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THE EFFECTS OF MULTIMEDIA E-BOOK
USE ON VOCABULARY ACQUISITION FOR
CHILDREN WITH LANGUAGE IMPAIRMENTS

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Structured Abstract

Clinical Question: Do kindergarteners with language impairments who use e-books containing interactive features, compared to e-books with static illustrations, exhibit greater vocabulary gains?

Method: Systematic Review

Study Sources: ASHA journals, EBSCO, Educational Resource Information Clearinghouse (ERIC), SpeechBite, Web of Science

Search Terms: The following terms were used individually and in several different combinations: language impairment, language disorder, language difficulty, e-book, ebook, electronic book, electronic storybook, enhanced e-book, touchscreen, hotspots, vocabulary

Number of Included Studies: 1 article (reporting two experimental studies)

Primary Results: E-book reading provides a context conducive for vocabulary development for children diagnosed with severe language impairments. Basic e-books with auto-narration and static illustrations appear more advantageous for vocabulary development compared to enhanced e-books embedded with multimedia features. The severity of the language impairment is a key consideration when selecting e-books. Children with mild language impairments demonstrate gains in vocabulary skills regardless of the type of e-book used. However, as the severity of the language impairment increases, the presence of background music or sound effects negatively impacts vocabulary acquisition.

Conclusions: A corpus of research investigates the relationship between e-book usage and the development of language and literacy skills in typically developing children. However, few empirical studies are available extending this line of research to children diagnosed with language impairments. Because of this lack of guidance, speech-language pathologists (SLPs) need to be cautious when selecting and using e-books. Until further research becomes available, SLPs should be mindful of the potential impact multimedia features and interactive hotspots have on vocabulary acquisition in children with language impairments.

The Effects of Multimedia E-Book Use on Vocabulary Acquisition for Children With Language Impairments

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Clinical Scenario

Jane is a school-based speech-language pathologist (SLP) with seven years of experience. A few years ago, her school district provided SLPs with touchscreen tablets to support using communicative and educational apps during speech therapy. Jane found that she frequently utilized her tablet with the majority of her students. Anecdotally, Jane's students often requested to use her tablet in therapy, and those who used tablet-based activities exhibited longer periods of sustained attention throughout the session. Jane's therapy data suggested that her students learned more words and talked more frequently during tablet-based activities compared to traditional therapy activities.

A significant portion of Jane's caseload consists of students diagnosed with language impairments. Jane recently began treating Emma, a kindergartener, with a severe receptive/expressive language impairment. Emma attended a special-education classroom where Jane provided group-based speech therapy addressing Emma's language goals, particularly receptive and expressive vocabulary skills. Jane designed therapy sessions around a storybook, providing a context to introduce and learn new vocabulary words that were embedded within the story. Afterward, Jane facilitated hands-on group activities designed to deepen student understanding and use of story vocabulary. The same story was read both days; however, the first day the group read the story using a traditional, print-based book and the second day the group used an electronic storybook (i.e., e-book) on Jane's tablet.

By integrating both story formats into her weekly group, Jane thought she was striking an appropriate balance between several contributory clinical factors. Jane had learned in graduate school that a large body of research supports shared book reading in promoting vocabulary and language development for both typically developing children and those with language impairments. Because this body of research encompassed using a traditional book with an adult facilitating high-quality communicative interactions, she ensured that both components were present in her treatment plan. Jane couldn't ignore the fact that a majority of her students were increasingly engaged during technology-based activities which resulted in a higher number of practice opportunities and a reduction in off-task behavior. Based on her clinical experience, Jane felt that some e-book features also added therapeutic value for her students. She suspected user-activated picture animation and sound effects within e-books provided cues to help Emma and other students learn unfamiliar vocabulary. For example, "fluttering" was illustrated by a butterfly fluttering around the page and "swooshing" was demonstrated by the sound of wind rustling through trees. Visually highlighted text within the story provided print referencing models for literacy development and characters modeled comments about the story for students. Finally, by using tablet-based e-books, Jane had an opportunity to show classroom special-education staff how to facilitate language-rich communication opportunities using district-provided technology.

Although technology use within the educational environment appears commonplace, Jane felt her lack of familiarity with the research might negatively impact the high-quality clinical care she strives to provide her students. She decided it was time to investigate the efficacy of using e-books with Emma and other students diagnosed with language impairments.

