Two may be better than one: Promoting incidental word learning through multiple media

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ABSTRACT

Previous studies have often compared and contrasted differences among media presentations, including traditional storybooks and videos and their potential for incidental word learning among preschoolers. Studies have shown that children learn words from a variety of media, and that repetition is an important source for incidental learning. Yet, to date, little is known about how repeated presentations of different media, and the possible additive effect of these presentations may affect incidental word learning. Conducted over three phases, 140 preschoolers viewed or listened to two stories, repeated either with a single medium (traditional book *or* video) or two media (book *and* video) to stories. Results indicated that gains in incidental word learning were significantly stronger when children viewed two different media of comparable content compared to two exposures to a single medium. However, neither condition affected children's comprehension of the story. Findings suggest that two media presentations of comparable stories may be more effective in promoting incidental word learning than repeated presentations of a single medium.

Introduction

Children seem to learn words effortlessly in the early years. Between the ages of 1 ½ and 5, for example, preschoolers will acquire over 20,000 words, or about an average of ten new words per day (Golinkoff et al., 2000). Most of these words will be learned incidentally, without explicit instruction, in typical and frequent encounters in everyday contexts as children listen, interact, and play with oral language (Dickinson and Morse, 2019). Rice and her colleagues have coined the term 'quick incidental learning' (QUIL) (Oetting et al., 1995; Rice and Woodsmall, 1988) to reflect on children's ability to quickly pick up at least a partial meaning of a word in context without ostensive reference or prompting from an adult.

Among these everyday contexts, book-reading is considered an especially rich source of language input. Meta-analytic reviews, for example, have reported substantial effects of book-sharing activities on children's expressive and receptive language (Bus et al., 1995; Dowdall et al., 2019; Flack et al., 2018) with effect sizes ranging from $d = 0.41$–0.59. Even without adult assistance, children seem to acquire new vocabulary from book reading (Horst, 2013). In several studies, for example, Elley (1989, 1991) reported substantial vocabulary gains for

primary grade children after hearing a story read aloud, whether or not the reading was accompanied by adult explanations of word meanings. *Re*-reading the book with repeated exposures appeared to instantiate these words into memory, with sustained gains over time as measured by a delayed posttest. Consequently, these results suggest that young children can learn words incidentally on their own from having illustrated storybooks read to them.

Books in print, however, are not the only medium for incidental word learning. Studies suggest that children may also learn words incidentally through educational screen media, videos, apps, and educational programs streamed on mobile devices (van Daal et al., 2019). In a classic study by Rice (1983), children as young as 2-years old learned word meanings while viewing *Sesame Street*, drawing on television as a source of verbal routines in their play. In a later investigation by Rice and Woodsmall (1988), 3- and 5-year-old children individually viewed animated programs that introduced unfamiliar words in a story context; After two viewings, the 5-year-olds comprehended an average of five new words, the 3-year olds, 1.5 new words, a finding that was replicated in a subsequent study (Rice, 1983). Similarly, Verhallen and her colleagues in more recent research (Verhallen and Bus, 2010), compared the effects of video and static images of a digital storybook, and found

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that preschoolers learned words receptively and expressively, with the addition of video providing a special benefit for second language learners.

The possibility that educational screen media might be an independent source for learning words may have practical benefits for expanding young children's vocabulary, particularly for those who might have limited access to traditional books in print. Previous research has shown that many low-income children live in book deserts (Neuman and Moland, 2019), neighborhoods that are bereft of appropriate books for young children. Screen media, on the other hand, has become a nearly universal part of children's media landscape with a 98% penetration level in all households (Rideout, 2017). Therefore, while book reading is widely acknowledged as an avenue for expanding vocabulary (American Academy of Pediatrics, 2014), educational screen media may play a role in bolstering language for young children. Streamed on popular platforms including Netflix, Amazon, and Hulu, such educational screen media, deliberately and systematically designed to enhance children's school readiness, have been shown to have language-promoting teaching strategies which may enhance vocabulary acquisition (Vaala et al., 2010). Programs such as Super Why! (e.g. Netflix), Bubble Guppies (e.g. Amazon), and Sesame Street (e.g. Hulu), all geared to the preschool audience are among the many educational programs offered that introduce children to novel words (Danielson et al., 2019).

