THE EFFECTS OF ENHANCED E-BOOKS ON YOUNG CHILDREN'S STORY COMPREHENSION AND VOCABULARY GROWTH

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Abstract

Background: Experimental studies investigating the effects of multimedia e-book enhancements such as animation, music and sounds, showed beneficial effects on 4- to 6-year-old children's learning. **Problem Statement**: However, few studies have included younger children (3-4 year old) in investigating the effects of e-book features on their story comprehension and word learning, nor have studies fully unraveled the effects of the various multimedia e-book features. **Purpose:** The purpose of the current study was to disentangle the effects of animation and music/sounds on children's story comprehension and vocabulary word learning, and investigate whether the effects of the enhancements in digital e-books vary with age groups. **Methods:** One hundred and thirty-six children from two different school age groups participated in the study. Seventy 3-4 year old children and sixty-six 5-6 year old children from 8 child care centers and elementary schools in the Southwest part of the United States were stratified for age and center, then randomly assigned to four experimental conditions. A balanced design was approximated in the four conditions with both the illustrations in the books (with or without animation) and (with or without music and sounds). The children read the same version of the story three times within three weeks. The Peabody Picture Vocabulary Test, fourth Edition (PPVT-4) screening assessment assessed children's prior vocabulary level and was used as a covariate. The posttests included book-based receptive and expressive vocabulary acquisition tests and comprehension of the target story. **Data Analysis:** Multiple linear regression was used to analyze which multimedia enhancement - animation or music and sounds, or a combination of both - was more effective to enhance learning, and whether the benefit from e-book enhancements varied by age groups. **Results:** Enhanced stories were more effective in supporting younger children's story comprehension than a story without enhancements. Targeting older children (5-6 year old), enhancements were in particular beneficial for promoting

expressive vocabulary acquisition. Either animation or music and sounds was a more favorable format than the combination of animation and music and sound in one format in promoting younger children's story comprehension and all children's receptive and expressive vocabulary. **Discussion:** The findings align with Mayer's (2009) temporal congruity principle and redundancy principle of the cognitive theory of multimedia learning. Practical implications are a better definition of well-designed e-books to implement in the school curriculum and family literacy, to consider by app designers when designing effective and educational e-books.

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Chapter I

Introduction

Reading is a key to language and literacy development as appears from several meta-analyses (Bus, Van IJzendoorn, & Pellegrini, 1995). Book reading enables the enjoyment of stories as children are more successful in making meaning of stories, thus their language proficiency is promoted as well. Therefore, it is important to develop young children's language and literacy skills from an early age through reading.

Nowadays, reading is not limited to print books. Usage of technology devices for reading is getting increasingly prevalent. It is reported that 51% of 2- to 4 years-old and 31% of 5- to 7-years-old are exposed to educational media devices daily (Rideout, 2014). E-books are accessible on all kinds of multimedia devices, such as touchscreens, iPads, or smartphones. E-books may include multimedia enhancements such as animated illustrations, music and sounds. Scholars focused on enhancements enabled by technology investigating whether they support young children's emergent literacy, including vocabulary learning and story comprehension. They examined enhanced e-books including animation, music and sounds, and found improvement in children's story comprehension and vocabulary learning though not all enhancements seemed to support meaning making (Bus, Takacs, & Kegel, 2015).

Verhallen, Bus, and de Jong (2006) examined the effectiveness of multimedia books on kindergarten children's vocabulary growth and story comprehension. The researchers found that enhanced e-books were beneficial for children learning Dutch as a second language. The findings revealed that e-books excluded animation, sounds, and oral reading made it more difficult for young children to grasp the story line – the authors referred to this as implied story events (Verhallen et al., 2006). Several follow-up studies showed that that children could retell the

story and learn the new words in particular after watching the animated illustrations (Sarı, Başal, Takacs, & Bus 2019; Takacs & Bus, 2016).

However, the number of studies disentangling the effects of various enhancements in electronic books is limited. In a meta-analysis, Takacs, Swart, and Bus (2015) found 43 studies (published between 1980 and 2014, 24 studies conducted in the US) comparing technology enhancements in the digital stories with traditional print books studies. Very few studies tested the effects of enhancements - animation as well as music and sounds – separately; more research is needed to better understand the effects of digital enhancements (Takacs et al., 2015).

Purpose of the Study

In this digital reading era, the specific mechanisms involved in e-book learning are unknown and future research work should focus on investigating the effects of e-book multimedia features on learning (Miller & Warschauer, 2013). More specifically, research should focus on effective feature designs to promote literacy development by technology affordances (Miller & Warschauer, 2013). Therefore, the purpose of the current study was to examine which multimedia e-book digital enhancements (animation, music and sounds, separately or combined) benefit 3-6 years old urban children in receptive and expressive vocabulary acquisition and story comprehension. The research investigated how e-book enhancements influence children's vocabulary word learning and story comprehension. It was hypothesized that children performed better from reading e-books that include digital enhancements as compared to an e-book format with static pictures and a voice-over. It was expected that single enhancement, either animation or music/sounds, was a better format for promoting learning. Animation was expected to be more effective than music and sounds.

Another purpose was to determine whether younger children benefitted more from multimedia e-books than older children.

Research Questions

The research focused on whether electronic book enhancements (animation, music and sounds) stimulated children's story comprehension and therefore contributed to them learning vocabulary words and whether language proficiency moderated effects. Another question was to find out which age group benefitted more from e-book reading.

Five hypotheses were tested in the current study:

- e-books with add-ons (enhancements), animation including visual camera movements and motion, music and environmental sounds, or both combined, may promote story comprehension and receptive and expressive vocabulary acquisition;
- e-books with visual enhancement may be more effective than e-books with auditory enhancement, particularly for vocabulary learning;
- two non-verbal information sources, animation and music/sounds presented simultaneously, may result in learning decrements compared to the presentation of one source of information, animation or music/sounds; redundancy may cause cognitive overload;
- children's vocabulary learning and story comprehension may depend on the effect of language proficiency.
- younger children may benefit more from reading the e-books with enhancements as compared to older children; language advanced children may less in need for support of understanding the narration.

Relevant Terminologies

Technology enhancements. Digital enhancements, such as animated illustrations (visual) or background music and sounds (auditory), are added in a way that they correspond with the narration (Takacs et al., 2015). Animation and music/sounds can be defined as nonverbal information, while narration can be referred to as verbal information (Takacs et al., 2015).