Background Information

Jane's experience illustrates the growing popularity and rapid infusion of technology in educational settings. Surveys suggest that roughly 73% of parents, general- and special-education teachers, and SLPs use e-books, tablets, and other forms of technology with children for educational purposes (Fernandes, 2011; Takeuchi & Vaala, 2014; Vaala & Takeuchi, 2012). The development of tablet-based e-books allows readers to explore stories that come to life with the touch of a finger. Although children are more attentive to e-books containing multimedia features, early research suggests some inherent risks. Compared to traditional toys and books, a decrease in the quality and quantity of

parent-child communication is evident in interactions involving electronic toys and videos (Nathanson & Rasmussen, 2011; Sosa, 2016; Wooldridge & Shapka, 2012; Zosh et al., 2015). Furthermore, conversational interactions focused more on how to use the device rather than on the content of the story (Chiong, Ree, Takeuchi, & Erickson, 2012; Richter & Courage, 2017; Strouse & Ganea, 2017). Notably, all of these studies involved typically developing children and their parents; such findings have not been investigated in educational settings with SLPs and children with diagnosed communication impairments. It remains unknown whether educators with increased awareness of these risks can strategically apply communication techniques during technology use needed to counteract the effects of reduced communicative interactions.

Deconstructing the composition of e-books may help Jane understand the ways readers interact with story content. E-books are comprised of two important components: 1) the content or story, illustrated using multiple forms of media (e.g., text, video, visual illustration, sound, etc.) and 2) the digital platform or device that delivers the story (e.g., computers, tablets, smartphones, etc.). A broad range of multimedia features and platforms are available that affect the way each reader accesses and interacts with an individual story (Shore, 2008). For example, a reader who actively customizes a story delivered through a touchscreen tablet interacts with the story content differently than a reader who passively watches a video e-book presented via television. Roskos, Burstein, Shang, and Gray (2014) suggest that specific user behaviors (e.g., looking, touching, gesturing, etc.) associated with e-book reading vary significantly according to the type of device used. In other words, readers interact with e-books differently depending on the type of device. As a result, it is possible that findings from a study using one type of device may inform but may not be fully generalizable to another type of device.

E-books are categorized along a continuum of complexity, ranging from basic to enhanced e-books. Basic, or static, e-books are characterized as digitized versions of traditional books whereas enhanced e-books contain multimedia features embedded within the story (Chiong et al., 2012). Among the most popular children's literary apps and e-books, the most prevalent features include story narration (95%), hotspots (75%), music/sound effects (60%), text highlighting (50%), and picture animation (50%; Guernsey, Levine, Chiong, and Severns, 2012). Interactive hotspots are defined as user-activated touch points within the e-book that immediately provide visual and/or auditory features, such as picture animations, sound effects, dictionaries, or games (Piotrowski & Krcmar, 2017; Smeets & Bus, 2014; Vaala, Ly, & Levine, 2015).

Recent research explores the relevance of multimedia features, which may or may not be directly related to story content (Smeets & Bus, 2014; Vaala et al., 2015). Findings suggest that e-books containing audio and visual features not directly related to the story are associated with reduced rates of comprehension (Chiong et al., 2012; Reich, Yau, & Warschauer, 2016). Although a large body of research focuses on story comprehension, a meta-analysis by Takacs, Swart, and Bus (2015) examined vocabulary gains. Their findings suggest that for typically developing children, using enhanced e-books does not significantly improve receptive vocabulary but is associated with improved expressive vocabulary skills. A review of the literature helped Jane develop her clinical question.

Clinical Question

Jane utilized a framework of evidence-based practice (EBP) to investigate the efficacy of using e-books in clinical practice. Evidence-based practice is "the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients" (Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996, p. 71). The EBP framework consists of three fundamental tenets: a systematic review of relevant research, a professional's clinical expertise, and respectful consideration of the patient's needs and goals (Sackett et al., 1996).

To begin, the SLP develops a clinical question central to the entire EBP process. Jane constructed her clinical question using the PICO framework to identify each of the following required elements: (P) population, (I) intervention, (C) contrasting or comparison treatment, and (O) the dependent outcome (Sackett, Straus, Richardson, Rosenberg, & Haynes, 2000). She formulated the following clinical question: Do kindergarteners with language impairments (P) who use e-books containing interactive features (I), compared to e-books with static illustrations (C), exhibit greater vocabulary gains (O)?