The potential of educational screen media to support incidental word learning

Screen media might offer several unique features to the learning of novel words. The visual representations of words, and sounds may draw children's attention to words and add new dimensions to their meaning (Bus et al., 2015). A recent study using eye-tracking technology, for example, found that certain attention-directing devices on screen (e.g. sound effects, music, zooms) affected the duration of preschoolers' focus on target vocabulary, with subsequent gains in word identification and word meaning (Neuman, Wong, Flynn & Kaefer, 2019). Paivio's dual-coding theory suggests that the visual and the verbal are distinct systems of representation, which may together create a more robust mental image (Paivio, 1986, 2008). Features like animated illustrations, background music, and sound effects, therefore, may not detract from the verbal messages, but add to the meaning of unknown words. Takacs and her colleagues in a meta-analysis of 29 studies (Takacs et al., 2014) suggest that these features can act as a scaffolding device, finding that encounters with digital stories were more beneficial than encounters with traditional story materials that did not include additional adult support.

Perhaps at its best, educational screen media through its zooms, sounds, and visual representations may create mental images of words, especially for children who might need additional supports in vocabulary development. Studies by Mayer (2001), for example, have provided convincing evidence that these features, working in close temporal proximity, can affect learning by reducing cognitive load and increasing memory of content.

Yet as a medium for word learning, screen media also has its constraints. Unlike carefully-crafted e-books or storybooks read aloud by adults, programs are often fast-paced, designed to be entertaining, with actions that may exceed children's capacity to comprehend the words and stories (Takacs et al., 2015; Winn, 1977). For example, in our previous studies, although preschoolers who were low in receptive language gained in word knowledge as a result of viewing clips from screen media, they were slower to process these words than those who were more language-proficient (Neuman et al., 2019). Examining novel word learning with slightly older children in primary grades, Oetting and colleagues (Oetting et al., 1995) reported similar results among typically developing children and those with language delays. Although all children demonstrated word-learning ability from the videotaped stories, gains were significantly less for those with delays.

This raises the possibility that each medium, print and digital, may contribute uniquely to word learning. Book-reading with its slower pace, and its static pictorial information may allow for greater auditory 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. Theoretically, these 'formal features' of the medium, according to communication scholars (Goodrich et al., 2009; Huston and Wright, 1983), may affect how a story is interpreted and comprehended in different ways. Conducting a series of experiments, for example, Meringoff and her colleagues at Project Zero (Meringoff, 1980; Meringoff et al., 1983) found that after hearing an unfamiliar story either read to them or presented as a televised film, primary-grade children in their recall focused more on story actions from the film, and on story characters from the book.

Therefore, each medium may expose children to a different set of processing tools, which in combination might contribute to incidental word learning and comprehension. In fact, several recent reviews have focused on the potential interaction among print and digital books, proposing that the unique features of each medium may provide a more comprehensive and dynamic model for examining socio-cultural and cognitive child outcomes (Courage, 2019; Kucirkova, 2019). Van Daal et al.'s recent meta-analysis of multimedia applications (2019), reflecting interventions that included the integration of text, images, and sound of 37 studies, reported an average effect size across all outcomes of 0.645, suggesting its potential to benefit preschoolers and kindergarteners' early literacy skills.

Rationale for quick incidental word learning and comprehension from different media exposures

Based on the premise that the "medium is the message," much of the literature to date, however, has been to focus on the 'medium' and its comparisons such as electronic books, tablet e-books, screen media with traditional print books (deJong and Bus, 2002; Munzer et al., 2019; O'Toole and Kannass, 2018). Recent reviews of this research (Courage, 2019; Kucirkova, 2019), comparing digital books to print books have been mixed, showing both positive and negative effects depending on the age, characteristics of the sample, and the methods, procedures, materials, and dependent measures used in the studies. For example, in a recent study comparing parent-toddler interactions with electronic versus print books, researchers found significantly fewer verbalizations with electronic books compared with print books (Munzer et al., 2019). On the other hand, O'Toole and Kannass (2018), in a study comparing print books and tablet e-books with 4-year olds, reported an overall pattern in favor of e-books over printed books on word learning.

Yet, increasingly the world in which stories are told has shifted and proliferated throughout the last two decades, with stories now increasingly crossing media boundaries on digital platforms *and* print books. Rather than a comparison of media, therefore, it might be profitable to consider the potential additive effects of two different media exposures of comparable stories on children's novel word learning and comprehension. Building on Paivio's dual coding theory (1986) and Mayer (2001), in this case, each medium would maintain its unique delivery system, allowing children 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.

Different media exposures to a comparable story could presumably take advantage of particular cues of each medium for promoting incidental word learning. In a recent content analysis of 200 educational screen media programs targeted to preschoolers, researchers found that attention-directing cues and visual images were the most prevalent approach to teaching vocabulary, with relatively few examples of explicit definition or other ostensive cues used throughout the episodes (Flynn et al., 2019). This approach differs in comparison to printed books which more often relies on direct referents, language, and contextual supports to convey its content (Beck et al., 1983). Bringing

these assets together might promote children's ability to fast map new words into their developing lexicon, and enhance comprehension.

