EMPIRICAL MANUSCRIPT

Facilitating Vocabulary Acquisition of Children With Cochlear Implants Using Electronic Storybooks

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Abstract

The present intervention study explored the word learning of 18 children with cochlear implants in response to E-book instruction. Capitalizing on the multimedia options available in electronic storybooks, the intervention incorporated videos and definitions to provide a vocabulary intervention that includes evidence-based teaching strategies. The extent of the children's word learning was assessed using three assessment tasks: receptive pointing, expressively labeling, and word defining. Children demonstrated greater immediate expressive labeling gains and definition generation gains for words taught in the treatment condition compared to those in the comparison condition. In addition, the children's performance on delayed posttest vocabulary assessments indicated better retention across the expressive vocabulary task for words taught within the treatment condition compared to the comparison condition. Findings suggest that children with cochlear implants with functional speech perception can benefit from an oral-only multimedia-enhanced intensive vocabulary instruction.

Researchers examining the academic achievements of children with severe-to-profound hearing loss have found there to be a large variability in skills and an evident language gap when the children with hearing loss are compared to their hearing peers (e.g., Geers & Sedey, 2011; Harris & Terlektski, 2011; Hayes, Geers, Treiman, & Moog, 2009; Holt & Svirsky, 2008; Marschark, Rhoten, & Fabich, 2007; Pisoni, Cleary, Geers, & Tobey, 1999; Schorr, Roth, & Fox, 2008). When examining proficiency scores on state tests, a recent study by Easterbrooks and Beal-Alvarez (2012) found that between 35% and 65% of children who are D/deaf or hard of hearing (D/HH) did not meet proficiency for the reading requirements in their state assessment, Grades 3–8. Although this study showed progress in literacy success to be possible for some students, it also demonstrated that interventions are needed to close the gap for the 35–65% of children who are performing below their same age peers.

In part, the academic delays seen in children who are D/HH may be explained by the gaps in their language framework caused by variables that are unique to the children's language modality or the presence of other disabilities (Perfetti & Sandak, 2000). Examples of influencing variables that are present for children with cochlear implants and hearing aids are: the type of sensory device (e.g., cochlear implant/hearing aid), language modality (e.g., speech vs. sign), degree of hearing loss, age when given amplification and/or implanted, and the presence of concomitant disabilities (Connor, Hieber, Arts, & Zwolan, 2000; Hammes et al., 2002; Peterson, Pisoni, & Miyamoto, 2010; Wie, Falkenberg, Tvete, & Tomblin, 2007). Each of these factors has been found to explain a significant amount of variance in their language and academic performance. Although educators have very little control over factors such as the type of amplification device the child uses or the degree of hearing loss, they are able to help children potentially decrease the academic gaps through language and literacy interventions that strengthen the child's lexical framework.

Currently, the majority of the intervention studies that are available include children with mixed degrees of loss and/or sensory device use (hearing aid and cochlear implant users), making a true understanding of learning potential difficult to acquire. Intervention studies that have incorporated children...
with cochlear implants and hearing aids have targeted areas such as phonological awareness (e.g., Miller, Lederberg, & Easterbrooks, 2013), phonics (e.g., Wang, Spychala, Harris, & Oetting, 2013), narrative production and comprehension (Pakulski & Kaderavek, 2012), fluency (e.g., Schirmer, Schaffer, Therrien, & Schirmer, 2012), and reading comprehension (e.g., Schirmer et al., 2012).

In their review of the available literature, Luckner and Cooke (2010) noted a shortage of research that examines interventions to promote vocabulary learning for children who are hard of hearing. Among the vocabulary interventions that were found, the authors noted a lack of reported effect size, replication of successful interventions, and studies examining children with cochlear implants separate from children with hearing aids.

The few studies that have examined word acquisition and vocabulary size exclusively in children with cochlear implants indicate a need to further investigate not only the processes that underlie children’s word-learning, but the components of successful vocabulary intervention (Connor, Craig, Raudenbush, Heavner, & Zwolan, 2006; Connor et al., 2000; James, Rajput, Brinton, & Goswami, 2008; Walker & McGregor, 2013). The purpose of the current study is to add to this literature through exploration of vocabulary intervention tailored to the learning needs of children with cochlear implants using a package of literacy facilitation components. Within this vocabulary intervention, technology—electronic storybooks, specifically—was utilized.

**Benefits of Cochlear Implants**

Cochlear implants give children with severe-to-profound hearing loss access to speech that cannot otherwise be available with hearing aids (National Institutes of Health, 1995). Specifically, there are significant increases in the child’s speech perception and recognition (Davidson, 2010; Martines, Martines, Ballacchino, & Salvago, 2013; Wie et al., 2007). These higher levels of speech perception are correlated with an increase in expressive and receptive language skills and, for some children, their language level approaches that of their hearing peers (Crosson & Geers, 2001; Geers, 2004). Unfortunately, the measured success of the cochlear implant has shown to vary due to several factors that influence language outcomes. These factors include, but are not limited to: age of implantation, child’s cognitive abilities, intensity of therapy, and age of implantation (Dunn et al., 2014; Geers, Strube, Tobey, Pisoni, & Moog, 2011). Although several factors exist that may impede the overall benefit of the cochlear implant, there has been evidence to suggest that when children are given cochlear implants, they demonstrate literacy and language gains (speech perception, production, and overall language) (Geers & Moog, 1994; Hamzavi, Marcel Pek, Gotoettner, & Baumgartner, 2004; Meyer, Svirsky, Kirk, & Miyamoto, 1998; Mok, Galvin, Dowell, & McKay, 2010; Tomblin, Spencer, Flock, & Gantz, 1999).

Contrary evidence to the superiority of cochlear implants to hearing aids was seen in a recent study by Harris & Terlektsi (2011). The authors examined the reading and spelling abilities of adolescents who were either given cochlear implants early, given implants late, or were hearing aid users. All three groups performed significantly lower than their same age peers with normal hearing on reading assessments, but the students who were using hearing aids demonstrated a greater performance on these assessments than the cochlear implant groups.

When the reading levels of the groups were more closely examined, almost half of the children with hearing aids were reading within 12 months of their same age peers. This is in comparison to the 20% of children who were given cochlear implants at or before 42 months old and the 17% given implants after 42 months old who were reading at the same level. The contrast in research findings may be indicative of younger children demonstrating immediate benefit from the cochlear implant but as the child gets older, a progressive gap between children with implants and their hearing peers begins to emerge.

**Literacy, Language, and Hearing Loss**

Acquiring the skills necessary to decode text is essential for the educational and vocational success of children. Unfortunately, there is a long history of studies indicating that children with hearing loss, of all severities, are at a disadvantage when learning to read (Luckner, Sebald, Cooney, & Young, 2005; Win, 2007) and a large percentage of high school students who are D/deaf continue to read below the fourth grade level (Traxler, 2000).

The gap in literacy achievements for children who are D/HH has, in part, been attributed to language deficits as a result of their inefficient auditory system (Perfetti & Sandak, 2000). Delays in expressive and receptive vocabulary will inevitably have a spiraling effect on academic success, as vocabulary competence is a necessary component of academic outcomes and reading success (Connor & Zwolan, 2004; Johnson & Goswami, 2010; Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2012).

During their elementary school years, children with typical hearing learn an average of 840 root word meanings per year, and as they progress through school, their vocabularies continue to grow (Biemiller & Slonim, 2001). The majority of vocabulary that children with typical hearing learn is through incidental learning or “passive listening” (Akhtar, Jipson, & Callanan, 2001; Oetting, Rice, & Swank, 1995). Children with cochlear implants, however, are at a disadvantage to learning new words incidentally as the speech signal received from the implant is considered to be highly degraded (Pisoni, 2000). As a result, a child with a cochlear implant misses a multitude of vocabulary learning opportunities throughout the day.