Search for the Evidence

In order to locate information that specifically addressed her clinical question, Jane developed well-defined search terms and inclusionary guidelines. She used combinations of the following search terms to systematically locate relevant information: language impairment, language disorder, language difficulty, e-book, ebook, electronic book, electronic storybook, enhanced e-book, touchscreen, hotspots, and vocabulary. Jane searched ASHA journals, EBSCO, Educational Resource Information Clearinghouse (ERIC), SpeechBite, and Web of Science for articles specific to her PICO question. Inclusion criteria included:

(a) published in peer-reviewed journals;

(b) used an experimental or quasi-experimental research design;

(c) participants were diagnosed with a language impairment absent of comorbid diagnoses;

(d) included receptive and/or expressive vocabulary as a dependent variable;

(e) children's stories were presented using e-books, containing multimedia features and/or interactive hotspots, including picture animation and/or sound;

(f) a comparison condition was present using traditional print-based or static e-books;

(g) participants were five years old (i.e., kindergarten students in the U.S.); and

(h) participants accessed e-books independently or with minimal adult support.

Jane excluded articles published before 2007, the year when the first-generation smartphone was released, providing a catalyst for the rapid development of touchscreen-activated e-books. Studies examining second language acquisition were also excluded.

Jane evaluated the title and abstract of the articles identified within each database search. (See Figure 1.) She identified 19 articles that met some, but not all, of her inclusion criteria. Next, Jane performed an ancestral search by reviewing each article's references and identified two additional articles. Of the 21 articles Jane identified for full-text analysis, only one article (reporting two independent, empirical studies) examined the relationship between e-book use and vocabulary skills in children diagnosed with language impairments. Jane did not anticipate locating only

one article that met her inclusionary criteria. She relaxed her criteria for participant age and type of book; however, the fact remained that there was only one article that investigated the influence of e-book format on vocabulary acquisition for children with language impairments.

Evaluating the Evidence

To critically evaluate the evidence's validity and importance, Jane utilized the Critical Appraisal of Treatment Evidence (CATE) framework originally outlined by Sackett, Straus, Richardson, Rosenberg, and Haynes (2000). According to Dollaghan (2007), evidence rated as *compelling* is considered indisputable, leaving only minute concerns for unbiased evaluators. Research deemed *suggestive* acknowledges that although debate may surround a few points, the same conclusions would likely be reached across reviewers. Finally, evidence rated *equivocal* raises serious points of contention resulting in the likelihood that evaluators will reach separate conclusions.

The article identified in Jane's search by Smeets, van Dijken, and Bus (2014) investigated the influence of static and animated video e-book formats on expressive vocabulary acquisition. (See Table 1.) Participants included Dutch kindergarteners diagnosed with severe language impairments. Intervention materials consisted of two e-book formats (static and animated video e-books, with variations in audio and visual effects).

In Experiment 1, Smeets et al. (2014) used a pretest/posttest within-subject design to determine if participants demonstrated vocabulary gains through independent e-book reading. Twenty-nine participants independently read four different e-book stories, four times each (e.g., two static e-books and two animated video e-books). The static e-book consisted of static illustrations and oral narration, and the animated video e-book consisted of motion picture animation, zoom effects, background noise, and sound effects. Researchers counterbalanced the order in which participants read each of the e-books. A criterion-referenced pretest/posttest measure assessed changes in expressive vocabulary skills using 28 vocabulary words embedded in the storybooks (i.e., experimental condition) and 14 additional vocabulary words not featured in any of the e-books (i.e., control condition). Findings suggested that all participants learned new vocabulary words, regardless of the e-book format. However, static e-books appeared more advantageous because participants

demonstrated increased vocabulary gains. In an attempt to further explain this finding, Smeets et al. (2014) initiated a follow-up study.

In Experiment 2, Smeets et al. (2014) used the same within-subject design to investigate the impact multimedia features embedded within e-books, such as audio and visual effects, had on vocabulary development in children with language impairments. Researchers used the Clinical Evaluation of Language Fundamentals®, fourth edition, Netherlands (CELF®–4-NL; Kort, Schittekatte, & Compaan, 2008) to measure each student's overall language in an effort to determine if language performance served as a moderator for vocabulary acquisition. Twenty-three kindergarteners independently read two stories in each of the four e-book formats (e.g., two static e-book versions containing static illustrations and auto-narration, with and without background music/sound effects; and two animated video e-book versions with motion picture animation and zoom effects, with and without background music/sound effects). Again, researchers assessed expressive vocabulary featured within the stories. Findings indicated that participants with stronger language skills learned more vocabulary words, regardless of the e-book format. Furthermore, for children with more significant language impairments, the presence of background music/sound effects in either e-book format interfered with vocabulary acquisition.