Receptive and expressive vocabulary acquisition. Receptive vocabulary refers that a person can comprehend and respond to the words meaning, even if the person cannot produce those words; while expressive vocabulary means that children can express or use words, for instance by completing a sentence with the target word (Smeets & Bus, 2012a). In this study, expressive vocabulary focused on testing children's expressive vocabulary acquisition, which means that children complete a sentence with a target word based on the learning from the digital story that they exposed to three times viewing and listening.

E-books. E-books are picture storybooks presenting a literary story in words and pictures enhanced with animated pictures, music and sounds, oral narration, embedded learning activities, or games (Korat, 2010; Smeets & Bus, 2015). E-books can be contained in a variety of hardware, such as CD-ROM storybooks or DVDs; e-book stories can also be accessed by using a tablet or a smartphone (Takacs et al., 2015). The e-book implemented in the current study was designed by a professional designer based on the multimedia learning theory, and added with multimedia features including animation and/or music and sounds.

Repetitive readings. Repeated reading of the same story boosts children's story word learning (Korat 2009; Verhallen & Bus, 2010), and enhances story understanding (Penno, Wikinson, & Moore, 2002). Verhallen and Bus (2011) tracked children's eye fixation during the

digital story watching and listening. During the fourth time reading, children were less likely to jump from one detail to another on the screen. Instead, they were more focused on certain details for a longer time. The authors explained that after three times watching and listening to the story, children were better in connecting verbal and visual information. Compared to two times reading, children gained 17% more vocabulary knowledge with four times exposure to the digital story reading (Smeets & Bus, 2012a; Smeets & Bus, 2012b). According to the research evidence, three to four repetitions might be the optimal frequency (Penno et al., 2002; Verhallen et al., 2006).

Chapter II

Review of Related Literature

This section describes basic theoretical concepts for a clear understanding of multimedia learning and related principles. Next, the literature review section highlights the effects of multimedia features, animation and music/sounds, in a multimedia digital story.

Multimedia Theoretical Framework

The current study enumerates principles form multimedia learning theory that may explain the effects of the technology enhancements in digital stories. The section explains the theoretical concepts of the multimedia learning theory, and derives from the theory principles that underlie the multimedia format: the temporal contiguity principle and redundancy principle.

Multimedia learning theory. It highlights learning from the presentations of words and illustrations rather than words presented alone (Mayer, 2009). Multimedia learning emphasizes that visual and verbal information presented in combination, are more effective than words alone (Mayer, 2014). Therefore, we assume that picture books that include verbal and visual sources are beneficial for children in learning story contents and vocabulary words (Sarı et al., 2019).

Temporal contiguity principle. Children benefit more from learning activities when illustrations and narration are attended simultaneously rather than in sequential order (Mayer 2009). When verbal and visual information are closely matched, children are better able to build the connection between both information and to hold mental representations of both information in working memory (Mayer, 2009). The e-book in the current research included illustrations animated in a way that was in sync with the narration, which predicted that children learned more new words and understood story events better as compared to a format without this

addition. For example, when narration expresses that the butterflies are fluttering, the animated illustration presents fluttering motions to support learning the vocabulary word fluttering.

Redundancy principle. Learning may decrement when the same information is presented in multiple formats simultaneously (Mayer, 2009). The redundancy principle predicts that when information is redundant, it requires children to make extra mental effort and this may cause cognitive overload (Mayer, 2009). In the current study, we assumed that when animations and music and sounds provided the same information (we see the giraffes running while we hear the sound of hurt running by), this may increase the cognitive load and thereby diminish learning. When attention is attracted to the same concepts through different (visual and auditory) sources, this may cause cognitive overload resulting in a negative effect on learning new vocabulary words and story comprehension. Elimination of one of the sources may improve learning.

Animated Presentation in a Multimedia Digital Story

Research showed that animated illustrations promoted children's learning. For example, children who watched and listened to multimedia e-books with animation and narration learned more new words than those who exposed to an e-book with static pictures and narration (Verhallen & Bus, 2010). This additional visual information in digital books may also improve story comprehension (Sarı et al., 2019). According to Mayer's (2009) temporal congruity principle, when visual and verbal information are bonded together in the presentation, these scaffold learning. In the current study, we focused on visual information optimally matched with verbal information to draw children's visual attention to the relevant story details in illustrations. Animated illustrations included zooming in and motion techniques may guide children's visual attention in sync with the narration.

The efficacy of integrated visual and verbal information. A close match between narration and illustrations (temporal contiguity) enables children to make mental connections between verbal and visual information (Mayer, 2001). Temporal contiguity is in line with Paivio's (1986) dual coding theory that verbal and visual information processing requires two channels, the visual and auditory. When matching visual and verbal information sources are processed in both channels simultaneously, learning is more effective, which makes it easier for children to learn new vocabulary words and understand and retain story events. It implies that visual and verbal information should be well combined in the presentation so that the key information from both visual and verbal information can be acquired at the same time (Takacs et. al, 2015).

Verbal and visual information process through two channels at the same time, which assists children to build mental connections of narration and picture representations (Paivio, 2007). Evidence showed that children performed better in recalling story events with the visual and verbal information presented together (Hayes, Kelly, & Mandel, 1986). Visual information also assisted children to better understanding of the story and therefore acquired the meaning of new words (Smeets & Bus, 2012a; Verhallen et al., 2006). Yet, designers must be aware that when visual material is incongruent with narration, the mismatched information may interfere with children learning new words from the story (Flack & Horst, 2017) and mislead children to construct a different meaning of the story events (Beck & McKeown, 2001).

In Takacs and colleagues' (2015) meta-analysis, the authors analyzed the effects of technological enhancements on children's vocabulary learning and story comprehension. They concluded that when animated pictures were closely matched to the verbal narration, young children's learning improved. They hypothesized that when the picture and narration were not

presented at the same time, it was hard for children to make a connection between visual and verbal information, which may result in inaccurate word knowledge storing for the expressive vocabulary word knowledge (Stahl, 1999).

Verhallen and Bus (2011) used an eye-tracker to trace kindergarten children's eye fixation during watching digital stories with five experimental digital picture storybooks. They found that children's visual attention was guided by verbal information. Children paid longer and more frequent attention to the visual illustrations with verbal information highlights (Verhallen & Bus, 2011; Takacs & Bus, 2016). Similarly, Takacs and Bus (2016) also found that when the illustrations were referred to the oral text, children paid more visual attention to details in illustrations. This is also evidenced in Evans and Saint-Aubin's (2005) finding that children's eye fixations on details in illustrations increased when these details were mentioned in the oral text. Moreover, children also fixated details of the illustrations longer when those were highlighted by the oral text; this may deepen children's understanding of the detailed illustrations and better integration of the verbal and visual information (Takacs & Bus, 2016).