Although cochlear implants give deaf children greater access to speech and language that would otherwise be unavailable, researchers have reported that children who use them continue to have difficulties making language and literacy gains as compared to hearing children (Spencer, Barker, & Tomblin, 2003). In addition, there is a high individual variability for success with the implants that has been reported across studies (Osberger, Robbins, Todd, & Riley, 1994; Svirsky, Robbins, Kirk, Pisoni, & Miyamoto, 2000). A striking variability in performance for expressive vocabulary for children with cochlear implants was seen in the work of Svirsky et al. (2000). Like previous authors, Svirsky confirmed that children with cochlear implants on average demonstrated a faster trajectory for vocabulary development than deaf children without implants. However, when examining performance 2 years after obtaining a cochlear implant, some children continued to show severely delayed expressive language skills compared to their hearing peers, while others demonstrated close to average skills. The authors suspected that the variability can be attributed to the children’s differences in speech perception. The most successful cochlear implant users were those that were enrolled in academic programs focused on developing auditory/oral capabilities. The authors concluded that although a gap still existed between children with implants and their hearing peers, the implant prevented further language delay. In order to “catch-up” on language-learning opportunities missed without the implant, the children would require a
speech/language intervention to provide support for language and vocabulary not heard before the cochlear implant.

**Storybook Reading as a Vocabulary Intervention**

Language intervention that focuses on the augmentation of a child’s vocabulary has been beneficial not only in expressive and receptive measures, but also in literacy development. A well-supported consensus derived from vocabulary intervention research for hearing children is that effective vocabulary instruction contains three main features (Coyne, McCauch, & Kapp, 2007; National Reading Panel, 2009; Silverman, 2007). These features include: (a) multiple exposures of novel words, (b) provision of both definition and contextual information, and (c) active student engagement with the words. When these elements are incorporated into storybook readings, the vocabulary intervention becomes one that has been demonstrated to be successful for typical learners (e.g., Coyne et al., 2007), those at risk (e.g., Justice, Meier, & Walpole, 2005; Spencer et al., 2012), and those with learning disabilities (e.g., Smeets & Bus, 2012).

Through storybook reading with adults, children are engaged in a motivating activity that provides multiple contextualized exposures to unknown words. Providing a framework, such as within stories, gives the child opportunities to apply meaning to the immediate context and has been demonstrated to significantly improve novel word learning for elementary school children (Biemiller & Boote, 2006; Stahl & Fairbanks, 1986). The addition of a brief explanation when an unknown word is encountered within a story may promote the child’s fast mapping and later recall of the new word. Increased word learning and word retention is seen in young children when given brief explanations of unknown words during a storybook readings (Brett, Rothlein, & Hurley, 1996; Elley, 1989). Although this effect may be due to the presence of a live adult–child interaction (Mol, Bus, Jong, & Smeets, 2008), children’s learning and retention of word meaning is found to be significantly better than children who are not given explanations when words are encountered.

Elley (1989) found that one of the key features that partially explains the variance in the children’s word-learning is the degree to which the word meaning can be inferred by the text. This finding further supports the teaching of new vocabulary words within a rich context, such as a story.

Although children are able to demonstrate word learning with a single exposure to a story, authors have found even greater word learning with a second or third retelling and an explanation of target vocabulary (e.g., Biemiller & Slonim, 2001; Elley, 1989; Ensor & Koller, 1997; Justice et al., 2005; Penno, Wilkinson, & Moore, 2002; Senechal, 1997; Smeets, van Dijken, & Bus, 2014; Spencer et al., 2013). When examining the word learning of preschoolers, for example, Senechal (1997) compared children placed in three conditions: single condition, repeated condition, and repeated-reading condition. Children within the repeated-reading condition demonstrated significantly more receptive and expressive vocabulary gains as compared to the children in the other two groups. In addition, the children within this condition demonstrated the ability to generalize their knowledge of the word meaning to other contexts, demonstrating flexibility in their understanding of receptive and expressive vocabulary.

Children demonstrate benefits from not only the repeated exposure to storybooks, but also the teachers’ explanations of target words (Biemiller & Boote, 2006; Penno et al., 2002). Effective adult explanations of novel words include both contextual and definitional information within multiple and varied contexts (Coyne et al., 2007). This type of interaction with target vocabulary helps to create a deeper processing of word understanding that is more complex than memorization of word definitions (McKeown & Clancy, 2004).

Embedded vocabulary explanations have been shown to not only improve language outcomes for typically developing children, but also for those who are at risk for language and literacy delays (Loftus, Coyne, McCoach, Zipoli, & Pullen, 2010). In their within-subjects comparison study, Loftus et al. (2010) explored the benefits of a vocabulary intervention in which targeted words were paired with an explanation for 20 children at risk for language and learning difficulties. The authors found that the children who were given the supplemental vocabulary intervention (explanation of vocabulary) made better word learning gains as compared to children who were given a simple definition and incidental exposure through the classroom instruction. This evidence suggests that children with cochlear implants may also benefit from this type of vocabulary intervention.

**Benefits of Technology in an Intervention**

Although the adult–child interaction during interactive/dialogic storybook reading may be important (Mol et al., 2008), technology may offer an effective supplement to word learning. When technology is effectively paired with an intervention, children are able to engage with a more novel media type while making learning gains (Leacox & Jackson, 2012; Marulis & Neuman, 2010; Wang & Paul, 2011). Electronic storybooks, or E-books, are an example of one such technology that has both academic and entertainment value (Hoffman & Paciga, 2014). Researchers have capitalized on the benefits of E-books for language intervention and have used them to capture children’s attention while providing an intervention that is consistent across children (e.g., Gibbons, Anderson, Smith, Field, & Fischer, 1986; Lugo-Neris, Jackson, & Goldstein, 2010; Silverman & Hines, 2009; Smee & Bus, 2012; Smeets et al., 2014; Verhalle & Bus, 2010). In their review of the literature regarding electronic storybooks and literacy intervention, Korat, Shamir, and Segal-Drori (2014) demonstrated that the benefits of electronic storybooks can extend beyond a child’s vocabulary learning to also helping to support story comprehension, phonological awareness, letter naming, and word reading/writing. These benefits were seen in children with and without language and literacy delays as well as children within families of low socioeconomic status.

The cognitive model, described by Paivio (2007), supports the use of using videos and pictures, which are common elements within an E-book, to support vocabulary learning. Within his dual-coding theory, visual imagery plays a supportive role as the child encodes new information. Paivio posited that the brain uses two systems for processing verbal and nonverbal information. When given novel information, the two systems can work to support each other, enabling more efficient recall. Additionally, when the children are given words and visual images either simultaneously or in a close proximity, they are more likely to maintain these concepts in working memory (Baddeley, 1998). Children with limited language skills, as is common in children with hearing loss, have an increased cognitive load when processing information. The E-books have the potential to give children access to simultaneous instruction, which reduces the cognitive load by using several modalities such as video, text tracking, pictures, and the story both heard and seen simultaneously.
Numerous authors have sought to determine the benefits of technology for increasing the vocabulary in children with hearing loss (see review by Beal-Alvarez & Cannon, 2014). Technology such as videos and closed captioning (Wang & Paul, 2011), electronic storybooks, and computer-based tutors (Massaro & Light, 2003) have been successfully incorporated into literacy interventions (Trezek & Malmgren, 2005; Wang & Paul, 2011). In their comprehensive review of the literature, Beal-Alvarez and Cannon (2014) found few group design or single-case design studies that met an outlined criteria for evidenced-based studies. The purpose of the current intervention is to add to the literature base in the area of technology use for augmenting the vocabulary for children who are D/HH.

Research Aims

The aims of this study are to investigate the benefits of a vocabulary intervention with embedded instruction and vocabulary enhancement (videos and illustrations) on immediate word learning and retention of taught vocabulary.

Specifically, the research questions are:

1. Is there a significant difference in word learning when children are exposed to novel words in the read-only book condition and words taught in the technology-enhanced book reading intervention with embedded instruction?
2. Is there a significant difference in retention between words experienced in the read-only book condition and words retained when given a technology-enhanced book reading with intensive embedded instruction?
3. What is the feasibility of a parent-implemented E-book intervention, without a researcher present, as reported by a parent survey?