Before applying these findings to her clinical practice, it was important to critically appraise the research. Using a within-subject or repeated-measures design allowed researchers to measure changes in participants over time using pretest/posttest assessments (Gravetter & Wallnau, 2013). Because the same individuals participated in every condition, the research design reduced or eliminated treatment effects caused by individual differences. Jane considered the role of subjectivity and bias in the research. Researchers used a Latin square design to counterbalance the order in which participants read e-books, an important tool used to address possible time-related factors associated with within-subject designs (Gravetter & Wallnau, 2013). Jane concluded that the quality of the research design may be improved upon by using blinded posttest assessors unfamiliar with the study's research aims. Although significant, these findings must be considered with caution because they have not been duplicated by independent researchers.

Next, Jane examined the effects of each study's findings. Regardless of the study's sample size, effect size provides a measurement conveying the magnitude of the treatment effect (Gravetter & Wallnau, 2013). Smeets et al. (2014) reported medium-to-large effect sizes. Jane was encouraged by the effect sizes reported; however, she expressed concern that the researchers did not provide confidence intervals. Using confidence intervals would have helped Jane understand the degree to which participants benefitted from the intervention conditions (Gravetter & Wallnau, 2013).

Jane concluded that there is a substantial cost-benefit advantage. Jane already owns a diverse collection of basic and enhanced e-books with varying degrees of audio and/or visual effects; most of her collection is enhanced e-books. Because findings indicate that the presence of background music and sound effects significantly reduce vocabulary acquisition, Jane realized that she could modify some of her enhanced e-books by manually lowering or muting the volume via the device. Furthermore, any future purchases to expand her collection of basic e-books would be of nominal cost.

The Evidence-Based Decision

Using the CATE framework, Jane weighed the importance of each of the above considerations and concluded that each of the two experimental studies warranted a rating of suggestive to compelling. Although Jane was concerned about a few points, the same conclusions would likely be reached across multiple researchers and would encourage her to consider the clinical implications these findings would have in her own practice (Dollaghan, 2007).

Jane had not anticipated that her search for evidence would produce only one article. Although EBP provides a framework to guide clinical practice, it is not without unanticipated results. Such results provide value to the field because they uncover gaps in the literature and shape the development of future lines of research (Schlosser, 2006). However, at this point in time, Jane's main concern is the direction she will take in her own clinical practice.

Although research specific to Jane's PICO question is only beginning to emerge, Smeets et al. (2014) provides her some measure of clinical guidance. The finding that children with severe language impairments demonstrated vocabulary gains, regardless of the e-book format, is promising. Because e-books are used within a broader intervention program, Jane decides that using e-books in her clinical practice is warranted. To make efficacious treatment decisions, Jane decides that she must consider more than the vocabulary and content of individual e-books. When

making e-book selections, she needs to consider the severity of each child's language impairment, the type of e-book, and the inclusion of audio and visual features embedded in the story. Given Jane's goal of supporting efficacious technology use in the classroom, she decides to share this information with the special-education staff. Finally, and perhaps most importantly, Jane makes a commitment to continue her search for evidence on this subject. She decides to begin by researching the efficacy of using e-books with other populations on her caseload (e.g., autism spectrum disorders, hearing impairment, etc.) and other intervention goals (e.g., story comprehension, phonological awareness, social skills, etc.).

Authors' Note

Willow Sauermilch, MA, CCC-SLP, holds master's degrees in both mass communications and communication sciences and disorders. She is currently a doctoral student in the College of Media and Communication at Texas Tech University. Her research interests involve investigating communicative interactions between adults and children when technology is present in the environment.

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Table 1. Summary of Included Studies

