Incidental Word Learning Through Multiple Media
A Case for Synergy

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Young children seem to pick up words quickly, almost effortlessly, through various media in the early years. Studies have shown that storybooks, TV, screen media, and ebooks can all be sources for incidental word learning without formal instruction. Yet, typically, research has investigated learning from a single medium in isolation or in comparison with another. In this article, we describe the potential for synergy—the combined use of multiple media platforms—and how the various symbol systems of these different media may support incidental word learning. We review recent eye-tracking studies that explore the formal features of a medium, its affordances and constraints, and suggest how multiple media might extend word-learning gains beyond those from a single medium alone. The article describes a theoretical mechanism to explain how these benefits might arise for word learning as well as implications for further research. **Key words:** *digital media*, *early childhood*, *early literacy*, *eye-tracking*, *vocabulary*, *word learning*

S INCE Marshall McLuhan's elliptical phrase, "the medium is the message" (McLuhan, 1964), there has been a continuing and broadening debate on the influence of media in shaping cognition. Much of the debate has focused on whether or to what extent media should be used in instruction and how they might maximize children's

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learning (Neuman, 1995). The argument centers around the relative role of the characteristic symbol system of such media as screen media, print, computers—the deployment of images, sounds, and print—and how these distinctive forms influence information-processing demands. A number of scholars have made the case that each medium implicitly cultivates a new set of skills for exploration and internal representation (Barr & Nichols Linebarger, 2017). For word learning, in particular, young children seem to benefit from information presented both verbally and nonverbally. Therefore, as children are learning new words and concepts, they are incorporating the symbol systems that are implicit in each medium.

Extending this theory, Gavriel Salomon (1974) proposed that by arousing certain attentional processes, each medium can become internalized as a "scheme of thought." Reporting on a number of intriguing studies, Salomon (1994) found that students deficient in cue-attending, after watching a film, were able to internalize the zooming of a camera lens into a stimulus field, thereby increasing their ability to identify details in a visual montage. In another study using

computers to stimulate meta-cognitive skills in reading, students were able to transfer these meta-cognitive modes of representation when given a new condition (Salomon & Gardner, 1986). Although they acknowledge that these features may merely activate already established skills, they contend that these data show evidence that media codes were internalized, schematized, and then applied to new circumstances.

These scholars suggest that capitalizing on the unique symbolic capabilities of each medium may benefit children's recall and retention in learning. A film's capacity to depict story actions, for example, may provide a more facilitating stimulus for recalling events than a book's still images. Conversely, a book's reliance on language to convey ideas might elicit greater attention to the verbal text and the specific words that may describe character traits (Meringoff, 1980). From this perspective, each form of experience including the various symbol systems tied to the media may support a distinctive pattern of skills for learning.

Nevertheless, the bulk of research to date has focused on the comparison between various media on children's learning. A substantial body of research from print-digital comparisons, for example, has reported learning effects for digital books (Biancarosa & Griffiths, 2012) or for print books (Miller & Warschauer, 2014). Generally, researchers (Furenes et al., 2021; Richter & Courage, 2017) have attributed differences in impact to the medium of instruction (e.g., paper advantage, i.e., print vs. digital books; Clinton, 2019), the age of the child (e.g., video deficit, i.e., young children learn less from screen viewing than comparable real-life experiences; Anderson & Evans, 2001), and/or the amount of scaffolding from an adult (e.g., coviewing; Strouse et al., 2013), with evidence of both positive and negative effects on children's comprehension and vocabulary development. For example, a recent quantitative meta-analysis of 39 studies examining reading on paper versus on-screen concluded that differen-

tial effects were equivocal (Furenes et al., 2021).

Such media comparison studies, however, have failed to take account of the dramatic shift in media consumption and availability of educational content for young children. Today's young children are multiplatform users, likely to take advantage of a variety of devices including tablets, smartphones, TV, and print books (Rideout & Robb, 2020). With the plethora of portable devices now commonly available, increasingly a child's initial exposure to a story is as likely to come from a mobile device as it is from reading it in a book. Children might see renditions of their favorite storybook characters in a live performance, an educational TV series, and online learning games, among many other forms.

Consequently, rather than comparing one medium with another, often in isolation, it might be more useful to focus on learning from multiple media platforms and the ways that different symbol systems might contribute to children's learning. For example, book reading, with its slower pace and its static pictorial information, may allow for greater attention to the words in the text. Screen media, with its access to visualization and movement, might support a focus on how words are related to the actions in a story and their meaning. Each medium, therefore, may expose children to a different set of processing tools, which in combination may contribute to children's word learning and comprehension. Under this assumption, exposure to a topic from multiple media platforms (e.g., books, TV) may elicit a synergy effect, supporting greater learning than with exposure to a single medium alone.

In this article, we describe the potential for synergy focusing on children's incidental word learning. *Incidental* implies that words may be learned while engaged in an activity, such as playing or viewing a program, and not through formal instruction. Recognizing that children's word knowledge plays a fundamental role in school readiness, and later school success (Dickinson & Porche, 2011), children will need to know a wide range of words to

understand the texts and discourse they will encounter in school. Therefore, the use of multiple media could become an important source for word learning, providing the additional supports that many children will need to accumulate a broad and deep vocabulary and conceptual knowledge base.

This article reviews recent studies to explore learning from multiple media and how such learning may compare with learning from one medium alone. It discusses a theoretical mechanism to explain how the benefits of synergy might arise, and the questions we might consider for research and practice in this emerging field. To do so, we first provide a rationale for the features of multiple media, specifically affordances and constraints for incidental word learning. We then argue that by using the affordances of each medium, we can combine the use of multiple media platforms to create a synergy for word learning that might be more powerful for learning than one medium alone.