Methods

A pretest-posttest comparison, within-subject group design was used for this intervention study. Eighteen children with cochlear implants were recruited from elementary schools and specialty learning centers for children who are D/HH within the United States. Selected collaborating sites were those that educate children with hearing loss within the mainstream classroom, total communication classroom, or an auditory/oral program.

All children were pretested to determine their expressive and receptive knowledge of vocabulary that would be targeted within the electronic storybooks. Each week, children alternated between the treatment and comparison condition. During the treatment condition, vocabulary learning was supported through a preview review, videos, elaboration, and highlighted aspects of each word’s phonology. In the comparison condition, the children experienced the electronic storybooks as a traditional story read-through. Families were asked to have their child “read” the electronic storybook three times during the week. At the end of the week, the child’s vocabulary learning was assessed. In addition, retention of vocabulary word learning was assessed after a 2-week period.

Recruitment

Recruited children met the following inclusion/exclusion criteria: (a) had a cochlear implant for over 2 years, (b) were between the ages of 4.0 and 9.0 years, (c) English was their primary language, (d) used speech/hearing for at least 75% of the time, and (e) scored 3 or above on the Early Speech Perception Test (ESP; Moog & Geers, 1990). In an effort to recruit eligible children, a description of the intervention study was first emailed to potential collaborating sites and interventionists who were asked to distribute the information to eligible families. Interested families contacted the primary investigator directly.

Prior to the initial assessment, families received packets containing a parental consent form, parent questionnaire, and permission to share testing information. The questionnaire was used to obtain further information regarding child demographics, specifics on the cochlear implant device and hearing loss, family demographics, educational placement setting, and language modality sign or oral. These characteristics have been shown to influence the language and literacy gains of cochlear implant recipients (Connor et al., 2000; Peterson et al., 2010; Wie et al., 2007).

Participants

Twenty-nine families agreed to participate in the study. The final cohort of participants included 18 children. Of the initial consenting families, 4 of the 29 children were excluded from the study because they did not meet the inclusion criteria. Two families were unable to participate in the intervention after providing consent due to personal circumstances. Additionally, two children were excluded because they demonstrated over 90% knowledge of targeted vocabulary words. Another participation was not included because the family was unable to be reached after providing consent and one family withdrew from participation during the initial assessments because of scheduling conflicts. Once the intervention began, there was no attrition for participating children.

Children participating in this study (6 males and 12 females) ranged in age from 4 to 9 years ( \( \bar{x} = 5.9 \) years, \( SD = 1.32 \)) and were between preschool and second grade. The range of cochlear implantation was between 9 months and 6 years old ( \( \bar{x} = 2 \) years). Thirteen children had a second implant. Parents reported all children to use their cochlear implant(s) 100% of the day, excluding times when the child was sleeping or in water. The children used speech as their primary mode of communication (100% of the time), and English was the first, and primary language of all participants. Reported family characteristics included parent education, income, and family size. One family did not complete the questionnaire. A summary can be found in Table 1.

A closed-set speech perception test, the ESP (Moog & Geers, 1990) was used as both a participant descriptive and exclusion measure. Previous authors (e.g., Geers, 2004; Miller et al., 2013) have also used this assessment for exploratory and intervention studies because it assesses perception of monosyllables, disyllables, nonsense syllables, sentences, phonemes, and words. In this assessment, the child’s performance is classified into one of four categories with associated numerical values: detection (1), pattern perception (2), some word identification (3), and consistent word identification (4). Due to the limited speech perception of children who score a one or two on this measure, and the limited benefit that providing vocabulary instruction would have for these children, only those with a score of three or higher were included in this study. All of the children who were assessed scored 4 on this measure.

Assessment Procedures

The primary investigator administered all assessments, in a randomized order over one to three sessions. Six children were
administered the assessments during non-instructional times during the school day in a quiet classroom, and seven children were administered the assessments during sessions with a parent present in a quiet setting. The assessments included standardized assessments, collection of two language samples, and researcher-created vocabulary assessments.

### Standardized assessments

The Expressive One Word Picture Vocabulary Test (EOWPVT; Martin & Brownell, 2011a) and the Receptive One Word Picture Vocabulary Test (ROWPVT; Martin & Brownell, 2011b) were used to evaluate expressive and receptive single word vocabulary. These assessments are reported to be highly correlated (r = .69) and have a high average reliability for children between the ages of 4 and 9. During the administration of the EOWPVT, the examiner showed the child an illustration, and the child orally labeled the object, action, or concept. During the administration of the ROWPVT, the child pointed to one of four pictures that represented an object the examiner named. For both assessments, children are given 1 point for each illustration correctly labeled (EOWPVT) or indicated (ROWPVT) and a standardized score is calculated. For these assessments, 85–115 is considered “average range.” The mean standard score on the EOWPVT was 93.83 (SD = 16.92, range = 68–133), five children (27.8%) scored below average on this measure. The mean score on the ROWPVT was 92.44 (SD = 14.51, range = 69–119). Six children (33.3%) received scores one or more SDs below the standardized mean score.

As an additional measure of speech perception and comprehension, each child was asked a set of six listening comprehension questions, taken from the Listening Comprehension subtest in the Woodcock Reading Mastery Test III (Woodcock, 2011). These items, increasing in complexity, required the child to listen to an examiner prompt (e.g., “Point to the zebra following an elephant to the pond”) and then point to a corresponding picture. For each item, the child was given a choice of four pictures that varied by one feature. One example item was given at the beginning of this task. The children’s average for accurately answered items was 5.3 items.

The Primary Test of Nonverbal Intelligence (PTONI; Ehrler & McGhee, 2008) was used as an assessment to measure nonverbal intelligence. This measure has been found to be a reliable measure, $\alpha = .90–.95$ for children between the ages of 4 and 7 years old. This measure is frequently used in studies for young children who are deaf or hard of hearing because it does not rely on strong expressive and receptive language skills, nor does it require a verbal response (e.g., Lund & Schuele, 2013). The average standardized score for the PTONI was 116.78 (SD = 29.61, range = 70–149), indicating that the majority of the children (77.8%) scored in the average/above average range. Four children scored less than 1 SD below the mean on this assessment.

### Narrative language assessment

Narrative assessment tasks are reliable and predictive language measures that provide a rich description of children’s oral language skills (Heilmann, Miller, & Nockerts, 2010). In addition, they are sensitive to both qualitative and quantitative language differences for children with typical and atypical language development (Boudreau & Hedberg, 1999; Scott & Windsor, 2000). Two narrative retell samples were collected and used to describe aspects of the child’s language such as mean length of utterance (MLU) and number of different words (NDW).

This narrative retell assessment included two tasks, the retelling of a story seen in a picture book and the retelling of a story seen in a short video clip. In each condition, movie or storybook, the child heard the story and was asked to retell the story. The child’s narratives were audio recorded and later transcribed for analysis. The audio recording of two children was unintelligible and unable to be transcribed. The average MLU for 16 children was 5.71 (SD = 1.86). The average NDW was 70.79 (SD = 25.61).

### Researcher-created vocabulary assessments

When learning new vocabulary, authors have posited that a child’s “knowing” a word can reflect different levels of word knowledge (Beck & McKeown, 1991; Nagy & Scott, 2009). These levels reflect the quality or extensiveness of their knowledge. To capture the extent of the child’s vocabulary understanding, this study utilized the child’s ability to select an illustration that depicts an examiner produced word (receptive understanding), label illustrations depicting targeted words (expressive understanding), and produce definitions (to assess their higher level understanding). Previous research has used both a definition generation task (Duff et al., 2008; Justice et al., 2005) and multiple-choice selection tasks (Penno et al., 2002; Senechal, 1997) to evaluate children’s working definitional knowledge. Researcher-made vocabulary probes requiring receptive word recognition, naming, and/or producing definitions have been used in the relevant literature to monitor vocabulary learning progress (Beck & McKeown, 2007; Nash & Donaldson, 2005; Ordonez, Carlo, Snow, & McLaughlin, 2002). These types of assessments were used for

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both the baseline assessment and to monitor vocabulary learning and retention throughout the study.