The effects of animated enhancements. Animated e-books imply media techniques that can maximize the connection of visual and verbal information; motion and zooming effects can guide children's attention to the elements depicted in the illustrations where the oral reading refers to (Smeets & Bus, 2012a), thus facilitating those young children extract deeper meaning of words or phrases as compared to static illustrations (Smeets, van Dijken, & Bus, 2014). For example, when the narration addresses that monkeys are jumping from tree to tree, the motion and corresponding narration presented at the same time, this may help children understand the meaning of jumping from tree to tree and what is meant when the actions are denoted as dangerous. When jumping from tree to tree and narrations are closely matched, children can

build a connection between the words and motion illustrations in working memory (Baddeley, 1998). According to Paivio's (2007) cognitive theory, visual illustrations presented simultaneously with the text may result in stronger memory traces, thus revealing an increase in meaning-making and expressive vocabulary learning. Verhallen and Bus (2010) claimed that children exposed to animated illustrations learned more new vocabulary than from static pictures alone, especially in forms of expressive words.

Takacs and Bus (2016) investigated the effects of illustrations added motion on children's story comprehension and vocabulary word learning. The results showed that motion alone without music and sounds increases story comprehension. This aligns research showing that children's attention was attracted by motion (Levin & Anderson, 1976; Alwitt, Anderson, Lorch, & Levin, 1980). In other words, when motion corresponds with the narration, beneficial learning may take place. Zooming in is another technique that can be used to match illustration and narration (Smith, Anderson, & Fischer, 1985). For instance, in the digital story used in the current study, the narration describes that the Mama Kangaroo is proud that little Kangaroo can hop on her own, and at the same time the camera zooms in on the Mama Kangaroo's happy and proud face. In other words, zooming in and motion are both techniques that attract children's attention to visualizations of story events in sync with the narration thereby promoting children's story comprehension (Smith et al., 1985).

Music and Sounds in Multimedia Digital Story

Music may stimulate the learner's arousal level and mood, thus enhancing their story comprehension (Schellenberg, 2005). For instance, when the narration in the e-book story Little Kangaroo explains that the world is much more exciting than the mama's pouch, happy background music highlights at the same time this mental model of the story scenario. Sound

effects may increase children's attention to the story events and maximize their comprehension (Anderson, Lorch, Field, & Sanders, 1981). For example, in the current e-book story, when mama Kangaroo is too tired of carrying the little Kangaroo for a long time, the background music and sounds saddened, thus matching mama Kangaroo's state of exhaustion. Such cues may help children construct a coherent mental model of the story details and apprehend the story events, and thus they may learn new vocabulary words.

More evidence confirmed that perceptual salient features, such as music and sounds, highly increase young children's attention when reading the story (Alwitt et al., 1980; Barr, Zack, Garcia, & Muentener, 2008; Huston & Wright, 1983); children become more engaged in the story and may deeply process the information (Barr et al., 2008). According to Schnotz's (2014) the integrated model principle, nonverbal information, such as music and sounds, is conveyed to working memory and may help to construct mental representations, thus facilitating content comprehension.

Additionally, when children heard the familiar music that matched with the previous learning content, background music may serve as an auditory retrieval cue to facilitate children to recover the memory from previous learning (Fagen, Prigot, Carroll, Pioli, Stein, & Franco, 1997). Thus, repeated reading of the digital stories accompanied by background music may scaffold young children to learn new vocabulary words. When sound effects are matched with animation in a video demonstration, it attracted children's attention to the targeted motions, and thus improved their learning (Barr, Shuck, Salerno, Atkinson, & Linebarger, 2010) as well. Nevertheless, the fact that some studies show negative effects of music and sounds cannot be ignored. Music and sounds might interfere with learning when there is a mismatch with the visual content (Barr, Wyss, & Somanader, 2009). Background music might also create cognitive

overload and distract attention from the visualizations, thereby interfering with learning (Barr et al., 2010; Su, Kao, Hsu, Pan, Cheng, & Huang, 2017). Furthermore, music and sounds as extraneous sources added to the oral rendition of text may interfere with children's learning of unknown words (Smeets et al., 2014). This is in line with Mayer's (2009) coherence principle, which states that when extraneous materials are included, learning will diminish. Moreover, two auditory modalities, music/sounds and narration, use the same channel to process information (Paivio, 2007), thereby creating a situation in which both compete for limited cognitive processing capacity in working memory. Background music and sounds may interfere with isolating words from narration, which may impede learning new words (Sarı et al., 2019). In sum, music and sounds could divert attention from narration, interrupt information process in the mental representation, or link visual and verbal information inappropriately (Mayer, 2009).

According to the *redundancy principle* (Kalyuga & Sweller, 2014), the same information is presented by multiple media formats simultaneously, which demands processing extraneous information and this may limit the child's cognitive ability due to processing unnecessary sources. When more modalities are activated for one information source, young children are easily overloaded. The perception of verbal information may be negatively affected by the presentation of music and sounds and this may interfere with children's learning. As a result, learning is inhibited.

Summary

The purpose of the study was to investigate the effects of digital enhancements on 3-6 years old children's vocabulary word learning and story comprehension. The study aimed at testing effects of enhancements and comparing the efficacy of the combined enhancements with

the single visual and auditory enhancements among two groups of young children's learning outcomes.

Few studies studied the effects of digital enhancements, especially for preschool-age children. In a pilot study, I found that either animation or music and sounds supported preschool-age children's learning new words and story comprehension. Contrary to the results of my pilot study, Sarı and the colleagues (2019) found that kindergarten children's learning was disrupted by music and sounds, but stimulated by animation.

Further, the pilot study revealed another result that when animation and music and sounds were combined in one digital format, children learned less compared to a single enhancement. This result is in line with Mayer's (2009) redundancy principle, predicting that redundant information causes cognitive overload. Sarı and the colleagues (2019) found that music and sounds interrupted with learning new vocabulary, which matches the outcomes of Mayer's (2009) modality principle. The modality principle addresses that when music and sounds plus narration are processed in the auditory channel, this may impose extraneous cognitive load that causes a negative impact on children's learning due to the auditory masking (Sarı et al., 2019). Due to the inconsistent results from the two studies, the current study including 3-6 years old reexamined the effects of digital enhancements in one urban education settings. The aim of this study was to find out whether animation as well as background music and sounds were supportive techniques in the digital stories for young children.