THE POTENTIAL AFFORDANCES OF MEDIA FOR INCIDENTAL WORD LEARNING

Children seem to pick up words quickly, almost effortlessly, through various media in the early years. Studies have shown that storybooks, TV, screen media, and ebooks can all be sources for word learning without formal instruction. For example, in an early study, Elley (1989) reported that first graders gained an average of five words simply from listening to a single story reading without any teacher explanation. Follow-up tests several weeks later showed that the word learning was sustained. Similarly, in a classic study, Rice and Woodsmall (1988) found that 5-year-olds identified an average of 4.87 new words after watching two 6-min animated videos. Even toddlers aged 22 months and older seem to pick up various novel words from television (Krcmar et al., 2007). Together, these studies suggest that children are capable of mapping a word to an underlying concept quickly, de-veloping at least a partial understanding of its meaning after limited exposures to different media.

Perhaps even more remarkable, however, is that much of this initial word learning is accomplished incidentally without ostensive reference provided by an adult. This notion is consistent with the idea of "fast mapping," in that children are regarded as able to recognize a new word in context. Yet at the same time, Carey and Bartlett's classic study (1978) assumed that learning occurred in the presence of an adult who was there to interact with a child and to manipulate joint attention to the target object while naming it. Since then, Rice and her colleagues (Oetting et al., 1995; Rice et al., 1990) have shown through a series of illuminating studies that children did not need such focused adult input. Rather, children could develop initial, partial comprehension of a word's meaning through the situational context. Coining the term QUIL for "quick incidental learning," that context might consist of an incoming stream of linguistic information coexisting with referential and pragmatic information. Consistent with this thesis, Takacs et al. (2014) in a meta-analysis of 29 studies found that children could learn words incidentally from well-crafted multimedia stories without adult scaffolding ($d = 0.30$).

Although we have evidence that children can learn words in these contexts incidentally, to date there has been little research on children's linguistic processing of an unfamiliar word in media and the situational contexts that might either support or thwart it. Rice and Woodsmall (1988), for example, modified videotaped stories from children's television programming to examine word learning in a simulated natural context. In their work, they found that incidental word learning varied as a function of learner characteristics and word class (e.g., nouns, adjectives, adverbs). However, although groundbreaking in many ways, the researchers were not able to unambiguously isolate the features of the stimuli that seemed to account for this quick incidental learning.

How digital media may contribute to incidental word learning

Digital media combines verbal (e.g., language), visual, and other nonverbal (e.g., sound, music) stimuli to convey its messages. On the one hand, these multiple features have the potential to support word learning; on the other hand, these same features, if not related to the story text, may possibly interfere with learning. Paivio's dual coding theory (1986), for example, suggests that humans process visual and auditory information in separate channels, and when incoming sensory information occurs in both, children can learn and retain better than in one channel alone. According to Mayer's cognitive theory (2001), however, each channel has a limited capacity for processing information, requiring a rather delicate balance between the text or the narration and the relevant visual and auditory messages.

In considering the potential of synergy, therefore, more media components are not necessarily better. Rather, it is how these media components are deployed to direct children's attention and subsequent learning that matters most for word learning. For example, cues supporting word learning in social–interactional contexts may provide an instructive case for the ways in which educational screen media might be most useful. During social–interactional word learning (Akhtar & Tomasello, 2000), two individuals (e.g., child and adult) jointly interact over a third entity (e.g., unfamiliar object). During such interactions, adults typically teach new information by attracting and directing children's attention toward relevant or salient information. To do so, they may take advantage of a range of communicative and referential signals, such as using exaggerated prosody, establishing joint attention, and overtly pointing. In reading a storybook to a young child, for example, Ninio and Bruner (1978) found that a parent may explicitly solicit the child's attention by pointing to a referent while labeling (e.g., "Look at this! It's a picture of the sun rising"). Therefore, attention-directing cues, such as sound or visual symbols (e.g., highlighting), may help direct children's attention to key words.

In addition, certain pedagogical cues are known to support word learning (Csibra & Gergely, 2009). Instructional strategies such as explicit definitions along with repeated exposure to words in multiple contexts are known to be associated with vocabulary development (Stahl, 2003). Similarly, features of key words that extend their meaning (e.g., "Otters have webbed feet that help them swim") as well as multiple exemplars (e.g., "A career is a job that you train for. That job could be an architect, a teacher, or a scientist") are ostensive cues that can make salient the learning goal by telling and showing, often followed by telling and showing again (Pinkham et al., 2012).

Based on an initial analysis of 20 scenes from 10 different programs, we identified two major categories of pedagogical support for word learning: ostensive and attention-directing cues. Ostensive cues, as described previously, convey the meaning of a word through definition, multiple exemplars, and repetition. For example, the narrator might say, "A subway is an underground train." Or, the on-screen character might give a more elaborated description, "You're an author. That means you wrote your own book." On the other hand, attention-directing cues might be those that help direct children's attention to the target word. For example, the narrator might say, "Wow, that's a volcano," followed by a rumbling sound and a picture of a volcano popping up on the screen. Therefore, in contrast to ostensive cues, attention-directing cues are likely to signal the importance of a target word and not explicitly its meaning.

Reviewing more than 2,000 episodes of educational screen media on major streaming platforms (e.g., Disney, Amazon), our research team examined the prevalence of these cues for word learning (Neuman et al., 2019). Our findings revealed that more than 66% of these programs had at least one or more vocabulary-specific scenes, a percentage substantially more than found in previous

content analyses (Vaala et al., 2010), suggesting the potential of screen media to promote vocabulary development. But as one might suspect, media producers tended to rely on attention-directing cues (47% of the time), specifically visual effects and sound effects, far more than ostensive cues (19%).