**Baseline assessment**

Two informal vocabulary probes, the expressive labeling probe and receptive probe, were used to select E-books for the intervention and to determine baseline vocabulary knowledge. Both assessments included 48 potential vocabulary words, all nouns, taken from the 12 electronic storybooks designed for this study. Included illustrations were unique to the assessment. In other words, the pictures did not appear in the intervention or in the posttests.

Both the receptive and expressive labeling probes were designed in a similar format as previous authors used to measure expressive and receptive vocabulary (e.g., Martin & Brownell, 2011a, b). During the expressive labeling probe, the examiner showed one illustration and asked the child to label it. If the child responded using a synonym or homonym to the target word, the examiner prompted the child to provide an additional label. In the receptive probe, the examiner presented the child with four illustrations on a single plate—one portraying the target word, and three foils (refer to Figure 1 for an example). The examiner asked the child to point to the picture representing the given word. Criteria to select picture foils were based on semantic, phonetic, and/or phonologically similar features to the target vocabulary. For example, for the target word “tail,” the foil items included pictures of pail (phonological), teeth (semantic and phonetic), and a horse (semantic). On average, the children correctly identified 30 (SD = 8.95) words in the receptive pointing probe and correctly labeled 18 (SD = 12.61) in the expressive labeling probe. A t-test revealed there to be significantly more accurately answered items on the receptive pointing probe than the expressive labeling probe, t(17) = 3.62, p < .001.

To obtain a baseline of the child’s ability to verbally define targeted vocabulary, a higher level linguistic task, the examiner asked the child to verbally generate a definition for the four words that were targeted in the book for the following week. The examiner provided the word and asked the child to “tell me everything you know about ______”. Additional prompts such as repetition of the child’s definition and “tell me more” were utilized. After the child provided a definition, the examiner prompted with “Is there anything else you can tell me about ______”. The child’s responses were audio recorded and transcribed for scoring. Using the scoring methodology similar to previous authors (e.g., Beck & McKeown, 2007; Bedore, Pena, Garcia, & Cortez, 2005; Justice et al., 2005), the child received points based on a scoring rubric ranging from 0 to 3 points.

**Vocabulary learning assessment**

The vocabulary learning assessment, given at the end of each week, was used to assess the children’s word-learning of words targeted within that week’s book. Designed in a similar format as the vocabulary probes, this assessment contained the four words that were targeted within that week’s story, as well as items to assess retention learning. The child was first given the definition task, followed by the labeling task and finally the receptive vocabulary task. In an effort to minimize practice effects, word order was randomized within each task and practice items were built into each task.

**Retention**

In studies that compare immediate posttest vocabulary learning to delayed posttest learning, children with typical hearing are able to retain word knowledge, and for some, demonstrate additional word learning weeks after the intervention (Biemiller & Boote, 2006; Brett et al., 1996; Senechal & Cornell, 1993). Biemiller and Boote (2006) attributed the additional word learning to the child’s heightened awareness for the vocabulary in their environment and posited that the intervention provided in their study gave the lexicon mapping needed for further word learning.

To determine if children were able to retain receptive word knowledge and ability to expressively label words after a 2-week period, the vocabulary learning assessment from 2 weeks prior was re-administered. Due to time constraints and task difficulty, it was decided that the definition generation task would not be used to measure the children’s word retention. The 2-week follow-up tasks used to measure retention consisted of the receptive pointing and expressive labeling tasks. These were administered within the same session as the new vocabulary probes for the next week’s E-book. Items were randomized with the current week’s word task to reduce practice effects.

A retention word gain score was calculated by subtracting the child pre-word knowledge, seen in their probe scores, from words they recalled in the 2-week follow-up for both the receptive pointing and expressive labeling tasks. This value represents words the child learned through the intervention and was able to retain after the 2-week period. This score was calculated to account for word knowledge within the books selected for each child (as indicated by the expressive and receptive probe) prior to beginning the intervention and reduce inflation of the “word gain” score.

**Materials**

**Study book selection**

Guidelines to select books for this study were adapted from Hargrave and Senechal’s (2000) criteria which suggest that the books: (a) are high interest to the targeted age group, (b) contain vocabulary that may be novel to the children, (c) have multiple instances in which the vocabulary appears in the text, (d) have colorful illustrations to support the text, and (e) do not contain an excessive amount of text (e.g., maximum of three to four lines of text per page). Consultation with speech language

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**Figure 1.** Examples taken from the researcher-created expressive labeling probe and receptive pointing probe.
pathologists and researchers also investigating vocabulary word learning helped to guide selection of the storybooks.

Vocabulary selection
This study targeted children whose vocabulary tends to develop more slowly and has a higher variability as compared to their hearing peers (Prezbindowski & Lederberg, 2003). Therefore, the words targeted in the intervention are likely to occur in the child’s academic and social interactions but may not have been fully incorporated into their lexicon.

Although nouns, verbs, and adjectives are classes of words that have been shown to be successfully taught to young children (Robbins & Ehri, 1994), nouns, specifically, were selected for the purposes of this study. It was felt that nouns were easily depicted in illustrations and can be explained using Tier 1 words (more general wording) which was expected to be the primary level of vocabulary used in the targeted population. Using the word frequency calculator, the Michigan Corpus of Academic Spoken English (online version; Simpson, Briggs, Ovens, & Swales, 2002), word properties were examined. Words selected for this intervention occurred more frequently in literature than in conversation. Therefore, the discussion of their definition within their environment has a decreased probability to occur outside of storybooks—further helping to maintain fidelity of the intervention. Refer to Appendix A for a list of vocabulary words used within the storybooks.

Electronic storybooks
A total of 12 books, each containing four target vocabulary words, were selected to accommodate the children’s varying language needs. Minimal text modifications were made so that targeted vocabulary occurred at least three times within the story. The modifications ranged from three to six words per vocabulary word and an average of two text modifications were made per book. The text modification was done for both the treatment and comparison condition to ensure that the child had exposure to the target words in both conditions; however, in the treatment condition, the text was not only modified for exposure but also enhanced with language facilitation components. With exception to the targeted words within the story, supporting text of the story was not assessed or controlled.

The storybooks were made into E-Books using the program, Microsoft PowerPoint. Scanned pages of the storybook and audio recorded text were placed in sequential order within the program. Two versions of each story, a treatment and comparison condition, were created. Using the options available in the Microsoft PowerPoint program, the PowerPoint were used to create videos which could be played using Windows Media Video player. The videos, sent to the families each week, were created to ensure that all of the children received the intervention with the same flow and pace, and interacted with the storybooks for a uniform amount of time, thereby reducing variability in implementation.

Treatment storybooks
The treatment condition contained the principles of preview/review, embedded and extended vocabulary instruction, and phonology highlighting. Videos and pictures, which were given during word explanations, further supported the children’s understanding of novel words. The treatment E-books ranged from 7:20 to 16:35 min (X = 11:04 min) to view.

A word preview, given at the beginning of the story, contained a simple definition, an illustration depicting the word and a short video clip containing the target word. This preview served to prime the child to attend to the targeted vocabulary words throughout the story (Ausubel, 1960). At the end of each story, a word review served as reinforcement for highlighted words.

Similar to previous studies, (Brett et al., 1996; Elley, 1989, Justice et al., 2005), when the target word occurred within the story text, a definition followed. The scripts used for the definitions exposed the child to the target word an additional nine times per book and provided four to six new semantic features within each definition.

Attention to phonological aspects of the word preceded each definition. Specifically, the initial phoneme, syllables, and individual phonemes were highlighted. Highlighting aspects of phonological awareness provides additional benefit to word learning (Konold, Juel, Mckinnon, & Deffes, 2003; Silverman, 2007). Although it was not directly investigated within this study, it was believed that the inclusion of this instruction would increase the saliency of the target words.