Words learned through fast mapping and quick, incidental word learning (QUIL)

Children's partial understanding of a word's meaning on the basis of a single exposure has been explored in a number of contexts through book reading (Bus et al., 1995), playing with objects (Dickinson et al., 2019), and video (Verhallen and Bus, 2010). These studies have demonstrated that as early as 18-months and beyond, children can "fast map" in each of these contexts. Yet, as noted by Rice and Woodsmall (1988), a single exposure is a highly conservative, minimal learning situation. Rather, educational programs and printed books are likely to present key vocabulary words more frequently than a single exposure (e. g. Larson and Rahn, 2015). In a content analysis of *Word on the Street*, a Sesame Street segment, Larson and Rahn reported a wide range of repetitions of key words, from a low of 6 to 87 repetitions in a single segment (2015). Repetition of key words in printed books, as well, has been shown to support incidental word learning and their meanings (Biemiller and Boote, 2006). Therefore, previous studies of fast mapping may have under-estimated incidental learning and the potential of media to support a more robust representation of words and their meanings.

Fast mapping studies have largely focused on nouns (e.g. object names) or in some cases object attributes (e.g. color) in word learning (Horst et al., 2011). Horst and her colleagues, in her studies of incidental word learning from storybooks, for example, only introduced novel nouns, suggesting that children do not learn verbs and adjectives as well as nouns (Horst et al., 2011). Studies have also shown that children can acquire words of different classes including action and affective states from media (Oetting et al., 1995). Although it may be that some word classes are more amenable to fast mapping than others, children may be able to develop partial understanding of words more than previous fast mapping studies have assumed (Roseberry et al., 2009).

The purpose of this study

The purpose of these study was to examine the potential additive effects of two storybook presentation formats—traditional print books and video– on children's incidental word learning and comprehension. In addition, we explored whether some word classes (e.g. nouns, adjectives, verbs) might be learned through fast-mapping more than others. We tested the following hypotheses:

1) To what extent does exposure to two different media presentations of comparable story content compare with a repeated presentation of a single medium? In support of Mayer's multimedia framework, we hypothesized that children would acquire gains in word learning to a greater degree when exposed to two different media presentations than to a single medium (either video or printed book). Consistent with previous research (Huston and Wright, 1983), we proposed that the "formal features" of each medium, their unique features in conveying a story together might create an additive effect, providing a more robust understanding of novel words in comparison to a single medium presentation.
2) What are the effects of two different media presentations compared to a repeated single medium presentation on children's story comprehension? Previous studies (Meringoff et al., 1983) have suggested that story recall might be differentially influenced by the medium of presentation, with print focusing more on characters and their development, and video, more story actions. Related to our first question, therefore, we hypothesized that the viewing and reading of a story might lead to a more robust story recall of characters and action, and overall story comprehension compared to a repeated presentation in a single medium.

3) Given that there are differences in the kinds of words that children find easy to learn (Golinkoff et al., 2000), are there differences in word classes (e.g., nouns, verbs, adjectives) in fast-mapping incidental word learning among the two conditions. Studies suggest that regardless of medium, nouns are easier to learn than other word classes. Although the actions in video might support the learning of verbs more than print, we do not predict differences for condition.
4) Are the effects of condition on children's quick, incidental word learning maintained when words are embedded in a new story? We proposed that the gains in word learning will be maintained in a new story context.

Methods

Participants

A total of 140 preschoolers (M_{age} = 52.56 months, SD_{age} = 3.60 months) participated in this study; 55% were female. Children were enrolled in four Head Start centers in an urban setting. All qualified for free and reduced lunch. The sample was highly diverse: 59% were African American, 30% Hispanic, 6% West Indian, and 5% Asian. Educational directors, teachers, and parents provided consent for participation. All of the children spoke English as their primary language. IRB approval was obtained from the host institution before recruitment and data collection commenced. Prior to the start of the study, we administered the Peabody Picture Vocabulary Test-IV (PPVT-IV; (Dunn and Dunn, 2007) to examine children's receptive language. Standardized scores averaged 85.33 (SD = 14.02), approximately one standard deviation below the population mean.

Research design

Our study was conducted in three phases. Children were randomly assigned to groups in all three phases of the research. In the first phase, we examined the differences between two groups, and whether repeated exposure to words in the same medium (book or video) affected word learning (N = 35). For this analysis, we randomly selected individuals from the larger sample to participate in this phase. In the second phase, we examined differences in word learning and comprehension for two groups: those who received a repeated presentation of the story in either book-reading or video, or the comparable story in both media (N = 70). Here, once again, we randomly selected children to participate based on the larger sample. In the third phase, we engaged our full sample to examine whether our phase two findings would be replicated if words were embedded in a different story (N = 140). At each phase, children were individually pre- and post-tested on target words.