Using eye-tracking technology in a series of studies (Neuman et al., 2019, 2020, 2021), we sought to better gauge children's ability to engage in quick incidental word learning with screen media without any media modifications or support from an adult. Eye-tracking allows for a finer-grained analysis of attention than more traditional print-based measures (Karatekin, 2007) and can identify where a child is attending precisely when new information is introduced. Whether in printed text (Rayner, 1998) or video (Kaefer et al., 2017), studies have shown that attention can predict comprehension, helping us to better understand the cognitive processes involved in learning from media. This information could potentially help us understand how a medium's symbol system—its affordances as well as its limitations—might contribute to word learning. At the same time, it also might suggest the conditions under which another medium might complement such learning, producing stronger and more robust word-learning outcomes for young children.

Using eye-tracking technology, we examined 110 preschoolers' attention to target words that employed both ostensive and attention-directing cues. Children were randomly selected from 12 classrooms for 3- and 4-year-olds in two Head Start centers. The sample was culturally diverse; 60% African American, 38% Hispanic, and 2% Caucasian. Average receptive language as measured by the Peabody Picture Vocabulary Test was 87.13 ($SD = 15.21$). Individually, each child was shown 12 brief scenes on an eye-tracking machine with an average scene length of 21.42 s, six words per cue type counterbalanced for treatment, for a total of 257 s of viewing. Areas of interests were drawn around the pictorial representation of the word after it was spoken (no printed words were on screen). Shown in Table 1, we found that, although children were quicker to orient to the specific context of the word when an ostensive cue was provided, they actually spent less time looking at the target word itself. On the other hand, with attention-directing cues, once the target word was named, children spent more time looking at it and were likely to identify the word label and the word in new contexts. For ostensive cues, the proportion of time attending to the target word was 0.31 s, whereas for attention-directing cues, 0.49 s. In short, attention-directing cues seemed to be the most effective for word learning. The music, sound effects, and visual images that would pop up when the target word was spoken seemed to encourage young children's thoughtful processing of words.

Words in context in digital media

Nevertheless, words embedded in digital media may vary quite strikingly in contextual

Table 1. Means and standard deviations of children's attention to vocabulary scenes

Variable	Ostensive Cues	Attention-Directing Cues
Proportion of total time spent fixated on screen***	0.57 (0.19)	0.25 (0.10)
Proportion of time attending to target (after target named)***	0.31 (0.12)	0.49 (0.15)
Time in seconds to fixation on target***	7.71 (1.71)	9.68 (1.19)
In context word learning-proportion correct	0.61 (0.23)	0.62 (0.23)
New context word learning-proportion correct**	0.55 (0.24)	0.62 (0.25)

**$p < .01$. ***$p < .001$.

support. To date, there have been few studies that have examined how the context of child-programming episodes may support word learning. According to Nichols Linebarger et al. (2017), the narrative story structure should work to children's advantage in word learning because young children can relate their own narrative experiences in real life to what they watch on a screen. On the other hand, Fisch (2000) has posited that due to the limitations of working memory, children might attend more to the narrative and characters in the context to the exclusion of its educational content or target words.

Interestingly, neither premise has been subject to empirical testing in terms of word learning. As Beck et al. (1983) found in printed texts, some contexts may be more facilitative for word learning than others. In our next series of studies, therefore, we examined the three most common contexts for word learning in children's programming: words that were embedded within a narrative structure (e.g., *Martha Speaks* adhering to a story structure that included setting, characters, events, and a resolution); an expository context, with words directly taught, followed by examples and category comparisons (e.g., the *Word on the Street* from Sesame Street); and a participatory context (e.g., *Bubble Guppies)*, with a "direct-to-audience" approach in which the character may address the audience and use pauses for responses to encourage participation (Neuman et al., 2020).

In this case, we used a within-subject design, engaging 102 Head Start preschoolers in watching brief episodes from three types of programs in a counterbalanced order. Children were randomly selected from the same sites as our previous research and represented a similar demographic profile. We selected nine target words, all nouns, considered to be challenging based on the frequency of their occurrence according to the CHILDES database to examine partial word knowledge, word meaning in context, and word meaning in a novel context. All words in the episodes contained ostensive cues, conveying the meaning of the term with examples, and were repeated seven times to ensure comparability across the different genres.

Our results (see Figure 1) showed that children learned more words incidentally in the participatory context compared with the narrative or expository contexts.

These episodes engaged children by pausing, asking questions, and soliciting viewer participation. Previous studies (Roseberry et al., 2014) have proposed that social contingency might play a role in these results, simulating the types of conversational activities and joint focus that is known to be associated with children's language acquisition. Although certainly not a substitute for in-person interactions, recent studies have confirmed that video and Skype among other in vivo sources may support language interactions
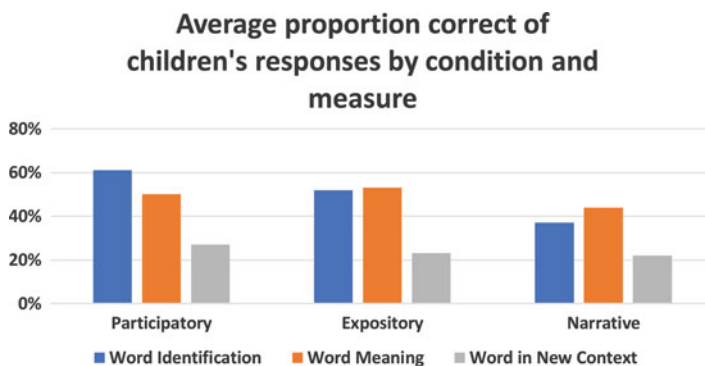

Figure 1. Word learning in episode context. This figure is available in color online (www.topicsinlanguagedisorders.com).

and word learning (Kirkorian et al., 2016; Krcmar et al., 2007).