Comparison storybooks
In the comparison condition, children listened to the E-book which contained recorded narration. Like the stories heard in the treatment condition, the narration was altered from the printed text to include incidental exposure to each of the targeted words; however, the recordings did not include any direct instruction of the targeted words such as preview/review, phonology highlights, and embedded word definitions. The comparison E-books ranged from 1:59 to 8:07 min (X = 4:03 min) to view.

Book Selection for Participants
Six storybooks were used, per child, for the length of the 6-week intervention, allowing for one book per week. The books were selected, within the pool of 12 created E-books, according to the child’s previous vocabulary knowledge, as determined by the receptive and expressive labeling vocabulary probes. To demonstrate optimal word learning, six books with the least amount of words known in each probe task were selected for the intervention. The six books were first randomly assigned to a treatment or comparison condition and then randomly assigned to a week in which the child would interact with the story. A child never received the same book for the treatment and comparison condition. Some books were rearranged, after condition assignment, to ensure that the number of known words within each task was balanced across the treatment and comparison condition. Efforts were also taken to ensure that each book was assigned an approximate equal number of times to the treatment and comparison condition across the participants (refer to Appendix A).

Implementation of E-Books
At the beginning of each week, for 6 weeks, the families were sent a link to an E-book that was stored on a Google Drive. This link gave them access to the E-book chosen for the child that week. Parents were instructed to have their child view the storybook three times throughout the week and complete the Parent Survey (described below). Specific instructions given to parents regarding book viewing can be found in Appendix B.

The treatment and comparison books were provided in an A-B sequence, so that the child received the treatment book 1 week and the comparison book the next. The beginning condition (treatment or comparison) was first randomized across the children then adjustments were made to balance the starting condition across the children. In the final participating cohort,
11 children began with a book from the control condition and 7 children began with a book from the treatment condition. At the end of the week, the vocabulary knowledge of the child was assessed. The assessment took place using the internet-based program, Blackboard Collaborate in which the child and interventionist could interact in real-time. After logging into the program, the interventionist guided the child through the vocabulary learning assessments. The assessment sessions ranged from 10 to 25 min across the 6 weeks.

**Parent Survey**

After each E-book story viewing, the parent completed a brief survey related to the child’s attention/interest to the story and environmental noise (refer to Appendix B for parent survey). The use of the survey served two purposes. The first was to increase the reliability of the delivery of the intervention, and the second was to obtain information regarding the child’s compliance, interest, and engagement in the E-books.

Using the parent survey, an intervention compliance percentage could be calculated. Across all children included in this study, 324 E-book viewing sessions were scheduled (three times per week for 6 weeks for 18 children). Within the 324 sessions, parents reported that 99% of the sessions were watched (seven viewing sessions were missed across the cohort as a whole). Three children watched two books only twice, one child watched one book twice and one child was reported to have seen a book one time. The missed sessions occurred in both the treatment (three viewings) and comparison (four viewings) conditions. For these weeks, parents reported difficulty managing their schedule and/or lack of child interest in the story.

**Reliability of Scoring**

Research assistants were trained to administer the weekly assessments. Those administering the weekly assessments were required to observe three assessment sessions, participate in a training session (approximately 1 hr), and complete a practice session with the primary investigator. In addition, the primary investigator observed the first three sessions and one additional session during the 7-week intervention. Research assistants were given feedback for each session observed. To check for scoring reliability within each assessment session, the primary investigator checked 20% of each research assistants’ sessions. Reliability was 100% across all research assistants.

The primary investigator trained two research assistants to score the children’s’ pre- and posttest definitions of target vocabulary obtained each week. Training included discussion of the definition rubric and practice on sample items. Training continued until research assistants were in at least 90% scoring agreement for a group of 48 sample items. Research assistants were considered to be in scoring agreement when each assistant assigned the same score to a definition. Once training was complete, the research assistants independently scored the transcribed pre- and posttest definitions. The agreement percentage of 90% was calculated by multiplying the number of instances in which the research assistants agreed by 100. When research assistants did not agree on a score, the item was scored by the primary investigator who served as a third scorer to resolve disagreements.

**Completion Survey**

A final survey was distributed to parents at the completion of their child’s intervention program. This survey sought information related to the feasibility of a parent implementing vocabulary intervention and their child’s familiarity with selected storybooks prior to beginning the intervention. The child’s familiarity with the selected books was not analyzed for the purposes of this study, as it would be difficult to validate the number of times the child might have seen a particular book prior to entering the study. However, if a child’s pretest scores indicated prior receptive knowledge of words that appear within a particular storybook, then the book was not selected for that child in either the treatment or comparison conditions, thereby controlling for previous knowledge. Refer to Figure 2 for additional survey questions. Qualitative information related to the study’s feasibility was derived from parent answers.

**Results**

The purpose of this study was to examine the effectiveness of vocabulary instruction within electronic storybooks for children with cochlear implants. The children’s learning of vocabulary was compared in two conditions when exposed to words within the intervention package and in a traditional story read-through; both delivered via E-books. Three dependent variables were used to measure vocabulary growth: (a) a definition task, (b) a labeling task, and (c) a receptive vocabulary task. The children’s retention of vocabulary was also examined.

**Pretest Scores Across Conditions**

To gain further information regarding the children’s vocabulary performance before beginning participation in the study, a pretest score describing vocabulary abilities for the six selected books in the child’s E-book sessions was calculated. The pretest scores for the expressive labeling and receptive pointing tasks reflect the child’s knowledge of the 24 words targeted within the selected E-books (12 words within each condition). On average,

1. How did you feel about working through telepractice?
2. How often did you hear your child using the words taught in the intervention throughout the day?
3. How did you feel about participating in the intervention 3 times a week?
4. How did you feel about participating in the intervention for 6 weeks?
5. Additional comments:

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**Figure 2.** Feasibility questions taken from final parent survey.
the children accurately labeled 4.67 of the total 24 words, with a range of 0–12 accurate labels (SD = 3.34). Children accurately identified 15.05 items in the receptive pointing task with a range of 9–21 correct (SD = 4.51). Overall across both conditions at pretest, the children demonstrated greater receptive word knowledge than expressive word knowledge, \( t(17) = -11.40, p < .001 \). On the definition task, the children obtained an average of 16.33 points out of 72 points with a range of 6–43 correct (SD = 8.68) at pretest.

**Pretest and Posttest Scores Within Condition**

Children’s pretest scores for each researcher-created task were aggregated by condition (i.e., treatment or comparison condition). Table 2 displays the children’s pretest and posttest scores within condition.

A large variability was noted in the range of children’s performance at pre- and posttest in the definition generation task. To visualize individual differences in responsiveness, individual children’s mean pre- and post-scores in each condition were graphed to display and examine potential outliers. Figure 3 displays pre- and posttest mean scores by individual children within each condition.

When examining individual child results in the treatment condition, Child 8 made little gains from pretest to posttest, this is illustrated by a relatively flat slope in Figure 3. It should be noted that Child 8 had considerably more points within the definition task at pretest compared to his/her peers. Although there was potential for score growth, Child 8 had limited room for improvement as compared to a child whose score at pretest was much lower, as seen in Child 4. The steep slope of growth seen in Child 4 and Child 16 shows a discernible positive change from pre- to posttest. This change indicates that the children made improvement in their definition generation score after having participated in the intervention. Child 4 and 16 appear to have a significantly steeper growth slope compared to the other children in the study.

Visual examination of the comparison condition graph indicates that approximately one third of the children’s growth lines (\( n = 7 \)) were clustered together, all with minimal gains from pretest to posttest (e.g., Child 10, 13, 17). These children did not demonstrate significant benefit from the exposure to E-books. Additionally, when examining steep slopes of change in the comparison condition, Child 16 was seen to have made noticeable improvement in his/her definition generation from pretest to posttest. A similar slope, although not identical, was seen in Child 2. Child 16, having benefited from both the treatment and comparison condition, may have a unique propensity for vocabulary learning that sets him/her apart from peers with cochlear implants. Child and family characteristics that may aid vocabulary learning were not further explored in this study.