	Smeets, van Dijken, & Bus (2014) (Experiment 1)	Smeets, van Dijken, & Bus (2014) (Experiment 2)
Study design	Within-subject repeated measures using 3 conditions (2 experimental and 1 control condition); Randomized using a Latin square design	Within-subject repeated measures using 4 experimental conditions; Randomized using a Latin square design
Research aim	(a) Examine the extent children with severe language impairments learn new words during independent e-book use. (b) Determine which type of e-book is associated with increased vocabulary skills: static or animated video e-book.	(a) Examine the influence of multimedia features (motion picture animation, background music/sound effects) on vocabulary learning for children with severe language impairments. (b) Determine if phonological working memory and language skills moderate vocabulary learning using e-books.
Participants	29 Dutch kindergarteners diagnosed with severe language impairment Ages 60–80 months ($M = 69.34$, $SD = 5.92$) No comorbid diagnoses	23 Dutch kindergartners diagnosed with severe language impairment Ages 60–90 months ($M = 71.56$, $SD = 7.15$) No comorbid diagnoses Did not participate in Experiment 1
Story type	Static e-book: Static electronic illustration, oral story narration, no audio effects Animated video e-book: Static e-book with additional multimedia features (motion picture animation, zoom effects, background music, sound effects)	Static e-book: Static electronic illustration, oral story narration (two versions, one with/without background music/sound) Animated video e-book: Static e-book with motion picture animation and zoom effects (two versions, one with/without background music/sound)
Intervention activity	Participants independently read four different stories, four times each (two stories via static e-book and two stories via animated video e-book)	Participants independently read two stories in each of the four e-book formats: (a) Static e-books without background music/sound (b) Static e-books with background music/sound (c) Video e-books without background music/sound (d) Video e-books with background music/sound
Dependent variable	Expressive vocabulary	Expressive vocabulary
Statistical analysis	Repeated measures ANOVA	Repeated measures ANOVA
Findings, significance, and effect sizes	Without adult support, participants learned new vocabulary words using both story formats ($p < .001$, $d = 1.54$) Compared to animated video e-books, participants demonstrated higher vocabulary gains using static e-books ($p < .01$, $d = 0.48$)	Participants with stronger language skills learned more vocabulary words ($p < .001$, $d = 1.62$) Regardless of story type, participants with more severe language impairments, learned fewer words when background music/sound effects were present ($p < .05$, $d = 0.43$)
Confidence intervals	Not provided	Not provided
Quality rating	Suggestive to compelling	Suggestive to compelling
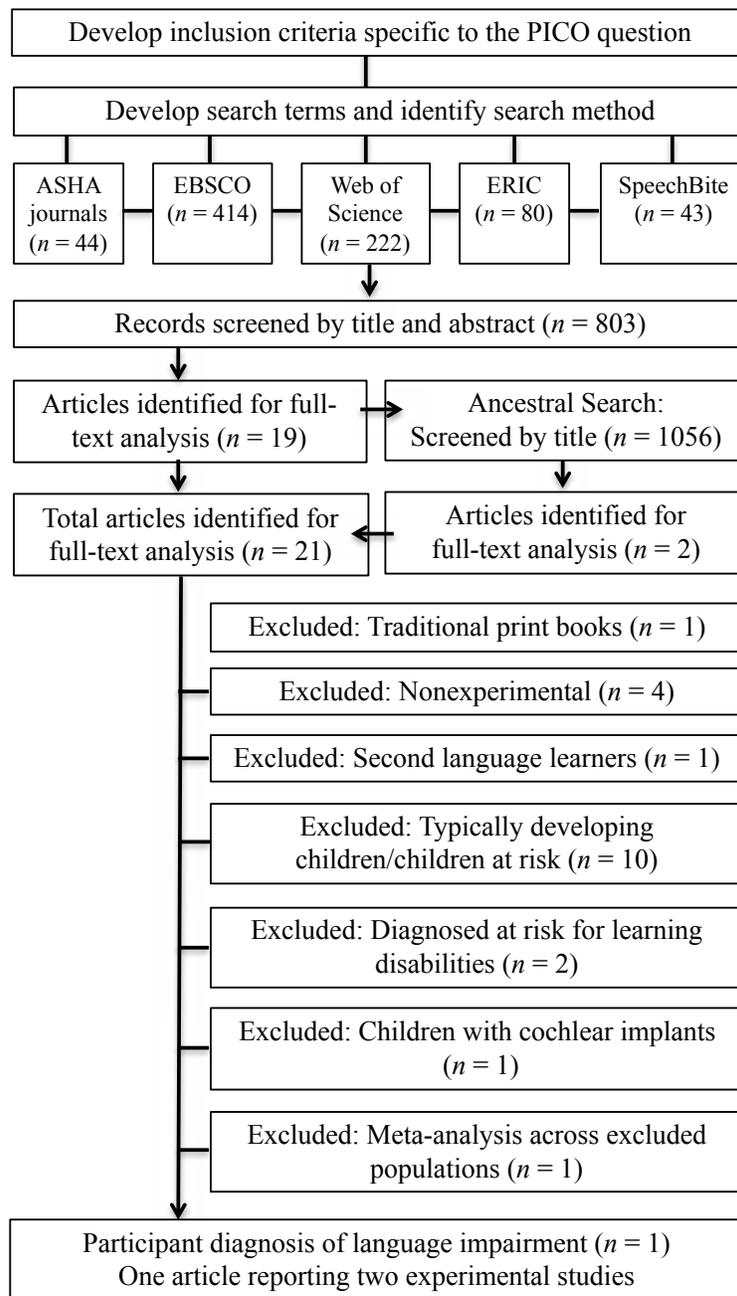
Figure 1. The search and selection of evidence.