All procedures were fully counterbalanced. We counterbalanced the specific medium (book or video) used in the single medium conditions, the specific story in the same story content conditions, as well as the order of media and/or story content in the relevant conditions. The study took place over four months.

Materials and word selection

We selected two stories from the archived episodes of *Peep and the Big Wide World,* a PBS science program designed for preschoolers. The program uses simple animations to tell its stories in short episodes that include all the components of a well-formed story (e.g. settings, characters, events that include a problem, and resolution). The first story, "*I wish*," was about two feathered friends, Peep and Quack, who each had a wish. One wished to be bigger, the other wished she could fly. They try to make their wishes come true and learn that it will take time for that to happen and as a result, they should enjoy being little. The second story, "*Sounds like*," the wide-eyed Peep and his skeptical robin friend Chirp search for a quiet spot to sing a song, but pass through so many noisy places that they get lost in the process. They follow all the noises they

hear before finally finding their way home.

We modified the stories to include target words that would relate to both stories. Nine target words were selected based on several criteria: a) words could be defined as 'Tier 2″ (Beck et al., 2002), those considered to be useful across content domains; b) words likely to be unknown by preschoolers, identified as low-frequency (< 5/1,000,000 instances) based on the CHILDES data base (MacWhinney, 2000); c) words of different word classes (nouns, verbs, adjectives). Each of the target words (3 nouns; 3 adjectives; 3 verbs) were repeated 4–5 times in each story/video. Although the context for the target words in each story was different, the syntax remained the same across both stories. See Table 1 for the characteristics of the words in the book and video stories.

In the design of the study, it was essential to have enough similarity between the story's content, yet reflect the characteristics of each medium's format. In the picture book format, the story was 33 pages long and illustrated using still pictures from the video. To conform to a typical story, it included verbalizing actions, and dialogue features, such as "Quack said." While in the video, for example, an action would show Chirp bumping into Quack, in the story context, it would read, "On the way, Chirp bumped into Quack."

The video format consisted of the same story but structured the temporal and spatial dimensions of the story differently than the book. Therefore, in terms of comparability, the story was visualized with similar images in both media; what varied was the amount of verbalizing actions, connecting phrases (e.g. he said) for the story, and the visual information and resulting degree of visual and temporal continuity for the video. (Examples of the video and book versions are available in the online supplemental file.) Timing each stimulus, the book-reading took between 5.5 and 6 min each; the video, 5.5 min, again, indicating their comparability.

Measures

Peabody Picture Vocabulary Test – Fourth Edition (PPVT-IV)

We administered the Peabody Picture Vocabulary Test (PPVT) prior to the start of the study. The PPVT-IV (Dunn and Dunn, 2007) is a validated, norm-referenced assessment designed to measure children's receptive language skills. The assessment was individually administered

Table 1
Target word characteristics.

Word	Word class	CHILDES word freq (per 1,000,000 words)	Repetitions in Story 1	Repetitions in Story 2
Reflection	Noun	2	5	4
Dragonfly	Noun	1	4	4
Hummingbird	Noun	0	4	4
Hollow	Adjective	0	4	5
Clumsy	Adjective	2	4	4
Enthusiastic	Adjective	0	4	4
Discuss	Verb	0	4	4
Panting	Verb	0	4	4
Admire	Verb	0	4	4

Example of Target Words in Scripts of Two Stories.
I Wish   Sounds Like.
1 On the way, Chirp bumped into Quack. 1. They ran away from the noise, "Really, Chirp?" said quack. "You can be. panting with big breaths. so **clumsy** Suddenly, they were **clumsy** and fell.
2. But Chirp couldn't fly. She tried and   2. Ahh! I'm such a **clumsy** chick. and tried but was quite **clumsy** at it.
3. Wow! Look at that hummingbird   3. Chirp said, "Come on up, Peep! fly. Not **clumsy** at all said Quack.   Just be careful. We shouldn't be **clumsy** and fall.
4. She tried and tried, but couldn't   4. Are those the dragonflies we fly like the hummingbird. Instead   heard before?" asked Chirp. she was **clumsy** and fell.   Follow that sound! And don't be **clumsy** and fall!

as an indicator of baseline language proficiency. Reliability of the measure ranged from 0.91–0.94. Raw scores were converted to standardized scores for this analysis.