Although gains were not as strong, children learned words in the expository context, with video representations that seemed to bolster children's word learning. But the narrative context proved to be most challenging to these young preschoolers. In this case, children learned far fewer words, supporting Fisch's contention that the processing of narrative and educational content might compete for children's attention (Fisch, 2000). Consequently, a greater proportion of working memory may be devoted to the narrative than to a focus on the words.

Together, this research further suggests that children learn words from digital sources on their own without direct adult intervention. However, some contexts that more closely mimic the participatory exchanges that one might have with an adult or more capable peer in day-to-day interactions seem more optimal for word learning. Program features that engage children in participating while viewing may serve as a type of socially contingent interaction that supports word learning.

Word class in digital media

These studies and others that have examined partial word learning from media have typically focused on children's ability to acquire object names or, in some cases, object attributes (e.g., color; Horst, 2013). For example, Horst et al. (2011) introduced only nouns when investigating incidental word learning from storybooks. Their presumption was that preschool children do not learn verbs and adjectives as well as nouns. A plethora of studies have substantiated the conclusion that nouns are more likely to be acquired incidentally than other word classes (Harris et al., 2011). However, as Roseberry et al. (2009) have noted, verbs are the architectural centerpiece of language ultimately controlling the shape of sentences. In fact, it has been hypothesized that video's ability to depict story actions dynamically and concomitantly to visually reinforce the corresponding text might make verbs more salient in the context of

a story and, therefore, more easily acquired. For example, low-income preschoolers seem to especially benefit from the multimedia additions of music and sounds for gaining knowledge of implied elements of a story and for expanding their vocabulary and syntax on a receptive measure that included nouns, adjectives, and verbs when compared with static pictures (Verhallen & Bus, 2010).

Yet, digital media do not seem to have a particular advantage for helping children learn action words. It might make more visible the actions themselves but not the specific words connected to them. Roseberry et al. (2009), for example, found that it was possible for toddlers to learn action words from video but only when supplemented by live interaction from an adult. Our studies (Neuman et al., 2021), as well as those by Oetting et al. (1995), have shown that children can learn verbs and adjectives incidentally through media supporting their understanding of the story; however, children seemed to be able to more easily pick up nouns than other word classes.

THE POTENTIAL CONSTRAINTS OF MEDIA FOR INCIDENTAL WORD LEARNING

Along with its affordances, there are clearly some constraints for word learning from digital media. Perhaps most notably is the invariant pacing of the story presentation and the density of the actions in which words are presented (Winn, 1977). Previous studies, for example, have shown that although children with language delays or lower receptive language scores are able to pick up words incidentally through video, they do so at a lower rate than those with average or above average language abilities (Neuman et al., 2019; Rice & Oetting, 1994). Conceivably, without additional supports, this could exacerbate the stark differences in vocabulary among young children from different ability groups rather than narrow it.

To examine at least some of the mechanisms for these findings, we slowed down the

pacing of episodes from a children's program (Bubble Guppies) in one of our experiments (Samudra et al., 2019). The notion was that the slower pace might help children with lower language skills benefit from additional processing time while viewing a typical program. This was an ideal study to examine how children's eye movements might vary with the slower pace. Measuring children's ability to visually orient to the novel words in our eye-tracking research, we found that slowing the pace by 150% of the standard time helped these children process the words more easily with subsequent greater gains in word learning.

We found similar effects when adding attention-directing cues to a program (Samudra et al., 2022). For example, although typical attention-directing cues in screen media were most supportive of children's word learning, those who had lower language skills still learned fewer words. In this case, we strategically placed an additional auditory sound effect (i.e., a bell ringing) before a specific target word to orient the child to the word-learning experience on screen. We also superimposed a circular border on the image to draw attention to the target word.

Both strategies seemed to enhance the efficiency of orienting children's attention to the novel words, perhaps reducing the processing demands for word learning. Yet, even with these changes, the digital medium was still challenging for those with weaker language skills. Recognizing that digital programs were never specifically designed for these specific instructional purposes, it suggests that additional supports will be needed to promote word learning.

Printed books

Printed books used in the more typical storybook reading context are widely recognized as a medium for incidental word learning. Meta-analytic reviews have reported substantial positive effects of book-sharing activities on children's expressive and receptive language (Dowdall et al., 2019; Flack et al., 2018). These studies have shown that book-reading interactions between young children and supportive adults provide language-rich experiences with multiple opportunities for word learning.

Yet, book-reading interactional routines are highly variable and not necessarily universal across cultures. There have been relatively few studies focused on children's word learning through storybook-reading sessions with no deliberate use of interactive techniques that might direct attention to the words. Understanding the mechanisms involved in incidental word learning without such supports may provide greater insight into understanding how the medium might convey the message.

A study of this type was conducted by McLeod and McDade (2011) to examine preschoolers' ability to acquire novel words without adult interaction. In this innovative study, novel words (i.e., nonsense words) were embedded in two reading conditions, one in which the target word appeared only once in a story with children hearing the same story over three different sessions, the other in which the target word appeared three times in the story, with children hearing the story in a single session. Their results indicated that children who heard the words across three sessions recalled significantly more words than those who heard the words in a single session. Children appeared to benefit from hearing words in the same contexts using the same grammatical structures and format, suggesting that the contextual supports might have aided fast mapping of the words, a finding that has been substantiated in a number of studies (e.g., Biemiller & Boote, 2006; Senechal & Cornell, 1993).