Chapter III

Method

Participants

One hundred and forty-eight (148) children received parents' consent to participate in the research activities. Twelve children (12) did not meet the participation criteria or dropped out. Therefore, 136 children participated in all activities. Children aged between 3 to 6 years (M = 56.18, SD = 12.94) with 53 girls and 83 boys. None of the participating children had a hearing, visual, language impairments, or learning disabilities. Prior to the data collection, a power analysis (g*power) revealed a minimum of sample size for each age group 55 given the effect size of .90 in a mixed linear model.

The participating children were from five child care centers and three schools located in the southwest urban area of USA. One private child care center is religion-based and serves children from toddler to Kindergarten age. Most of the children are white and a small portion is Hispanic and Asian, and most of them are from the middle--class families. Another religion-based child care center serves diverse background children from toddler to Kindergarten age. Most of the children are White and Asian from middle-class families. Another participating child care center is affiliated with a university and serves diverse background children with a high percentage of White followed by Asian American, Hispanic, and African American. The center provides Spanish language immersion learning. They only accept children whose parents are university alumni or current students. The children are from low- or middle-class families. One community child care center serves mostly Asian children from 15 months to 5 years old. Children are from low- or middle-class families. Another community child care center serves low-income children from infant to 4 years old. Most of the children and teachers are Hispanic or

African American. One elementary school is affiliated with a university that serves diverse children and more than half of them from low-income families. Nearly 20% of the students are at the risk of dropping out of school. Most of the students are African American and Hispanic and with a small portion of White and Asian. Another private school serves diverse children from toddlers to eight graders. Half of the children are White, another nearly half of the children are Asian and Hispanic, a small portion is African American and other ethnicities. Another religion-based school serves the majority of African American children from preschool to fifth graders and they are from low-income families.

Research Design

The design of the study was a randomized controlled experimental study. Prior to the intervention, all the children took a PPVT vocabulary screening assessment. During the intervention, for each age group, individual children, stratified for age and center/school, were randomly assigned to the four e-book conditions. A balanced design was approximated in the four conditions by manipulating both the illustrations in the books (with or without animation) and (with or without music and sounds). All e-books include the same narration, but the four versions differed as follows:

(1) an e-book with animated illustrations, music and sounds;

(2) an e-book with animated illustrations, no music and sounds;

(3) an e-book with static illustrations, music and sounds;

(4) an e-book with static illustrations, no music and sounds.

An overview of the conditions number of children in each is presented in Table 1.

Table 1

Overview of the Assigned Conditions

	Animated		Static	
Music/sounds	With	Without	With	Without
Younger children (*N*)	23	19	17	11
Older children (*N*)	22	16	15	13

The total number of younger children participating in this study was 70 and the total number of older children was 66. The participating children viewed and listened to the assigned e-book format for about 5 minutes per time for three times within three weeks in a quiet room. Penno and the colleagues (2002) reported that reading the story at least 2-3 times is needed to enhance story understanding. During the first two sessions, four children were allowed in one room to watch and listen to the assigned e-book format by using a laptop and a headphone. The researcher provided participating children technical support. During the third time e-book reading, only one child at a time watched and listened to the same e-book format in the room because the post-tests were administered immediately after the third session. Immediately after the third time watching and listening to the digital story, each child took post-tests of book-based receptive and expressive vocabulary acquisition and story comprehension.

Measurement

Pre-test.

Screening assessment instrument. The Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4) was used to assess all the participating children's vocabulary level (Dunn & Dunn, 2007). The average internal consistency reliability of PPVT-4 was .94 or. 95 for the assessment. The average test-retest correlation between was .93. The assessment contained 228 test items that covered 19 sets; each set covered 12 items. Each item included four colorful pictures displayed

on one page. During the one-on-one assessment, a training easel was placed on the table, the examiner said a word and asked the child to respond by pointing the picture that corresponded to the word. For example, the examiner said to a child that "Put your finger on [word]." When the child made eight or more errors in one item set, the ceiling was established, and the test was stopped. The assessment took 10 -15 minutes depending on the children's language skills and the total correct items was calculated right after the test.

Post-tests.

Receptive vocabulary instrument. Twenty words (verbs, nouns, adjectives) and phrases from the story were chosen for the digital book-based post-test receptive vocabulary assessment. These are infrequent or low-frequency words for children (College of Education and Human Sciences, 2019). The selected words are not included in the word frequency list of American English (Davies and Gardner, 2010), such as exhausted, run across, pride, etc. The researcher designed a vocabulary test based on the PPVT-4 model. The pictures illustrated for the assessment were selected from the story. For example, the researcher asked the child, "Here are the four pictures, point to picture that shows 'exhausted'." Cronbach's Alpha reliability equaled .738.

Expressive vocabulary acquisition instrument. The expressive vocabulary acquisition assessment used the same set of the vocabulary words that selected for the receptive vocabulary test. The computer displayed a picture from the digital story used in the current study and read to the child an incomplete sentence that missed the target word. The last word was the target word for the child to complete the sentence based on the presented picture. The similar test was implemented by Sarı and the colleagues' (2019) study. For example, "Baby Kangaroo likes the

monkeys, but swinging in the trees is _ [dangerous]". The Cronbach's Alpha reliability equaled .730.

Story comprehension instrument. For the story comprehension, the instrument was constructed similar to Paris and Paris's (2003) Narrative Comprehension Instrument, which included five explicit questions and five implicit questions to assess children's understanding of the story. Explicit questions assessed if children can retell basic information including characters, setting, problem, and solutions. For example, "Who are the main characters in the story?" Implicit questions assess children if they can make inferences based on the picture in the story. For example, "This is the last picture in the story. What do you think happens next?" (Paris & Paris, 2003). These questions aimed at assessing children's understanding of the story content in terms of problem-solving, initiating event, emotions, dialogue, prediction, etc. The ICC equaled 0.96 [95% CI= .90, .98] and the Cronbach's Alpha reliability.746.

Electronic Books

The story of Little Kangaroo (Van Genechten, 2005) was translated into English and presented on the computer. Only children who are unfamiliar with the story were included in the experiment. The story was about a Mama Kangaroo who tries to encourage the Little Kangaroo to get out of the comfortable pouch and to explore the world. All four formats shared the same story content, illustrations and the same voice recording of the narration. The versions of this book differed in whether or not the illustrations were animated and whether or not music and sounds were added. Comparing the animated and static versions, the quality of the resolution was the same. Animation was created by adding zooming in and motion to the illustrations; this was done in a way that the visualizations were in sync with the narration. For example, when Mama Kangaroo was trying to take the Little Kangaroo out of her pouch, this action matched with what

was explained in the narration. In the conditions with static pictures, children watched the illustration of the same scene, but without motion or zooming in attracting children's visual attention to the relevant details of the picture (little kangaroo, the mama's actions). In addition, music and sounds were added to the digital book matching the story events. Music highlighted the moods of the characters, while sounds represented the environment. For example, when the giraffes were running across the plain, there was the sounds of a hurt running by. When Mama Kangaroo was watching Little Kangaroo hopping on her own, the music was cheerful thus highlighting how happy mother kangaroo felt about this.