Target vocabulary

We constructed a receptive vocabulary test of target words, using a format similar to the PPVT as a pre-and posttest. The pretest included 12 items, 3 of which were nontarget words. Children were asked to point to a target word among three picture options (e.g. "Point to *clumsy*"), receiving one point for every item answered correctly. Distractors were selected to be perceptually and thematically similar to the target word. For example, for the word "hollow", the target word image was a hollow log, and the distractor images were a brown leaf and a tree stump. For the word "discuss", the target image had children talking to each other, while the distractor images were of children eating and children reading. The total score was converted to a proportion of correct responses for the pretest. Item reliability for the pretest was $\alpha = 0.60$.

For the posttest, we included the original 9-items, representing the target words from the pretest along with 9 additional items to measure the target words. Kearns and Biemiller (2010/2011) 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. The posttest was administered to each child once after their second exposure to a story. Item reliability for the posttest was $\alpha = 0.73$.

Therefore, although the internal consistency for our word knowledge measure was below desirable levels, this assessment was considered within acceptable range for researcher-development measure (Shadish et al., 2002). Gersten et al. (2005) have asserted that lower reliabilities can be considered acceptable for newly created measures and indicate that a coherent construct is being assessed.

Story comprehension

Following each viewing or reading, we assessed children's understanding of the story. Using a prompted recall technique, children were shown three pictures, one of which depicted an event from the story. Distractors included the same characters in a scene but from a different story. Children were asked to point to the correct picture from the story, for a total of 6 items. Items correct for each story were converted to percentage scores. Reliability for the comprehension posttest was $\alpha = 0.87$.

Following this assessment, we also asked children to verbally recall what they remembered about the story, with the prompt, "Can you tell me what happened in the story?" Research by Meringoff and her colleagues at Project Zero (Meringoff, 1980; Meringoff et al., 1983) had proposed that children were likely to recall more story information about the characters from books, and more story actions from video. Consequently, we coded two kinds of content for medium differences: actions, and characters from these brief transcripts. An action was defined as an independent clause containing an active verb. Characters and their behaviors were defined by their use of names or nouns referring to them and character traits. To test for reliability, an independent research assistant scored 20% of the transcripts blind to condition. An average of 90% agreement was achieved across the items between the researcher and the author's scores.

Procedure

Testing and the treatment sessions took place in a quiet location not used for other purposes at their preschool. Two trained graduate students conducted all sessions. Children first completed the target vocabulary pretest and PPVT-IV. They were then randomly assigned to a condition. Approximately 3 to 6 days after the pretest, the research assistant invited individual children to read a book or listen to a video.

Based on the condition, the participant read or viewed the story with

a research assistant. For book reading, the assistant was trained to read the book in a lively, animated manner that would be engaging for children. Individual comments by the child were acknowledged, with instructions to the assistant to quickly move on. For the video condition, the session began with the instruction, "On the computer, you are about to watch a short story." Although the research assistant sat close by, there was little to no interaction. Children rarely made verbal comments or asked questions in either condition.

Following the first session, the assessor administered the brief story comprehension measure, and then returned the child back to the classroom. After approximately one hour, the second session occurred, viewing or reading the story, depending on the assigned random condition. After the second session, the assessor administered the vocabulary posttest. Each individual session took approximately 12 min; 5.5–6 min either reading or viewing, followed by a comprehension posttest.

Results

Phase 1: differences in incidental word learning by medium

In our first analysis, we examined children's word learning from either the book or video presentation. This analysis was conducted to determine whether there were differences in incidental word learning by medium. Based on the condition, each story had been presented in the same format two times (e.g. book-book; video-video) about an hour apart.

Preliminary analysis of the PPVT, age, and the vocabulary pretest indicated no significant differences between groups (book, video) on the PPVT scores, $t(33) = -0.29$, $p = .774$, age, $t(33) = 0.51$, $p = .615$, or pretest scores $t(33) = 0.64$, $p = .527$. Next, we conducted a repeated-measures analysis of covariance (ANCOVA) with the within-subjects' factor of pre/posttest, and the between-subjects factor of medium and the covariate of mean-centered PPVT standard score. As shown in Table 2, children learned words through educational media, whether it was in a book or video form. Both groups showed significant gains in vocabulary from pre- to post-test, $F(1,32) = 4.46$, $p = .043$. However, there were no significant differences in learning between book and video formats, $F(1, 32) = 0.18$, $p = .674$. Gains were unrelated to PPVT, $F(1,32) = 0.06$, $p = .810$.

The rate of incidental word learning was constant across both groups of children.

These results indicate that children made gains in word knowledge from both media. Although listening to stories is known to support children's language development, it suggests that educational screen media might represent another avenue for word learning.