Three repeated-measure analyses of variance (ANOVAs) were conducted for each of the three dependent measures to determine if differences in preintervention knowledge existed between each condition. No significant differences were found in expressive labeling task, \( F(1,17) = 0.17, p = .68 \), receptive pointing task, \( F(1,17) = 0.98, p = .34 \), or the definition generation task, \( F(1,17) = 0.92, p = .35 \). This indicated that the children’s expressive and receptive word knowledge before beginning the intervention was not significantly different between the treatment and comparison condition.

**Within Condition, Pre–Post Comparison**

Three repeated-measure ANOVAs for each of the three dependent measures within each condition were conducted to determine if significant growth was made between pre- and post-scores in both the treatment and comparison condition (refer to Table 2 for pre- and posttest scores). Children demonstrated significant growth in receptive vocabulary, labeling, and definitions within both conditions. Table 3 displays the F-value for each ANOVA, their corresponding \( p \) value, and effect size.

**Vocabulary Gain Differences by Condition**

The next series of analysis sought to answer research question one and to determine if there is a significant difference in word learning in the read-only book condition and words taught in the technology-enhanced book reading condition. Calculated word gain was used to examine each task. Table 4 displays the children’s average word gain across researcher-made tasks.

A repeated-measures ANOVA was used to determine the effect of condition (treatment or comparison) on each of the researcher-created tasks. The children’s average gain score on the expressive labeling task was significantly higher in the treatment condition (\( M = 6.88 \)) than the comparison condition (\( M = 3.72 \)), \( F(1,17) = 27.27, p < .001, d = 1.73 \). A significant difference was also seen in the definition generation task. The children demonstrated a larger growth generating definitions to newly learned words in the treatment condition (\( M = 11.94 \)) than in the comparison condition (\( M = 5.50 \)), \( F(1,17) = 15.16, p < .001, d = 1.30 \). A significant difference was not found, however, in the

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**Table 2.** Pretest, posttest, and 2-week follow-up scores by condition

<table>
<thead>
<tr>
<th>Participant</th>
<th>Comparison condition</th>
<th>Treatment condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>n = 18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Definitions task</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>6.06 (5.62)</td>
<td>11.56 (8.03)</td>
</tr>
<tr>
<td>Expressive labeling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>2.38 (1.75)</td>
<td>6.11 (3.46)</td>
</tr>
<tr>
<td>Receptive pointing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>7.33 (2.97)</td>
<td>10.22 (1.43)</td>
</tr>
</tbody>
</table>

Note. The maximum obtainable score within each condition for the definitions task was 36. The maximum obtainable score, within each condition, for the expressive labeling and receptive pointing task was 12 (four words times three books). Retention of gains reflects performance two weeks later at follow-up minus pretest performance. N/A = not applicable.
receptive labeling task, $F(1,17) = 0.45, p = 0.51, d = 0.21$ with an observed power of 0.09.

**Word Retention**

To address the second research question and determine if a significant difference existed in the recall of targeted vocabulary words. Two repeated-measure ANOVAs were used in each condition to compare the pretest scores and the 2-week follow-up scores for the two dependent variables: receptive pointing and expressive labeling (refer to Table 5). Significant differences were seen in the expressive labeling task between the pretest and performance 2 weeks later at follow-up within both conditions indicating that the children, when words were taught in the treatment or comparison condition, retained the ability to name the targeted vocabulary 2 weeks after the intervention. Receptive pointing was significant for the treatment condition but not significant in the comparison condition, indicating children did not retain the ability to recognize the items 2 weeks after exposure to the stories without the explicit instruction.

The differences between the posttest and 2-week follow-up scores were also calculated across tasks and conditions. A difference in the child’s posttest and 2-week follow-up score knowledge indicates the child either forgot words learned after the initial posttest or potentially gained word knowledge (as seen in results from Biemiller & Boote, 2006). While the children...
made significant word learning gains within the treatment condition for both the expressive labeling and receptive pointing tasks, a repeated-measures ANOVA revealed there was also a significant loss of word knowledge 2 weeks later ($F(1,17) = 14.93$, $p = .001$, $F(1,17) = 13.02$, $p = .002$). This significant loss of word knowledge was not seen in the expressive or receptive pointing tasks within the comparison condition ($F(1,17) = 1.84$, $p = .19$, $F(1,17) = 4.11$, $p = .06$).

Finally, retention of word gains was calculated (i.e., 2-week follow-up score minus pretest score) to remove prior knowledge and examine retention of gains specifically (Table 2). Considering several of the children entered the study having demonstrated prior knowledge of some of the targeted vocabulary words, either on the expressive or receptive pretest tasks, retention of gains was calculated to represent retention of new words specifically, rather than items already known at pretest.

Comparisons of word retention gains between conditions were made to determine the effect of the treatment condition on the vocabulary maintenance in each of two dependent variables: receptive pointing and expressive labeling. For the expressive labeling task, the children labeled significantly more words for those in which they had received instruction in the treatment condition than exposure in the comparison condition, $t(1,17) = 2.18$, $p = .04$. No significant difference between conditions was observed in the receptive knowledge task, $t(1,17) = 1.42$, $p = .17$.

### Parents’ Feedback on Feasibility of Implementation and Social Validity

Thirteen of the 18 families completed the final parent survey to examine feasibility and social validity. Qualitative themes were developed based on parent answers related to feasibility of implementation without a researcher present. When asked about their impressions of working through telepractice, parents’ responses included words such as “easy” ($n = 5$), “enjoyed it” ($n = 4$) and “happy with it” ($n = 4$). One family commented “Getting the initial set up started was difficult. Once we got a routine started it was much easier. It was nice to be able to view the movies at our convenience.”

Parents also reported on the ease of implementing the intervention. When specifically asked about participation three times a week, the majority of the families felt that the schedule was “manageable” ($n = 8$). Two families reported that for some weeks, it was difficult to find the time in their schedule, but as one mother wrote “...if the books were longer, it would have been harder, but the short books made it easy”. With regards to the length of the intervention study, parents used words such as “just enough” ($n = 4$) or “went by quickly” ($n = 6$). One mother felt that if the study was more than 6 weeks “It would have been more of a fight to get ‘Susie’ to participate.”

Parents’ observance of the generalization of targeted vocabulary was captured with the survey question: “How often did you hear your child using the words taught in the intervention throughout the day.” Three themes emerged in the parent answers; “not much” ($n = 4$); “once in awhile” ($n = 5$); and “often” ($n = 4$). Two parents commented that the vocabulary from the Just Going to the Dentist (Mayor, 2001) (nurse, bib, braces, teeth) were heard the most often. One family attributed this to the child’s recent visit to the dentist.

Additionally, parents initiated comments about their child’s interest and engagement although not specifically requested. This is exemplified by one parent’s comment: “When a story did not have an interruption, ‘Joe’ was much more inclined to pay attention.” In response to the parents’ comments further investigation of the child’s interest was conducted to examine differential interest between conditions.

Parents perceived their child’s interest to be “very interested” 50% of the time when they were viewing stories in the treatment condition and 64.3% of the time in the comparison condition. Perceived “semi-interest” for books in the treatment condition occurred 42.9% of the time and 26.2% of the time for the comparison condition. The children perceived to be disinterested when books were assigned to the treatment condition 7.1% of the time and 9.4% of the time in the comparison books.

### Discussion

This study had three main purposes; (a) to describe the potential benefit of an E-book intervention program on vocabulary word learning for children with cochlear implants compared to a read-through condition, (b) to investigate differences in word retention between the treatment and comparison condition,
and (c) to explore the feasibility of a parent-implemented intervention program. The results will be discussed in terms of general findings, key findings, limitations, and clinical implications.

**General Findings**

The results of this intervention study suggest that children with cochlear implants, who use auditory/oral means of communication, demonstrated overall benefit from additional vocabulary instruction when embedded in electronic storybooks. In both the treatment and comparison condition, the children made significant vocabulary gains across three levels of language complexity, providing definitions, labeling pictures, and a receptive pointing task. These findings are consistent with authors who have found that children are able to learn word meanings through incidental exposures (e.g., Robbins & Ehri, 1994; Senechal & Cornell, 1993) and with additional support (e.g., Coyne et al., 2007; Justice et al., 2005).