Data Collection Procedure

Parents and child consent were obtained before data collection using University IRB approval consent forms.

Screening assessment. All the participants took a screening assessment using the PPTV-4 instrument in a quiet room. The assessment procedure followed the protocol established with PPVT-4, such as: in the beginning, the researcher built a rapport with the child, then the researcher explained to the child that, "We are going to play a picture game and you are free to stop the game anytime if you want to." The researcher gave an example and said, "During the game, I will ask you to point to the picture that shows the word that I say." The researcher practiced the activity with the child until the child felt comfortable and then proceeded with the test.

When starting the test, a baseline was set for each child following the PPVT-4 testing protocol. The test was stopped when the child makes eight errors in the item set. The researcher calculated the score immediately after the test. The researcher thanked the child and took the

child to the staff who was waiting outside of the room. The assessment took about 10-15 minutes according to each child's vocabulary ability.

Post-Tests. Each child participated in a post-test on receptive and expressive vocabulary acquisition and story comprehension. For the receptive vocabulary knowledge, the researcher showed four pictures related to the digital study on the computer screen for each target word, they pointed to the picture on the screen that shows the word the researcher said. For the expressive vocabulary acquisition knowledge, the researcher presented a picture and read the incomplete sentence correspondent to the picture, and asked the children to complete the sentence with the target word. For the story comprehension, the research asked ten open-ended questions with correspondent pictures from the story and each child answered the questions through oral responses. The researcher did not give any comments to the response. The post-test took about 15 minutes for each child.

Data Analysis

A series of mixed-effects regression models (also called multilevel or mixed model) were conducted with different outcomes (receptive vocabulary, expressive vocabulary, story comprehension) using SPSS 25. The mixed model considers fixed effects or variation that is explained by the independent variables. For each mixed model, fixed effects were three contrasts: enhancements versus static condition, combined animation and music and sounds versus either animation or music and sounds, and animation versus music and sounds. The mixed model also considers the random effects that are not explained by the independent variables. Due to the cluster data structure (students nested within center/school), random effects were variation associated with centers/schools (Snijders & Bosker, 2012). PPVT scores were entered in the

models as a covariate. PPVT scores were centered to assure an easier interpretation of the regression coefficients.

The models were run for younger and older children separately. Three orthogonal contrasts were created to test the hypotheses. Contrast (1): three conditions including enhancements versus static condition. This contrast was to test the first research question that e-books with enhancements were more effective than the static format without enhancements (animated pictures and music and sounds) in promoting children's vocabulary learning and story comprehension. Contrast (2): all enhancements (animation and music and sounds) versus either animation or music and sounds. This contrast was to answer the research question that an e-book with combined sources (animation and music/sounds) would be less effective than an e-book with one add-on (animation or music/sounds). Contrast (3): animation versus music and sounds condition. This contrast was to test whether an e-book with visual enhancement was more effective than an e-book with auditory enhancement. Next, interaction between language proficiency and contrasts were entered to test whether effects of conditions depended on the effect of language proficiency. All interactions were non-significant and thus were excluded in the final model. Finally, data analysis was carried out for younger and older children separately to test whether younger children's story comprehension and vocabulary words improved more than older children because older children are more advanced in language and therefore less dependent on conditions.

The effect size (Cohen's d) was calculated when the contrasts showed significant effects. Finally, it was compared which groups of children (younger or older children) benefitted more from digital book reading in vocabulary word learning and story comprehension.

Chapter IV

Results

Analyses were carried out for older and younger children separately to compare each groups children's learning growth. In the younger group (n = 70) children's age in months averaged 45.79 months, and in the older group (n = 66) children's age in months averaged 67.02 months. For younger children, 68 out of 70 children's parents reported that 72% of the children's home language was English. Sixty-seven (67) out of 70 parents reported that slightly more than half (57%) of them were full-time employed, 24% of them were part-time employed, and 19% were unemployed (housewife or student). For older group of children, 63 out of 66 parents reported that 92% of the children's home language was English. Sixty-one (61) out of 66 mothers reported that 79% of the mothers were full-time employed, 7% were part-time employed, and 15% were unemployed (housewife or student).

Table 2 illustrates an overview of descriptive statistics for the four digital book conditions for younger and older groups of children. Normality, outliers, skewness, and linearity were checked for satisfactory. Each of the outcome variables followed a normal distribution. There were no outliers for the three posttest scores. The linearity showed that the PPVT (centered) scores in the regression have a straight-line relationship with each posttest variables.

Table 2

Descriptive Information for Younger and Older Children (Mean and Standard Deviations) Per Condition

		Animation +Music/ sounds	Animation	Music/ Sounds	Static	Total	Statistics
				Younger Children			
n		23	19	17	11	70	
Age in months		45.96(5.87)	45.42(6.49)	46.00(5.52)	45.73(6.08)	45.79(5.87)	$F(3,66)=0.04$
Boys/Girls		9/14	14/5	12/5	7/4	42/28	$\chi^2(3)=0.09$
PPVT(raw)		58.09(26.73)	55.26(23.42)	57.24(26.33)	55.91(21.95)	56.77(24.55)	$F(3,66)=0.05$
PPVT_ centered		-17.24(26.73)	-20.07 (23.42)	-18.09 (26.33)	-19.42 (21.95)	-18.56 (24.55)	
Ethnicity							$\chi^2(12)=0.28$
	Asian	10(14%)	5(7%)	8(11%)	4(6%)	27(39%)	
	African American	2(3%)	0	1(1%)	1(1%)	4(6%)	
	Hispanic or Latino	2(3%)	7(10%)	2(3%)	0	11 (16%)	
	White	9(13%)	6(9%)	6(9%)	5(7%)	26(37%)	
	Others	0	1(1%)	0	1 (1%)	2(3%)	
	Total	23	19	17	11	70	
Mother's Education							$\chi^2(12)=0.38$
	High School	2(3%)	4(6%)	3(4%)	0	9 (13%)	
	Associate Degree	0	3(4%)	3(4%)	2(3%)	8(12%)	
	Bachelor	5(7%)	2(3%)	3(4%)	4(6%)	14(21%)	
	Master's	7(10%)	6(9%)	2(3%)	2(3%)	17(25%)	
	Doctorate	8(12%)	4(6%)	6(9%)	2(3%)	20(29%)	
	Total	22	19	17	10	68	
				Older Children			
n		22	16	15	13	66	
Age in months		67.05 (9.10)	67.00(8.49)	68.00(8.38)	66.77(8.27)	67.20(8.45)	$F(3,62)=0.59$
Boys/Girls		14/8	9/7	11/4	7/6	41/25	$\chi^2(3)=0.70$