Phase 2: two media compared to one

Our next analysis was to examine the potential additive effect of video and print, comparing the effects of listening or viewing a story with a condition that included both media presentations. Given our

previous findings, we combined the single medium groups (e.g. book-book; video; video) which had showed no differences in word gains, with a group that viewed and listened with both media, in a counterbalanced order to the story. No differences were observed by book or video in the same medium condition on pretest scores, $t(33) = -0.64$, $p = .527$, post-test scores, $t(33) = -1.16$, $p = .254$, or pre- to post-test growth scores, $t(33) = -0.43$, $p = .669$. This suggests that we could justify combining the two groups into a single medium condition. Whether through a single medium or two media, both groups heard and viewed the story twice.

We conducted a repeated measures ANCOVA on the dependent variable of receptive vocabulary with the within-subjects factor of test (pretest; posttest), the between-subjects factors of media presentation (single medium; two media), and the covariate of mean-centered PPVT.

Means and standard deviations are shown in Table 2. Results of our analysis indicated that children's vocabulary grew significantly from pre- to posttest in both conditions, $F(1,67) = 27.20$, $p < .001$, confirming once again the effects of media presentations on incidental word learning. Yet at the same time, our between-subjects analysis of one versus two media indicated significant differences between groups: Those children who were exposed to two media outperformed the single medium group in their growth from pretest to posttest, $F(1,67) = 4.91$, $p = .030$, with a substantial effect size of $d = 1.12$. These results suggest that two different media presentations of the same story seemed to better support word learning than a repetition of the story through the same medium. Once again, gains did not interact with initial PPVT scores, $F(1,67) = 0.61$, $p = .437$.

Neither repetition nor media condition, however, appeared to affect children's comprehension of the story. Conducting a repeated measures ANCOVA with the within-subjects factor of test (after the first or second exposure), the between-subjects factor of condition (one medium or two media), and the covariate of PPVT, there were no significant differences between groups, $F(1, 67) = 0.14$, $p = .709$, or between the first and second exposures, $F(1, 67) = 0.31$, $p = .578$. As shown in Table 3, there was even a slight decline in comprehension for the single medium condition, from the first to the second exposure to the story. Although scores rose for the different media condition after the second exposure, the interaction between media condition and test was not substantial enough to reach significance, $F(1, 67) = 1.60$, $p = .210$. There was an overall main effect of children's PPVT score on comprehension, $F(1, 67) = 16.68$, $p < .001$, such that children with stronger PPVT scores demonstrated greater comprehension of the story events.

Furthermore, children's recall did not show evidence of a media effect. Analyzing children's recall of story actions and characters, we conducted a repeated measures ANCOVA on their recall after their second exposure, including the within-subjects factor of recall focus (character, action), the between-subjects factor of condition, and the covariates of mean-centered PPVT, mean-centered first exposure character and action recall. As shown in Table 3, regardless of condition, children recalled more actions than characters or character traits, $F(1,63) = 46.44$, $p < .001$. Children's first recall of events predicted their second recall particularly for actions, $F(1, 63) = 12.80$, $p < .001$.

Table 2
Means (SDs) of Pre- and Posttest Vocabulary by Condition.

Group+	N	Pretest	Posttest	Cohen's d
Repeated presentation				
Book-reading only	18	0.33 (0.14)	0.39 (0.15)	
Video-viewing only	17	0.37 (0.21)	0.46 (0.20)	
				d = 0.22
Repeated presentation				
Single medium+		0.35 (18)*	0.43 (0.15)*	
Different media		0.33 (0.22)*	0.52 (0.14)*	
				d = 1.12

Note 1. + Single medium (either two repetitions of book or video); different media (book + video).
Note 2. * $p < .02$, difference between conditions.

Table 3
Means and (SDs) of Story Comprehension by Condition

Condition	Single Medium+	Different Media
Story comprehension		
First. presentation	0.68 (0.30)	0.65 (0.37)
Second presentation	0.66 (0.39)	0.71 (0.37)
Story recall		
Focus on action*	2.43 (1.77)	2.39 (1.82)
Focus on character*	0.91 (1.17)	1.12 (1.24)

Note +. Single medium (either repeated presentations of book or video); different media (book + video).
Note. * $p < .001$.

Children's PPVT scores also significantly predicted their recall, $F (1,63) = 4.12$, $p = .047$. However, there were no significant effects of condition, $F (1,63) = 0.56$, $p = .456$ in story recall.

Together, these findings from phase 2 indicated that exposure to two media rather than a single medium significantly improved children's incidental word learning. Yet, neither the story repetition nor the media condition appeared to affect children's comprehension of the story, or their recall of actions and characters.