As expected, children demonstrated greater accuracy in their receptive knowledge compared to their expressive knowledge. This is consistent with prior research substantiating that children’s recognition of words precedes their ability to label and generate definitions. This phenomenon may reflect that for the semantic representation of the word and to accurately access the sound patterns need to retrieve the label and spontaneously produce the word, rather than silently recognize it given a verbal label (Levitt, Roelofs, & Meyer, 1999).

The large variability seen among the children in their pretest definition generation task scores substantiates the varying degrees of expressive language skills seen in children with cochlear implants. The inconsistency in language outcomes after implantation has been attributed to factors such as hearing experience pre-implant, age of implantation, nonverbal IQ, and parent involvement (e.g., Spencer, 2004). Given the variability between children in their language learning and listening experiences after implantation, it is not surprising that we find wide variability across children in their expressive and receptive language performance after implantation.

**Key Findings**

The results of this study indicate that when providing a label or generating a definition to novel vocabulary, children with cochlear implants demonstrate additional benefit from intensified instruction, as compared to a read-through without embedded vocabulary instruction. The intervention package in the current project included enhancement strategies such as preview/review, embedded explanations, and videos, compared to a traditional storybook read-through. After having exposure to the E-book three times with the intensified instruction, the children were able to label significantly more words than when hearing words through incidental exposure within the context of the story. The current findings are consistent with previous authors who have found similar outcomes after providing children with vocabulary building strategies such as providing definitions (Brett et al., 1996; Justice et al., 2005), picture and video support (Chambers, Cheung, Madden, Slavin, & Gifford, 2006; Smeets et al., 2014), and multiple exposures (Penno et al., 2002; Senechal, 1997). Most previous studies incorporating such strategies have utilized live adult–children interactions during shared reading (Mol et al., 2008) and while this study did not compare the effectiveness of parent-child dialogic storybook reading, it suggests E-books could be an effective addition to reading experiences in home and school settings. Although the cause of the instructional advantage cannot be inferred from the data, the additional vocabulary support and highlighting of target vocabulary when it appeared in the text may have served to prime the child’s attention to the target words, making recall of the word label more accessible.

Differential benefit from the treatment vocabulary support, given in the treatment condition, was also seen during the definition generation task. These findings parallel or substantiate the reports of previous authors (e.g., Coyne et al., 2007; Justice et al., 2005; Lofthus et al., 2010) who also demonstrated significant improvements in a child’s production of word definitions when given additional support in vocabulary instruction (preview/review, repeated exposure), compared to incidental word exposure. The children within this study were able to generate more complete and less ambiguous definitions after being given explicit instruction of new vocabulary than when given incidental exposure. Notably, several children used exact wording and definition organization that was modeled in the embedded definitions provided in the treatment condition books. Although it is beyond the scope of the current study to splinter out which components contributed to learning specifically, the multiple exposures to the modeled definitions may have aided their recall by segmenting and reviewing the definition across the several exposures.

Although children were able to provide some semantic features when asked to define target vocabulary, the ability to provide a rich definition was limited even after intervention. This may be due to the children’s limited contextual and vocabulary knowledge that would be needed to provide a more complete definition. It is anticipated that the children may demonstrate greater gains when target vocabulary has contextual or semantic similarity between targeted words that aids in the anchoring of word meaning to similar concepts. Future analysis should compare the word-learning growth and retention in groups of words that were semantically similar (e.g., dock, fishing, bobber) compared to those word groups without an apparent categorical or thematic relationship (e.g., bandana, helmet, chain).

Unlike the expressive labeling and definition generation tasks, there was not significantly greater benefit in the treatment condition for the receptive pointing task. The lack of a differential treatment effect (versus exposure only) may be partially explained by two reasons: (a) receptive recognition is an easier skill that doesn’t require explicit instruction to show gains and (b) there were ceiling effects in the range of growth that limited the difference score and effect size. Theoretically, the receptive task represents a lower level of word knowledge (recognition level) than the expressive labeling and definition generation tasks. If the children were able to correctly label the items, as seen in the expressive labeling task, it would be expected that they would have enough word knowledge to be able to correctly select the item (Verhallen & Bus, 2010). Therefore, it would be expected that the children would be more sensitive to exposure, indirect instruction effects for this level of word knowledge. Although efforts were made to assign storybooks to children in which they had little prior knowledge of targeted vocabulary, for some children, a ceiling effect was reached at pretest for this task. Considerations for this researcher-created task will be discussed further in the limitations section.

**Word Retention**

This study also sought to investigate the maintenance of the child’s vocabulary knowledge after a 2-week period. The purpose
of this intervention was to provide a more robust instruction for novel vocabulary in which word knowledge would not be lost after a few days. This serves to further validate the need for a form of intensified vocabulary instruction for children with cochlear implants and suggests that the novel words may have begun to be slow-mapped into the children’s semantic network.

In the expressive labeling task, children demonstrated significantly greater word retention for vocabulary taught in the treatment condition compared to those in the comparison condition. The greater retention of targeted vocabulary in the delayed posttest task suggests that the additional vocabulary support such as; preview/review, text highlighting, embedded definitions, and phonology highlighting within the treatment condition is beneficial and needed for a more complete understanding of novel vocabulary.

When examining the receptive pointing task, the children did not demonstrate greater word retention in the treatment condition compared to the comparison condition. This finding suggests that for this level of language learning, an intensified form of intervention was not necessary in order for the children to successfully identify target words within the task. This form of assessment may have been less cognitively demanding for the children, as they would have to have only a minimal understanding of the target word’s meaning in order to correctly identify the corresponding item. The incidental exposure to the targeted vocabulary may have been enough to reach this level of familiarity.

**Parent Implementation**

A unique feature of this vocabulary intervention was its implementation by parents in their natural setting, without a researcher present. The children were to view the storybook three times during the week at times that was most convenient for their individual schedules. The high percentage of reported protocol compliance (99%) indicates that this form of intervention is a feasible method for service delivery. In addition, the positive parent comments in regards to the intervention frequency (three times a week) and length (6 weeks) demonstrates an intervention that has little impact on the family routine.

The difference in children’s interest in each condition (treatment or comparison) did not appear remarkable. The children were reported to have slightly more interest in books that were within the comparison condition (rating of “1”) compared to the treatment condition. Overall, however, there was little difference in children’s interest during a typical read-through of the story or when interrupted with further explanations of target vocabulary. The consistent interest in the stories, despite potential interruptions of the flow of the story due to intervention, may be due to the novelty of watching E-books or an influence of parent interest. Future studies may seek to quantify engagement and investigate if interest and engagement varied by storybook, story length, or where the story occurred in the intervention (i.e., interest may have waned over time).

**Limitations and Future Directions**

Despite the significant difference found in word learning between the intervention and comparison condition, caution must be exercised when interpreting these findings. Centers and schools that were invited to participate in this study were those that utilize an auditory-oral approach or framework. Children were recruited from these centers because of the increased probability that they used spoken language for the majority of their day, which was an inclusion criterion of the current study. It may be that the children within this study are more adept to learning the vocabulary in the E-book format, which requires stronger auditory comprehension skills, compared to children that are reliant on visual methods of communication. For this reason, the results of this study may not be generalized to children who are learning language visually (e.g., sign language or Cued Speech).

It is also important to consider that the results of this study reflect the vocabulary learning of children with cochlear implants as a group, without examining individual language or cognitive skill differences that may mediate growth. It may be that if the children were grouped by high and low language skills (Penno et al., 2002; Justice et al., 2005), a greater language growth may have been more evident. As a group, the children in this study scored within average range on expressive, receptive, and nonverbal standardized measures. Therefore, we cannot conclude that this intervention would be as successful for children with below average language skills.