(continued)

		Animation +Music/sounds	Animation	Music/Sounds	Static	Total	Statistics
PPVT(raw)		94.09 (18.17)	100.75 (19.83)	91.40 (20.34)	93.69(13.40)	95.02 (18.21)	$F(3,62)=0.76$
PPVT_centered		18.76 (18.17)	25.42 (19.83)	16.07 (20.34)	18.36 (13.40)	19.69 (18.21)	
Ethnicity							$\chi 2$ (9)=0.62
	Asian	5 (8%)	1(2%)	2 (3%)	3 (5%)	11 (17%)	
	African American	10(15%)	4 (6%)	6 (9%)	4 (6%)	24 (37%)	
	Hispanic or Latino	3(5%)	4(6%)	5 (8%)	3 (5%)	15 (23%)	
	White	4(6%)	6 (9%)	2 (3%)	3 (5%)	15 (23%)	
	Total	22(5%)	15	15	13	65	
Mother's Education							$\chi 2$ (12)=0.14
	High School	3(5%)	0	1(2%)	1(2%)	5 (8%)	
	Associate Degree	0	1(2%)	2(3%)	3(5%)	6 (10%)	
	Bachelor	11(17%)	7(11%)	5(8%)	6(10%)	29(46%)	
	Master's	6 (10%)	1(2%)	4(6%)	1(2%)	12(19%)	
	Doctorate	2(3%)	6(10%)	1(2%)	2(3%)	11(17%)	
	Total	22	15	13	13	63	

Note. PPVT, Peabody Picture Vocabulary Test.

For younger children, the average age in month was 45.79 (*SD*=5.87). The average PPVT raw score was 56.77 (*SD* = 24.55). All 70 children's parents reported their ethnicity: 39% Asian, 6% African American, 16% Hispanic or Latino, 37% White, and 3% others. Sixty-eight out of 70 children's mothers reported their education level: 13% of the mothers held a high school diploma, 12% held an Associate degree, 21% obtained a bachelor's degree, 25% had a Master's degree, and 29% were granted a doctorate. The 66 older participants had an average age in months of 67.20 (*SD* = 8.45). The average PPVT raw score for this group of children was 95.02 (*SD* = 18.21). Sixty-five out of 66 children's parents reported their children's ethnicity: 17% were Asian, 37% were African American, 23% were Hispanic or Latino, and 23% were White. Sixty-three out of 66 mothers reported their education level included 8% with a high school diploma, 10% with an Associate degree, 46% with a Bachelor's degree, 19% with a Master's degree, and 17% with a Doctoral degree. The statistics presented in the last column of Table 1

showed that there was no difference across the groups on the variables of age in month, gender, PPVT scores, ethnicity, or mothers' education for both younger and older groups of children, $p > .05$.

Table 3 illustrates younger and older children posttests' mean and standard deviations for receptive and expressive vocabulary acquisition and story comprehension based on the three contrasts: enhancements vs. static, combined animation and music/sounds vs. single enhancement, and animation vs. music/sounds. The maximum score for each posttest was 20.

Table 3

Mean and Standard Deviations for Receptive Vocabulary and Expressive Vocabulary Acquisition and Story Comprehension Among Three Contrasts for Younger and Older Groups of Children

		Receptive vocabulary (Max=20)	Expressive vocabulary acquisition (Max=20)	Story comprehension (Max=20)
		Younger Children		
Contrast 1	Enhancements	13.60 (3.69) (n=58)	5.46 (3.47) (n=56)	8.05 (4.05) (n=57)
	vs. Static	12.18 (4.29) (n=11)	5.44 (3.17) (n=9)	6.56 (4.69) (n=9)
Contrast 2	Combined	12.82(3.83) (n=22)	5.38 (3.81) (n=21)	7.38 (4.66) (n=21)
	vs. Single	14.08(3.57) (n=36)	5.51 (3.31) (n=35)	8.44 (3.65) (n=36)
Contrast 3	Animation vs.	13.95 (3.69) (n=19)	5.42 (3.17) (n=19)	7.89 (4.25) (n=19)
	Music/Sounds	14.24 (3.55) (n=37)	5.63 (3.58) (n=16)	9.06 (2.84) (n=17)
		Older Children		
Contrast 1	Enhancements	16.23 (1.86) (*N*=53)	7.91 (2.78) (*N*=53)	12.64 (3.53)(*N*=53)
	vs. Static	17.08 (1.75) (*N*=13)	6.69 (2.32) (*N*=13)	11.08 (2.02)(*N*=13)
Contrast 2	Combined	15.77 (1.97) (*N*=22)	6.95 (2.61) (*N*=22)	12.36 (3.44)(*N*=22)
	vs. Single	16.55 (1.73) (*N*=31)	8.58 (2.74) (*N*=31)	12.84 (3.63)(*N*=31)
Contrast 3	Animation vs.	16.44 (1.63) (*N*=16)	9.56 (2.34) (*N*=16)	13.19 (3.75)(*N*=16)
	Music/Sounds	16.67 (1.88) (*N*=15)	7.53 (2.83) (*N*=15)	12.47 (3.58)(*N*=15)

Note. Max = maximum score.