Phase 3. effects of media on different content

Given the findings in phase 2, our final analysis was to examine whether the effects of condition on incidental word learning might transfer to a different story. In this case, target words were embedded in the second story (e.g. "*Sounds like..*") in a 2×2 design, with children randomly assigned to one of four groups (e.g. same content; one medium; different content; one medium; same content, two media; different content, two media) ($N = 140$). In addition, with this larger sample, it was possible to examine which word classes were likely to be learned in these conditions.

Pretest scores indicated no significant differences prior to treatment across the four groups. We conducted a repeated measures ANCOVA with the within-subjects' factors of test (pretest; posttest) and word class (nouns, adjectives, verbs), the between-subjects factors condition (single medium; different media) and content (same content; new content), with the covariate of mean-centered PPVT.

Results of this analysis indicated that children in all groups learned words from the media. Regardless of condition, gain scores from pretest to posttest, overall, were significant, $F (1, 135) = 54.92$, $p < .001$. Furthermore, there is evidence that word learning was, to some extent, context-independent. Children seemed to learn the target words whether they were presented in the same story or in a different story $F (1, 135) = 0.07$, $p = .799$.

Yet once again, similar to phase 2, children made stronger gains when words were presented in two media compared to a single medium, $F (1, 135) = 4.69$, $p = .032$. These differences reported in Table 4, were evident if children heard the same story or a different story.

In short, these results replicated our phase 2 findings: children learned words incidentally from two comparable media presentations more than a single medium, and these differences remained whether these words were embedded in the same story or in a different story.

We next determined whether these findings were specific to a particular word class. Conducting a MANOVA we found a significant difference in pretest to posttest growth by word class, $F (1, 135) = 23.05$, $p < .001$. Paired *t*-test analyses revealed that children significantly improved their performance in all three word classes: nouns, $t (139) = 8.24$, $p < .001$; adjectives, $t (139) = 3.38$, $p < .001$, and verbs $t (139) = 2.42$, $p = .017$ (see Table 4). However, as predicted, gains were much stronger for the noun category compared to adjectives, $t (139) = 4.05$, $p < .001$ and verbs $t (139) = 4.75$, $p < .001$. There were no differences

between adjectives and verbs, $t (139) = 1.00$, $p = .319$. Finally, much like before, PPVT predicted stronger target word vocabulary in general, $F (1, 135) = 38.96$, $p < .001$, but improvement from pre to post-test was similar regardless of PPVT, $F (1, 135) = 2.16$, $p = .144$. No other interactions were significant in the model.

Discussion

This study was designed to examine the effects of two medium presentations of comparable stories, print and video, on children's incidental word learning and story understanding. It builds on the substantial research indicating the benefits of listening to stories for expanding vocabulary (Mol et al., 2009), and the more recent research indicating that educational screen media can represent an important opportunity for incidental word learning (Hirsh-Pasek et al., 2015; Neuman et al., 2019).

To date, most of the studies have examined the potential impact of media exposure on word learning and comprehension by comparing one medium's advantages with another (Courage, 2019; Kucirkova, 2019). Nevertheless, in everyday contexts children are likely to make cross-media connections, engaging in listening to stories and viewing programs (Takeuchi et al., 2019). Increasingly popular companies are likely to capitalize on this tendency, making versions of the same stories in both book and video formats (e.g. Disney). Traditionally these multiple contexts for learning words have been examined independently with little attention to learning across boundaries. In contrast, this research was designed to examine the potential additive effects of two *different* media exposures, hypothesizing that multiple exposures to different media may promote greater word learning and comprehension.

Our results indicated that two different media presentations of comparable stories were more effective in promoting word learning than repeated presentations of a single medium. These findings are consistent with the multimedia learning framework (Mayer, 2005), and Paivio's dual coding theory. It argues that incoming information processed using both visual and auditory channels may be learned and retained more effectively than through a single medium. Words and dynamic images may enhance children's ability to process novel words, and their meanings.

At the same time, our findings may both complement and extend these previous studies by understanding the inherent attributes of each medium. A number of communication scholars (Goodrich et al., 2009) have argued that content is conveyed differently in various media using different symbol systems that may influence cognition and learning. Symbol systems are codes, conventions, and formats that are often used by media. For example, video has the capacity to zoom closely to an object, focusing children's attention to certain objects, circling an object to convey perspective-taking. Classic studies by Salomon (1974) and Huston and Wright (1983) have shown that various formal features of video (e.g. edits and cuts) can affect children's comprehension of a story. Illustrated storybooks, as well, use symbol systems to deliver narrative content, but primarily through verbal language and static images. Unlike screen media, movement in a storybook must be implied by the position of characters and objects in a story frame. Verhallen et al. (2006), found that the multimedia features of video, sounds, music with oral text seemed to function additively in children's understanding of stories compared to static pictures from an illustrated storybook.