Repeated readings may help vocabulary acquisition because the context of the story is denser in printed texts with many more concepts and new vocabulary introduced than in the language of screen media. Children's storybooks are likely to include literary language and more unique words than conversational dialogue. As a result, children are likely to be exposed to more sophisticated or rarer words in storybooks (Hayes & Ahrens, 1988). In addition, the use of print in books offers the possibility for children to become acquainted

with some of the symbolic features of the print medium, and how the conventions associated with reading actually work.

At the same time, without additional conversational supports, the medium can be challenging for young children. In a recent study of 83 preschoolers (aged 3–6 years), Lenhart et al. (2017) studied word learning from book reading (e.g., without questioning or commenting) and found only modest gains in vocabulary learning (average 6%). Furthermore, in a second study with the youngest and oldest participants from the first study and using stories that were more intrinsically motivating and age-appropriate, vocabulary gains ($d = -0.08$) were negligible.

Consequently, there are affordances and constraints of various media for incidental word learning. Given these findings, it suggests that under some conditions, exposing children to different media treatments could potentially lead to stronger and more consistent learning outcomes than a single medium in isolation. This is not to suggest that more media is better; rather, it suggests that the medium's symbol system might help convey aspects of the content that could be especially helpful to children's learning.

THE CASE FOR SYNERGY

Collectively, these studies and others (Fisch, 2013) make the case for the potential of synergy, that is, cross-media connections may provide unique benefits to children's learning. A recent trial of incidental word learning among 140 preschool children in four Head Start centers lends further support to the prospect of synergy (Neuman et al., 2021). Children were on average 4.3 years old and ethnically diverse, with 59% African American, 30% Hispanic; 6% West Indian, and 5% Asian from an urban community. All children spoke English as their primary language. We explored the potential for word learning from multiple repetitions of a single medium compared with two media presentations. In the first phase of the study, we examined children's learning of target words in one of two formats, traditional printed book and video, to determine whether there were differences by medium. In the second phase, we examined the differential effects of word learning and comprehension in situations in which children were exposed to either a repeated presentation using the same medium or a different media—in this case, a story in print and a story on screen. And in our third phase, we replicated the second one using a new story context to determine whether the effects were maintained. In each case, we examined children's incidental word learning and comprehension.

We adapted two screen media stories from "Peep and the Big Wide World," two 9-min segments of a preschool science series on Public Broadcasting System. The program uses animation and cartoon characters to convey expository content. We inserted nine novel target words in scripts, three of which were nouns, three adjectives, and three verbs, all of which would be unknown to the average preschooler. We then developed comparable stories in traditional print, using the same images from the program. Individual children were randomly assigned to one of three groups: (1) listening to a printed story two times; (2) watching a digital depiction of the story two times; or (3) listening to a printed story one time and a video one time. This allowed us to understand whether children might benefit from hearing the story through a single medium (i.e., book or video) or different media (book and video). We repeated the experiment 2 weeks later using a different story.

One of our interesting findings is that children learned words incidentally from either medium (see Table 2). After two viewings or readings, preschoolers learned over four words on a receptive measure without explicit instruction. This suggests that both types of media were useful for helping children learn novel words. However, in the next phase of the experiment, we compared repeated experiences with a single medium against presentation with two media. Our results indicated that in the second phase and

Table 2. Mean proportion correct and standard deviations in the same and different stories for the receptive vocabulary assessment by condition

Outcome	Single Medium		Different Media	
	Pretest	**Posttest**[a]	**Pretest**	**Posttest**[a]
Receptive vocabulary				
Same content	0.35 (0.18)	0.43 (0.18)	0.33 (0.22)	0.52 (0.19)
Different content	0.39 (0.15)	0.50 (0.14)	0.37 (0.19)	0.51 (0.15)
Word class				
Nouns[a]	0.45 (0.30)	0.63 (0.28)	0.44 (0.31)	0.73 (0.23)
Adjectives	0.35 (0.24)	0.39 (0.21)	0.33 (0.31)	0.45 (0.23)
Verbs	0.31 (0.26)	0.34 (0.26)	0.28 (0.24)	0.36 (0.20)

[a]Pretest to posttest growth by word class, $p < .001$; gains stronger for noun category compared with other word classes, $p < .001$.

the third phase of the study, children identified more words from the two different media presentations than from the single medium presentation, and these differences remained whether these words were embedded in the same story or in a different story.

These findings suggest that both mediums' symbol systems may have provided multiple sources of information for children to learn new words, providing a more powerful intervention. Similar findings for comprehension skills have been reported by Fisch and Truglio (2001) in their studies of cross-platform learning. They proposed that the benefits might be attributed to providing multiple entry points for children to engage with educational content and the opportunity to match aspects of the content with the most appropriate medium or formal features for their delivery. They hypothesized that seeing the same characters and situations moving from one medium to another might support the transfer of learning, adding to a richer understanding and engagement with the story's characters and events.

Therefore, although the principle of synergy certainly requires further hypothesis testing, this area of research has several important implications in using media to foster word learning. First, it suggests that in contrast to comparing one medium against another, different media with their unique symbol systems might serve complementary purposes. Given that children tend to move freely

back and forth from visually oriented media (television, video games, and movies) to print-oriented media (books, board games), it appears that some combinations of materials may be complementary and have significant educational benefits for children.