Table 4

Correlations Between the Dependent and Independent Variables for Younger and Older Groups of Children

	1	2	3	4	5	6	7
			Younger Children				
1. Gender	__						
2. Age in months	.12	__					
3. Mother's education	.01	.16	__				
4. PPVT_centered	.13	.65**	.37**	__			
5. Receptive vocabulary	.09	.41**	.20	.65**	__		
6. Expressive vocabulary acquisition	-.05	.53**	.40**	.76**	.67**	__	
7. Story comprehension	-.09	.38**	.20	.53**	.57**	.67**	__
			Older Children				
1. Gender	__						
2. Age in months	.02	__					
3. Mother's education	-.15	-.46**	__				
4. PPVT_centered	-.08	.32**	.01	__			
5. Receptive vocabulary	-.12	-.19	.34**	0.14	__		
6. Expressive vocabulary acquisition	-.22	-.15	.32**	.35**	.41**	__	
7. Story comprehension	-.21	.19	.05	.35**	.27*	.33**	__

Note. * $p < .05$, ** $p < .01$

Table 4 presents the correlations between the independent and dependent variables for the younger and older groups of children receptively. For younger children, their vocabulary level PPVT score was related to the digital book-based receptive and expressive vocabulary acquisition and story comprehension scores. The correlation between PPVT score and receptive vocabulary and story comprehension scores was moderately strong. However, PPVT had a strong correlation with target expressive vocabulary acquisition score. The relationship between

target receptive and vocabulary acquisition tests was moderately strong. The relationship between story comprehension and all targeted vocabulary scores was moderately strong as well. For the older group of children, the correlation between PPVT score and digital book-based tests for expressive vocabulary acquisition and story comprehension was generally weak. However, there was no correlation between PPVT and the target receptive language test scores. The relationship between book-based receptive and expressive vocabulary acquisition tests closed to moderate. The links between story comprehension and book-based receptive and expressive scores were small.

Mixed Linear Models

Mixed linear models were performed to take into consideration of the center and school effect. For each outcome variable (receptive vocabulary, expressive vocabulary acquisition, and story comprehension) and for each age group, PPVT (centered) score was entered as a covariate along with three other contrasts (1) enhancements vs. static, (2) combined animation and music/sounds vs. separate enhancements, and (3) animation vs. music/sounds.

Finally, results showed that there was no interaction between PPVT (centered) score and any of the three contrasts, therefore interaction terms were excluded from the final model. Table 5 shows the final model results.

Table 5

Regression Estimates and Standard Errors of Receptive Vocabulary, Expressive Vocabulary Acquisition, and Story Comprehension on PPVT (Centered) Score and Experimental Conditions for Younger Children and Older Children

	Receptive vocabulary	Expressive vocabulary acquisition	Story comprehension
	Younger Children		
Intercept	15.18*** (0.42)	7.24*** (0.34)	9.32*** (0.66)
Background variable			
PPVT_centered score	0.10*** (0.01)	0.11*** (0.01)	0.11*** (0.02)
Contrasts			
Enhancements vs. static	0.34(0.22)	0.13 (0.19)	0.50* (0.29)
Combined vs. animation or music/sounds	-0.52* (0.25)	-0.22 (0.20)	-0.57* (0.30)
Animation vs. music/sounds	0.04 (0.45)	-0.06 (0.37)	0.49 (0.54)
	Older Children		
Intercept	16.89*** (0.66)	7.75*** (0.83)	11.22* (0.69)
Background variable			
PPVT_centered score	0.04** (0.01)	0.06*** (0.01)	0.07** (0.02)
Contrasts			
Enhancements vs. static	-0.22(0.11)	0.35* (0.15)	0.36 (0.23)
Combined vs. animation or music/sounds	-0.39** (0.13)	-0.57** (0.19)	-0.15 (0.28)
Animation vs. music/sounds	0.17 (0.26)	-0.89* (0.36)	-0.07 (0.54)

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

Story comprehension.

Younger children. For younger children, the regression models in Table 5 showed that PPVT (centered) had a main effect on story comprehension, t (33) = 5.67, $p < .001$. Children in

the enhanced conditions (M = 8.05, SD = 4.05) outperformed those in the static condition (M =6.56, SD = 4.69; t (61) =1.72, $p < .05$ (one tailed). The effect size equaled d = 0.36, indicating that affordances (animation, music/sounds, or both combined) improved these age group of children's story comprehension slightly less than half a standard deviation. When children received either animation or music and sounds (M = 8.44, SD = 3.65), children's comprehension outperformed the condition in which these enhancements were combined (M = 7.38, SD = 4.66), t (59) = -1.89, $p < .05$ (one tailed). The effect size, closed to a quarter of one standard deviation (d = 0.26), was small. The difference between animation (M = 7.89, SD = 4.25) and music/sounds (M = 9.06, SD = 2.84) favored music/sounds but was not significant, t (57) = 0.91, p = .367. Interaction between PPVT (centered) scores and the three contrasts were not significant and therefore not included in the final model.

Older children. A centered PPVT (centered) score had a main effect on the digital book-based story comprehension, t (64) = 3.28, $p < .01$. None of the three contrasts had a statistically significant main effect: enhancement vs. static t (35)= 1.56, p = .128; combined vs animation or music and sounds, t (44)= -0.56, p = .581; animation vs. music and sounds, t(36)= -0.12, p = .903. All interaction terms were non-significant and thus were excluded in the final model.

Receptive vocabulary.

Younger children. There was a main effect of the PPVT(centered) score on digital story book-based receptive vocabulary, t (69) = 7.58, $p < .001$. Children in either animation or music and sounds condition outperformed those in the combined condition (M = 14.08, SD = 3.57) and (M=12.82, SD = 3.83), t (69) = -2.11, $p < .05$. The effect size equaled one-third of a standard deviation (d = 0.34). However, the three enhancement groups did not show significant improvement compared with the static group, t (69) = 1.51, p = .135, nor did animation differ

from music and sounds, $t(69)= 0.10$, $p = .924$. The interaction terms between PPVT (centered) scores and the three contrasts were non-significant and were excluded in the final model.

***Older children*.** As appears from the regression model in Table 5, PPVT (centered) had a main effect on digital book-based receptive vocabulary, $t\ (62) = 3.49$, $p < .01$. Children in either animation or music and sounds ($M = 16.55$, $SD = 1.73$) outperformed those in the condition combining both enhancements ($M= 15.77$, $SD = 1.97$), $t\ (62) = -2.85$, $p < .01$. The effect size ($d = 0.43$) was moderately high. There was no statistically significant difference between enhancements groups ($M = 16.23$, $SD = 1.86$) and the static group ($M = 17.08$, $SD = 1.75$), $t\ (60) = -2.97$, $p = .053$. The main effect between animation and music and sounds were non-significant, $t\ (60) = 0.66$, $p = .512$. The interactions between PPVT (centered) and contrasts were not significant and therefore excluded from the final model.

Expressive vocabulary acquisition.

Younger children. The regression models in Table 5 showed that the PPVT (centered) had a main effect, $t\ (65) = 9.75$, $p < .001$. None of the three contrasts had a statistically significant main effect: enhancement vs. static $t(65)= 0.68$, $p = .496$; combined vs animation or music and sounds, $t(65)= -1.12$, $p = .269$; animation vs. music and sounds, $t(65)= 0.16$, $p = .877$. The interaction terms between PPVT (centered) scores and the three contrasts were non-significant and were excluded in the final model.