Conceivably, different media with their unique symbol systems might contribute to children's learning, giving them more resources to draw from in acquiring new words. Therefore, future research might consider the affordances of a particular medium and what it can provide for learning. For example, with its ability to depict story actions dynamically and concomitantly, digital media may make more salient the behavioral features of a character. In the same vein, it could be that the dialogue between characters in the print medium lend itself to a greater focus on story language. Together, these media might enhance memory traces that connect children's language and story

Table 4.
Means and (SDs) in the same and different stories for receptive vocabulary by condition.

Outcome	Single medium		Different media	
	Pretest*	Posttest*	Pretest*	Posttest*
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	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)

comprehension.

Multiple exposures to target words

Repeated encounters with words are known to support incidental world learning. Therefore, unlike the single exposure to a word in previous fast-mapping studies, in this study we chose to examine children's incidental word learning when were repeated 4 or 5 times within a story for a total of 8 to 10 repetitions after two presentations. Our results indicated that children who were exposed to two different media learned significantly more words than those who received only a repeated presentation from a single medium. Given that the amount of exposure and number of repetitions of words were consistent across conditions, these results seemed to further support the possible additive effect of two different media exposures compared to one.

These results stand in contrast to research by Horst and her colleagues (Horst et al., 2011) In their study, preschoolers were either exposed to repeated readings of the same storybook or different books that included the same target words. Those who heard the same story repeatedly recalled more words than the comparison group. Horst and her colleagues have suggested that the contextual repetition, the repeated readings of the same storybook texts and illustrations, helped the children develop a more robust representation of a new word. By keeping words in the same context, they suggested, children could attend better to the target words and away from other aspects of the story.

However, our research suggests otherwise. Children who were exposed to the words in the same medium-based contextual support did not perform as well as those who viewed and listened through two media. In addition, when these words were embedded in a new story, children in the two media condition still significantly outperformed those who listened or viewed in the same context. These contrasting finding could be due to the sample and the age differences in our studies, Horst et al.'s research involving a sample of 16 3-year olds, and ours, with a much larger sample of 140 4-year olds. Slightly older children might develop a more flexible understanding of the target words with two different media than within a single medium. Obviously, more research is clearly need to elucidate these findings.

Fast-mapping variations by word classes

The general pattern of particular word class results follows previous research on incidental word learning (Golinkoff et al., 2000). Although children learned verbs and adjectives, gains were greatest for words that entailed object properties. This finding suggests that an object label is definitely an advantage in children's quick, incidental word learning. These findings are consistent with previous research indicating that nouns are generally easier to learn than adjectives or action words (Horst, 2013).

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 (McDonough et al., 2011; Paivio, 1986), the ease with which a concept may evoke a mental image. These results, therefore, are consistent with previous research, suggesting that nouns are likely to be learned more easily than other word classes.

Limitations and future directions

There are a number of important limitations that need to be addressed in this research. Our approach to examining two media presentations in this study was to develop comparable materials in printed stories and video versions. It did not represent different scripts or unique treatments or interpretations of a similar story that might be found in the marketplace. Relatedly, our two media treatments included the same vocabulary. It is unlikely that a screen adaptation of a popular children's story and a traditional book would so perfectly align. In addition, our materials were based on a well-designed educational program for preschoolers, and may not represent the general content of what children might likely view on screen media. And finally, our research took place in the schools, with both book-reading and viewing conducted in a manner that is most likely not representative of home viewing/listening to stories where frequent comments or interruptions from other family members may occur.

In examining children's incidental word learning, we concentrated on receptive language gains with researcher-developed measures. In the future, it would be beneficial to include more comprehensive measures with higher reliability than in this research (Barr et al., 2020). Using additional measures might enhance our understanding of the incremental nature of word learning (Stahl and Nagy, 2006). Fast-mapping, for example, may represent only a partial understanding of a word. Developing measures that focus on a deeper understanding of a word's meaning might be a useful next step.

Taking these limitations into account, this study suggests that two media presentations of comparable stories may be more effective in promoting incidental word learning that repeated presentations of a single medium. This research may have important practical implications. Today, the media in which stories are communicated have shifted dramatically, with quality educational programing burgeoning on digital formats in recent years. The same storylines now routinely cross media boundaries, with children's initial exposure to stories as likely to come from the screen as it is from the book. It is time to take advantage of the multiple representations of stories, and the potential added benefit they may produce for children's incidental word learning.

Author note

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Author statement

Informed consent was obtained for the experimentation of human subjects. All authors contributed equally to the formulation of the study, methodology, data analysis, results and writing of the manuscript.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appdev.2021.101252.

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