Additionally, the current findings do not necessarily extend to recommendations for parents’ live shared-readings since the stories utilized in this study were prerecorded. This was done in an effort to promote internal validity across the intervention delivery. As a result, storybook readings were somewhat unnatural with limited parent involvement. Reduced interaction with the parents and reliance on hearing a prerecorded story may have negatively affected the children’s performance. In other words, the children may have a greater benefit to 1:1 reading with an adult who could adjust reading style, pace, and support based on the child’s interest, understanding and hearing abilities. Although parent–child interactions during reading continue to be well recognized as an important activity to promote active learning (Salmon, 2013), the current results suggest that E-books can be useful to add to vocabulary learning activities in children’s natural environments such as home and school settings. Comparison in child vocabulary learning from an E-book and face-to-face parent reading would be an interesting future study.

Another potential limitation of the current study is the accuracy of parent report. It cannot be presumed with certainty that the intervention was implemented with fidelity. This intervention study was designed to meet the needs of the individual families and simulate book reading within their daily routine. Families were encouraged to play the story for their child during a time that they would typically read a story with them. The primary investigator asked parents to have their child view the story three times throughout the week, but specific days for book viewing were not scheduled. In addition to documenting child interest, the parent survey served to create a sense of accountability for delivery of the intervention. A noted limitation to this method of intervention delivery is that although parents were told to limit their child to watching the story three times, on 3 different days, they had access to play the story more or less than what was prescribed. Although all parents reportedly followed the treatment protocol, it is uncertain if the reported information is accurate.

The proximal measures for the dependent variables should also be noted in interpreting the findings and effect size observed. The intervention gains were detectable on a measure that drew upon specific words targeted. Because the researcher-created tasks only assessed the children’s word knowledge for the specific words targeted, it cannot be assumed that the vocabulary gains would be detectable on a more distal measure of vocabulary such as performance on a standardized vocabulary test that may not include the exact words targeted.

An additional limitation of the researcher-created probes is in a potential ceiling or upper limit. In other words, the child’s
word gain was restricted by the number of items he/she accurately answered in the receptive pointing and labeling pretests. Additionally, due to the nature of the receptive pointing task, the children had a 25% chance of answering the item correctly through guessing alone. The high average of accurate items answered during pretest in both the treatment and the comparison condition suggests that the majority of the children had receptive recognition of at least half of the total items within each book at pretest. This substantially reduced the potential word gain for this task. Similar results were seen in vocabulary intervention studies that used a receptive language task that was created in the same format, suggesting an issue with the format of the task and suggesting that the results may underestimate the potential receptive language learning given a larger number of possible word growth or unrestricted measures (Loftus et al., 2010; Lugo-Neris et al., 2010).

**Clinical Implications**

The multimedia nature of the E-books gives children access to storybooks and texts before they are able to independently read. Previous authors have demonstrated the value of using interactive E-books when teaching vocabulary to young children (Hoffman, Teale, & Paciga, 2014; Korat, 2010; Shamir, Korat, & Shlafer, 2011; Verhallen & Bus, 2010). Those with less developed language skills who are unable to fully benefit from the verbal explanation of targeted vocabulary may also benefit from the images and videos provided (Korat, 2010; Shamir et al., 2011; Verhallen & Bus, 2010). The intent of this study is not to suggest that the use of electronic storybooks is the only and best method for development of vocabulary for children with cochlear implants. Instead, educators and parents can use storybooks as a means to build on a child’s prior knowledge, discover where vocabulary gaps may be occurring, and help to support and develop the understanding of words that are already in their lexicon.

A child’s depth of word knowledge reflects they not only are able to verbally produce a definition, label a picture, or point to it, but they have some knowledge of how the word fits into the world. The plethora of research related to vocabulary acquisition suggests that there is a significant complexity to how a child develops his/her lexical map. The method to how educators can tap into a child’s lexicon and support the expansion and connection to other words in their world cannot be the result of a single type of vocabulary instruction. A notable disadvantage that children with hearing loss have to their hearing peers is a limited speech perception (Blamey et al., 2001). As a result of hearing segments of conversation and words, the vocabulary for children with hearing loss has been described as “swiss cheese effect” (Johnson, 2005). In addition, when considering the reduction in word-learning opportunities as a result of missed listening opportunities, there will inevitably have a negative effect on how the child develops his/her semantic networks (Fagan & Pisoni, 2010). Educators and parents of children with hearing loss can reduce these negative side-effects by using strategies such as increasing the children’s encounters with novel words, explaining word meanings, and extending the meanings to the child’s world. This intervention study is one example of how parents and educators can successfully use these types of strategies for explicit instruction within the readily accessible context of shared reading.

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**Conflicts of Interest**

No conflicts of interest were reported.

**References**


Davidson, L. S. (2010). Comparing speech perception of children with cochlear implants or hearing aids. Perspectives on Hearing and Hearing Disorders in Childhood, 20, 70–75. doi:10.1044/hhdc20.2.70


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## Appendix A

<table>
<thead>
<tr>
<th>Words targeted</th>
<th>Length (min:s)</th>
<th># times used in intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Treatment</td>
</tr>
<tr>
<td>Chameleon, claws, bark, spikes</td>
<td>7:20</td>
<td>2:22</td>
</tr>
<tr>
<td>Chain, helmet, overall, pedal</td>
<td>10:09</td>
<td>5:39</td>
</tr>
<tr>
<td>Fins, grasshopper, shovel, visor</td>
<td>7:58</td>
<td>2:27</td>
</tr>
<tr>
<td>Ambulance, stethoscope, cast, crutches</td>
<td>10:39</td>
<td>4:05</td>
</tr>
<tr>
<td>Hook, basket, dock, bobber</td>
<td>10:42</td>
<td>5:01</td>
</tr>
<tr>
<td>Goggles, cape, crater, broom</td>
<td>7:35</td>
<td>3:46</td>
</tr>
<tr>
<td>Blueberry, griddle, spatula, syrup</td>
<td>12:47</td>
<td>5:50</td>
</tr>
<tr>
<td>Nurse, tooth, bib, braces</td>
<td>8:30</td>
<td>3:13</td>
</tr>
<tr>
<td>Alarm clock, bandana, sleeping bag, suspenders</td>
<td>16:35</td>
<td>8:07</td>
</tr>
<tr>
<td>Beak, comb, seed, wheat</td>
<td>15:37</td>
<td>5:12</td>
</tr>
<tr>
<td>Dough, tomato, cheese, measuring cup</td>
<td>9:52</td>
<td>2:50</td>
</tr>
<tr>
<td>Compass, whistle, wool, trail</td>
<td>16:37</td>
<td>1:59</td>
</tr>
</tbody>
</table>

Number of books by condition 54 55

## Appendix B

**Directions emailed to parents regarding book viewing:**

Hello (INSERT PARENT NAME),
The link for the first book was just sent through a GoogleDrive account. Please let me know if it does not appear in your email. Sometimes it gets put into the junk folder, so check there as well.

Have (INSERT CHILD’s NAME) watch the story three times this week (viewings on different days). Please take care to reduce any visual and/or auditory distractions before beginning the story so that (INSERT CHILD NAME) can get the full benefit from the vocabulary instruction. Although the stories selected are short in length, (INSERT CHILD NAME) may need to be redirected to the story, please do so when needed.

Each time (INSERT CHILD NAME) watches the story, please jot down the date and answers to the survey at the end of this email. You can either email me the answers or hold onto them and report them at the end of the week during our online meetings.

We will meet online using the Blackboard Collaborate program on (INSERT DAY AND TIME). Please have (INSERT CHILD NAME) view the story three times before that day. If you have any technology issues or need to reschedule the meeting please do not hesitate to call or email me.

Parent survey to be completed after each storybook viewing:

**What is your relationship to the child?**

**How would you rate your child’s interest in this activity?**

**How confident are you in observing your child’s interest?**
1. I was next to him/her the whole time
2. I checked on him/her
3. I was not in the same room

**How many times did you have to guide your child back to the story?**
1. 0 times  2. 1–2 times  3. 3–4 times  4. more than 5 times

**How would you rate the child’s listening environment**