But second, the principle of synergy actually goes beyond an assumption of complementarity. It assumes that the whole may be greater than the sum of its parts. Considering their distinctive features, it suggests that each medium's physical features, its structure, and its method of handling material, may *add* new dimensions to children's word learning and the means they employ to attain deeper knowledge of words. In this respect, each medium may expose children to a different set of processing tools, which in combination may contribute to children's word learning and comprehension. Because children apparently learn words from different media, it is possible that these word-learning abilities are refined through practice and enhanced through their application in another medium.

Third, studies have demonstrated the power of repeated presentations on children's word learning and story comprehension (Biemiller & Boote, 2006). Children seem able to use new vocabulary and recall story details in more elaborated forms after hearing a story multiple times. Yet, there is always the challenge of "intervention fatigue" or boredom in hearing the same text again and again. Rather, our experience suggests

that repeated experiences with stories from *different* media might be superior to multiple repetitions in the same medium. When words are presented or heard, the most likely cognitive process will be to decipher words, organize words, and integrate words with prior knowledge. But when words, pictures, and moving images are presented, for example, learners also can engage in selecting and organizing images and integrating words, pictures, and the moving images. In other words, children benefit from a "redundancy effect." Considering the distinctiveness of medium presentations, and that each is a delivery system of information, it makes sense that multiple deliveries of information may be more effective than one delivery alone. This is especially true when one delivery system is not available, perhaps because the learner is not motivated to learn from that format or does not have the opportunity. Think of the young child who is eager to be read to but does not have the benefit of a caregiver reading to her on a regular basis. Different media might provide another route. Given that word learning is so central to children's developing semantic knowledge (Pinkham et al., 2014), a different medium's capacity to provide initial information or redundant information might create a critical safety net.

Fourth, one of the benefits of media's multiple entry points is that it may reach individual children through the medium that they might find most appealing. For example, years ago Gavriel Salomon (1984) proposed a theory of amount of mental effort. In his view, certain media such as television were considered "easy" to access; others, such as reading, required more effort and often were identified as "tough." Conceivably then, entry into learning-specific topics could be enhanced through a medium that might seem easier to some children than tough. In other words, feeling more efficacious in learning a topic might avoid the cycle of low self-esteem and low achievement that often occurs when someone is struggling with reading. Conventional storybook reading relies heavily on verbal information—essentially one system only; different media offer a potentially powerful way for children to understanding things that would be very difficult to grasp from words alone.

At the same time, we want to make clear that our description of synergy differs from multimedia learning. As described by Meyer and others, multimedia learning generally refers to the presentation of materials using words, pictures, video, or other forms of representation (Mayer, 2001). Studies show, for example, that when Mayer's principles of temporal contiguity, coherence, and redundancy are in place, digital stories can positively affect children's story comprehension and vocabulary development (Mayer & Moreno, 2003). Multimedia applications, therefore, use different elements of media along certain design principles to create a new product or intervention. In contrast, the synergy principle assumes that each medium maintains its unique delivery system, providing children with multiple points of entry, repetition, and reinforcement to learn new words. In this case, children are likely to have at their disposal the sensory modalities (auditory and visual) and the formal features (e.g., cuts, zooms, pacing) that can lead to meaningful learning outcomes.

Nevertheless, a principle of synergy is not about using a greater number of media components. Rather, as Bus et al. (2015) have shown, it is more about understanding the affordances and limitations of each medium for learning. In our case, we were particularly interested in how the unique capacities of different media could produce stronger and more consistent word-learning outcomes than the use of a single medium in isolation.

Of course, we need to be mindful that the way in which any medium is used, as well as its educational potential, is based on the content and guidance from an adult—a parent, caregiver, or educator. In addition, there are skills involved in using any media. Acquiring the set of skills inherent in each medium may help orient children to its symbol systems and the processes that it uses to create meaning.

We also need to recognize that access to these multiple-platform resources may still be out of reach for many of our children. A recent Pew report (Winslow, 2019), for example, found that 44% of households with incomes below $30,000 still do not have internet capabilities. Furthermore, 40% of schools in poor areas lack broadband, with numbers even higher for those who live in rural communities. Therefore, the digital divide is still very much a barrier to providing access to multiple resources for families and their children.

In addition, our presumption about the potential for synergy must be based on the quality of the content and features of each medium. When designed well, a medium such as digital stories and ebooks may contribute to children's learning. However, programs and ebooks with distracting music, sounds, animations, and too many hotspots can potentially detract from learning (Korat & Falk, 2017; Reich et al., 2016). Moreover, there is some evidence that the overuse of any one digital device (e.g., mobile phones or tablets) might be associated with fewer interactions between parent and child (Radesky et al., 2015). Consequently, monitoring of activity to avoid excessive use is clearly needed.

With these cautions and limitations in mind, our work suggests that stories told through multiple platforms may enhance children's opportunities for word learning. Although the virtue of books has been widely acknowledged as an avenue for learning, screen media, digital stories, video, and images have only rarely been recognized. What we now know is that different types of media or cross-media platforms have the capacity to be used constructively for learning. Just as children are exposed to a steady diet of genres and levels of reality and fantasy in print stories, so too should they be exposed to stories (and, of course, other types of discourse) in a variety of media presentations. Such experiences may enrich children's understanding of words, stories, and events and are likely to motivate them to become literacy learners.

REFERENCES

Akhtar, N., & Tomasello, M. (2000). The social nature of words and word learning. In R. M. Golinkoff & K. Hirsh-Pasek (Eds.), *Becoming a word learner: A debate on lexical acquisition* (pp. 115–135). Oxford University Press.

Anderson, D., & Evans, M. (2001). Peril and potential of media for infants and toddlers. *Zero to Three*, *22*, 10–16.

