takacs, Z., Swart, E., & Bus, A. (2014). Can the computer replace the adult for storybook reading? A meta-analysis on the effects of multimedia stories as compared to sharing print stories with an adult. *Frontiers in Psychology, 5*, 1–12. https://doi.org/10.3389/fpsyg.2014.01366.

Takacs, Z. K., Swart, E. K., & Bus, A. G. (2015). Benefits and pitfalls of multimedia and interactive features in technology-enhanced storybooks: A meta-analysis. *Review of Educational Research, 85*(4), 698–739. https://doi.org/10.3102/0034654314566989.

Takeuchi, L., & Stevens, R. (2011). *The new coviewing: Designing for learning through joint media engagement*. Retrieved from https://www.joanganzcooneycenter.org/wp-content/uploads/2011/12/jge_coviewing_desktop.pdf.

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education, 2*, 53–55. https://doi.org/10.5116/jme.4dfb8dfd.

Tamis-LeMonda, C., Luo, R., McFadden, K., Bandel, E., & Vallotton, C. (2017). Early home learning environment predicts children's 5th grade academic skills. *Applied Developmental Science, [Early view]*. https://doi.org/10.1080/10888691.2017.1345634.

Vaala, S., Linebarger, D., Fenstermacher, S., Tedone, A., Brey, E., Barr, R., et al. (2010). Content analysis of language-promoting teaching strategies used in infant-directed media. *Infant and Child Development, 19*, 628–648. https://doi.org/10.1002/icd.715.

Valentino, R. (2018). Will public pre-K really close achievement gaps? Gaps in prekindergarten quality between students and across states. *American Educational Research Journal, 55*, 79–116. https://doi.org/10.3102/0002831217732000.

Verhallen, M., & Bus, A. (2010). Low-income immigrant pupils learning vocabulary through digital picture storybooks. *Journal of Educational Psychology, 102*, 54–61. https://doi.org/10.1037/a0017133.

Verhallen, M., Bus, A., & deJong, M. (2006). The promise of multimedia stories for kindergarten children at risk. *Journal of Educational Psychology, 98*, 410–429. https://doi.org/10.1037/0022-0663.98.2.410.

Waxman, S., & Leddon, E. (2010). Early word learning and conceptual development: Everything had a name and each name gave birth to a new thought. In U. Goswami (Ed.), *The Wiley-Blackwell handbook of children's cognitive development* (Vol. 2, pp. 180–208). New York: Wiley.

Weisberg, D. S., Zosh, J. M., Hirsh-Pasek, K., & Golinkoff, R. M. (2013). Talking it up: Play, language development, and the role of adult support. *American Journal of Play, 6*(1), 39–54.

Woodward, A., & Markman, E. (2003). Early word learning. In W. Damon, D. Kuhn, & R. Seigler (Eds.), *Handbook of child psychology: Cognition, perception, and language* (pp. 371–410). New York: Wiley.

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