Barr, R., & Nichols Linebarger, D. (Eds.). (2017). *Media exposure during infancy and early childhood*. Springer.

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

Biancarosa, G., & Griffiths, G. (2012). Technology tools to support reading in the digital age. *Future of Children*, *22*, 139–160. https://doi.org/10.1353/foc.2012.0014

Biemiller, A., & Boote, C. (2006). An effective method for building meaning vocabulary in primary grades. *Journal of Educational Psychology*, *98*(1), 44–62. https://doi.org/10.1037/0022-0663.98.1.44

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.

Clinton, V. (2019). Reading from paper compared to screens: A systematic review and meta-analysis. *Journal of Research in Reading*, *42*, 288–325. https://doi.org/10.1111/1467-9817.12269

Csibra, G., & Gergely, G. (2009). Natural pedagogy. *Trends in Cognitive Sciences*, *13*(4), 148–153. https://doi.org/10.1016/j.tics.2009.01.005

Dickinson, D., & Porche, M. (2011). Relation between language experiences in preschool classrooms and children's kindergarten and fourth-grade language and reading abilities. *Child Development*, *82*(3), 870–886. https://doi.org/10.1111/j.1467-8624.2011.01576.x

Dowdall, N., Melendez-Torres, G., Murray, L., Gardner, F., Hartford, L., & Cooper, P. (2019). Shared picture book reading interventions for child language development: A systematic review and meta-analysis. *Child Development*, *91*(2), 383–389. https://doi.org:10.1111/cdev.13225

Elley, W. (1989). Vocabulary acquisition from listening to stories. *Reading Research Quarterly*, *24*, 174–187. https://doi.org/10.2307/747863

Fisch, S. (2000). A capacity model of children's comprehension of educational content on television. *Media Psychology*, *2*(1), 63–91. https://doi.org/10.1207/

Fisch, S. (2013). Cross-platform learning: On the nature of children's learning from multiple media platforms. *New Directions for Child and Adolescent Development*, *139*, 59–70. https://doi.org/10.1002/cad.20032

Fisch, S., & Truglio, R. (Eds.). (2001). *"G" is for growing: Thirty years of research on children and Sesame Street*. Erlbaum.

Flack, Z., Field, A., & Horst, J. (2018). The effects of shared storybook reading on word learning: A meta-analysis. *Developmental Psychology*, *54*, 1334–1346. https://doi.org/10.1037/dev0000512

Furenes, M., Kucirkova, N., & Bus, A. (2021). A comparison of children's reading on paper versus screen: A meta-analysis. *Review of Educational Research*, *91*, 483–517. https://doi.org/10.3102/0034654321998074

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

Hayes, D., & Ahrens, M. (1988). Vocabulary simplification for children: A special case of 'motherese'? *Journal of Child Language*, *15*, 395–410. https://doi.org/10.1017/S0305000900012411

Horst, J. (2013). Context and repetition in word learning. *Frontiers in Psychology*, *4*, 149. https://doi.org/10.3389/fpsyg.2013.00149

Horst, J., Parson, K., & Bryan, N. (2011). Get the story straight: Contextual repetition promotes word learning from storybooks. *Frontiers in Psychology*, *2*, 17. https://doi.org/10.3389/fpsyg.2011.00017

Kaefer, T., Pinkham, A., & Neuman, S. B. (2017). Seeing and knowing: Attention to illustrations during storybook reading and narrative comprehension in 2-year-olds. *Infant and Child Development*, *26*, 1–10. https://doi.org/10.1002/jcd.2018

Karatekin, C. (2007). Eye-tracking studies of normal and atypical development. *Developmental Review*, *27*, 283–348. https://doi.org/10.1016/j.dr.22007.06.006

Kirkorian, H., Choi, K., & Pempek, T. (2016). Toddlers' word learning from contingent and noncontingent video on touch screens. *Child Development*, *87*(2), 405–413. https://doi.org/10.1111/cdev.12508

Korat, O., & Falk, Y. (2017). Ten years after: Revisiting the question of e-book quality as early language and literacy support. *Journal of Early Childhood Literacy*, *19*(2), 206–223. https://doi.org/10.1177/1468798417712105

Krcmar, M., Grela, B., & Lin, K. (2007). Can toddlers learn vocabulary from television? An experimental approach. *Media Psychology*, *10*, 41–63. https://doi.org/10.1080/15213260701300931

Lenhart, J., Lenhard, W., Vaahtoranta, E., & Suggate, S. (2017). Incidental vocabulary acquisition from listening to stories: A comparison between read-aloud and free storytelling approaches. *Educational Psychology*, *38*, 596–616. https://doi.org/10.1080/01443410.2017.1363377

Mayer, R. E. (2001). *Multimedia learning*. Cambridge University Press.

Mayer, R., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist*, *38*, 43–52. https://doi.org/10.1207/S15326985EP3801_6

McLeod, A., & McDade, H. (2011). Preschoolers' incidental learning of novel words during storybook reading. *Communication Disorders Quarterly*, *32*, 256–266. https://doi.org/10.1177/1525740109354777

McLuhan, M. (1964). *Understanding media*. Signet Books.

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

Miller, E., & Warschauer, M. (2014). Young children and e-reading research to date and questions for the future. *Learning, Media, and Technology*, *39*, 283–305. https://doi.org/10.1080/17439884.2013.867868

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

Neuman, S. B., Flynn, R., Wong, K., & Kaefer, T. (2020). Quick, incidental word learning in educational media: All contexts are not equal among low-income preschoolers. *Educational Technology Research and Development*, *68*, 2913–2937. https://doi.org/10.1007/s11423-020-09815-2

Neuman, S. B., Samudra, P., & Wong, K. (2021). Two may be better than one: Promoting incidental word learning through multiple media. *Journal of Applied Developmental Psychology*, *73*, 101252. https://doi.org/10.1016/j.appdev.2021.101252

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. In R. Barr & D. Nichols Linebarger (Eds.), *Media exposure during infancy and early childhood* (pp. 97–133). Springer.

Ninio, A., & Bruner, J. (1978). The achievement and antecedents of labelling. *Journal of Child Language*, *5*, 1–16. https://doi.org/10.1017/s0305000900001896

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. (1986). *Mental representations: A dual coding approach*. Oxford University Press.

Pinkham, A., Kaefer, T., & Neuman, S. B. (Eds.). (2012). *Knowledge development in early childhood*. Guilford.

Pinkham, A., Kaefer, T., & Neuman, S. B. (2014). Taxonomies support preschoolers' knowledge acquisition from stories. *Child Development Research*, *1*, 1–10. https://doi.org/10.1155/2014/386762

Radesky, J., Miller, A., Rosenblum, K., Appugliese, D., Kaciroti, N., & Lumeng, J. (2015). Maternal mobile device use during a structured parent-child interaction task. *Academic Pediatrics*, *15*(2), 238–244. https://doi.org/10.1016/j.acap.2014.10.001

Rayner, K (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, *124*, 372–422. https://doi.org/10.1037/0033-2909.124.3.372

Reich, S., Yau, J., & Warschauer, M. (2016). Tablet-based e-books for young children: What does the research say? *Journal of Developmental & Behavioral Pediatrics*, *37*, 7. https://doi.org/10.1097/DBP.000000000000335

Rice, M., Buhr, J., & Nemeth, M. (1990). Fast mapping word learning abilities of language delayed preschoolers. *Journal of Speech and Hearing Disorders*, *55*, 33–42. https://doi.org/10.1044/jshd.5501.33

Rice, M., & Oetting, J. (1994). Frequency of input effects on word comprehension of children with specific language impairment. *Journal of Speech & Hearing Research*, *37*, 106–122. https://doi.org/10.1044/jshr.3701.106

Rice, M., & Woodsmall, L. (1988). Lessons from television: Children's word learning when viewing. *Child Development*, *59*(2), 420–429. https://doi.org/10.2307/1130321

Richter, A., & Courage, M. (2017). Comparing electronic and paper storybooks for preschoolers: Attention, engagement and recall. *Journal of Applied Developmental Psychology*, *48*, 92–102. https://doi.org/10.1016/j.appdev.2017.01.002

Rideout, V., & Robb, M. (2020). *The Common Sense census: Media use by kids age 0-8, 2020*. Common Sense Media.

Roseberry, S., Hirsh-Pasek, K., & Golinkoff, R. (2014). Skype me! Socially contingent interactions help toddlers learning language. *Child Development*, *85*(3), 956–970. https://doi.org/10.1111/cdev.12166

Roseberry, S., Hirsh-Pasek, K., Parish-Morris, J., & Golinkoff, R. (2009). Live action: Can young children learn verbs from video? *Child Development*, *80*(5), 1360–1375. https://doi.org/0.1111/j.1467-8624.2009.01338.x

Salomon, G. (1974). Internalization of filmic schematic operations in interactions with learners aptitudes. *Journal of Educational Psychology*, *66*, 499–511. https://doi.org/10.1037/h0036753

Salomon, G. (1984). Television is "easy" and print is "tough": The differential investment of mental effort as a function of perceptions and attributions. *Journal of Educational Psychology*, 76, 647–658. https://doi.org/10.1037//0022-0663.76.4.647

Salomon, G. (1994). *Interaction of media, cognition, and learning*. Erlbaum.

Salomon, G., & Gardner, H. (1986). The computer as educator: Lessons from television research. *Educational Researcher*, *15*, 13–19. https://doi.org/10.3102/0013189X015001013

Samudra, P., Wong, K., & Neuman, S. B. (2019). Promoting low-income preschoolers' vocabulary from educational media: Does repetition and pacing support memory for learned word knowledge? *Journal of Cognitive Education and Psychology*, *18*, 160–173. https://doi.org/10.1891/1945-8959.18.2.160

Samudra, P. G., Wong, K. M., & Neuman, S. B. (2022). Can small changes matter? Reducing cognitive load in educational media supports low-income preschoolers' vocabulary learning. *Journal of Educational Psychology*, *114*(6), 1277–1291. https://doi.org/10.1037/edu0000742

Senechal, M., & Cornell, E. (1993). Vocabulary acquisition through shared reading experiences. *Reading Research Quarterly*, *28*(4), 360–374. https://doi.org/10.2307/747933

Stahl, S. (2003). How words are learned incrementally over multiple exposures. *American Educator, Spring*, *18-19*, 44.

Strouse, G., O'Doherty, K., & Troseth, G. (2013). Effective co-viewing: Preschoolers learning from video after a dialogic questioning intervention. *Developmental Psychology*, *49*, 2368–2382. https://doi.org/10.1037/a0032463

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), 1–12. https://doi.org/10.3389/fpsyg.2014.01366

Vaala, S., Linebarger, D., Fenstermacher, S., Tedone, A., Brey, E., Barr, R., Moses, A., Shwery, C., & Calvert, S. (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

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

Winn, M. (1977). *The plug-in drug*. Viking Press.

Winslow, J. (2019, July 26). *America's digital divide*. https://www.pewtrusts.org/en/trust/archive/summer-2019/americas-digital-divide