***Older children*.** PPVT (centered) had a main effect, $t\ (5) = 4.42$, $p < .001$. Children in the conditions with enhancements ($M = 7.91$, $SD = 2.78$) outperformed the children in the static condition ($M = 6.69$, $SD = 2.32$), $t\ (60) = 2.28$, $p < .05$. The effect size equaled $d = 0.47$. Children in the conditions with either animation or music and sounds ($M = 8.58$, $SD = 2.74$) outperformed those in the condition with both enhancements ($M = 6.95$, $SD = 2.61$), $t\ (62)= -$

3.00, $p < .05$. It had a moderately strong effect of slightly more than half a standard deviation ($d = 0.61$). Children in the animation condition ($M = 9.56$, $SD = 2.34$) outperformed children in the music and sounds condition ($M = 7.53$, $SD = 2.83$), t (61) = -2.47, $p < .05$. The effect size equaled three-quarter of a standard deviation ($d = 0.78$). The interaction terms between PPVT (centered) scores and the three contrasts were non-significant and were excluded in the final model.

Chapter V

Discussion

Empirical Contributions

Although both younger and older children learned receptive vocabulary words, younger children showed the strongest effects in story comprehension and older children in expressive vocabulary. In the older group, there was not much to gain in story comprehension but there was in (expressive) vocabulary. On the other hand, the younger group gained in comprehension but not so much in expressive vocabulary. The story may have been easy to understand for the older children but rather complex for the younger group. The older group did not score at the ceiling, but some questions were rather hard and rarely answered correctly. For instances, the inferential question "Why is this an important part of the story" appeared to be too difficult; very few children were able to identify how this event links with other relevant story information. Assuming that learning new vocabulary is grounded in a better comprehension of the story it makes sense that older children's vocabulary benefited more from the picture book than younger children. Understanding the story text, children are able to comprehend the meaning of unknown words from the context.

The advantage of an enhanced book to a static book. Three important empirical findings revealed from the current study. The book enhanced with visual and auditory effects was more effective than the static book. These effects were statistically significant for the variables that showed the most gains: younger children's story comprehension and older children's expressive vocabulary acquisition. This result is consistent with a recent meta-analysis (Takacs et al., 2015) that enhancements served as contextual cues to help children construct

meaning and attain story information, resulting in elevated story comprehension for young children and growth in vocabulary for older children.

The effect of combined versus single enhancement. Secondly, the findings evidenced the strongest effects on single enhancement compared to combined enhancements. Either animated illustrations or music and sound was more effective than both combined. This effect was manifested for younger children's receptive vocabulary and story comprehension and for older children's receptive and expressive vocabulary acquisition.

The effect between animation and music and sound. Finally, the effect of visual versus auditory enhancements was similar in younger children's book-based tests. However, visual enhancements tended to be more beneficial for vocabulary acquisition than music and sound. The findings showed that animated illustration outperformed music and sound in the older group's expressive vocabulary acquisition. The visual enhancements may be more intensive stimuli (Takacs & Bus, 2016) than the music and sounds and may therefore be most effective (Takacs et al., 2015). Also, the visual superiority effect may play a role assuming that retention is higher when children are exposed to visual information than to auditory information (Hayes, Chemelski, & Birnbaum, 1981).

Theoretical Implications

Results aligned with the *multimedia principle* (Mayer, 2009) predicting that learning from picture books improves when new sources of information made possible by the recent advent in technology are added to explain story events. People's comprehension may deepen when additional information sources help children to understand what exactly happened and how characters respond to story events. The target book, Little Kangaroo, includes both visual and auditory enhancements, the overall effects of enhancements on comprehension in the youngest

group and on expressive vocabulary in the oldest group, which supported the importance of this multimedia principle for picture books.

Moreover, nonverbal information added to the book in a way that helped children build direct connections between nonverbal and verbal information, thus facilitateed comprehension of story events and retention of story language. This effect, defined as *temporal contiguity principle* (Mayer 2009), may be expected when nonverbal information sources added to the picture book are closely matched with the narration. That is, both information sources, nonverbal and words, are present simultaneously. In the current study, the animated e-books were designed along these lines. The current findings provide some evidence that particularly visual information in sync with the narration is helpful. When visual and verbal information are closely integrated, this enhances connections between visual and verbal information (Paivio, 1986), thus facilitating retention of unfamiliar words and story details. Auditory information seems less effective particularly in the older group. This did not come as a surprise given that the music and sounds added to Little Kangaroo come less to the fore than the visual enhancements.

A third principle, the *redundancy principle*, predicts that multiple sources presenting the same information simultaneously may cause children's cognitive overload. For instance, animation and music/sounds, simultaneously present in the book, may result in learning decrements compared to the presentation of one source of information, animation or music/sounds. Trying to attune the two sources of information may add unnecessary extra load to working memory (Kalyuga & Sweller, 2014). Evidence for the importance of this principle is provided in the current study: both younger and older children show negative effects of combined enhancements, the younger children on comprehension and receptive vocabulary and the older on receptive and expressive vocabulary. Elimination of extraneous information reduces

cognitive load in the working memory. The findings evidence that either removing animation or music and sounds is beneficial for learning. There is no support for the hypothesis that particularly the youngest children who have a more limited working memory, may experience negative effects of processing the two different resources of information simultaneously (Strommen, 1993). Visual and auditory information together seems to impose too much working memory for younger as well as older children.

Practical Implications

The current findings provide practical evidence that the recent advent in technology enabling either animated e-books or music and sound added to the e-books are beneficial for 3-6 years old children's learning. School curriculum and family literacy environments should consider implementing well-designed e-books for children to develop their word learning and story comprehension. Enhanced e-books show an advantage for preschool children's (3-4-year-old) story comprehension compared to static pictures. However, even though 3-6-year-old children need support from either animation or music and sound enhancement to understand the story and language, it is important to measure out the amount of additional information. Combining visual and auditory enhancements as in Little Kangaroo may cause cognitive overload and thus impair learning.

Limitation and Future Directions

For a critical test of the effects of digital enhancements, it is preferable to dispose of more than one picture book app designed according to the same principles. Similar findings for different books including the same enhancements guarantee that effects are real and not the result of accidental book features. New research should include two or more books that are designed according to the same principles as Little Kangaroo.

Chapter VI

Conclusion

The unique of the current findings filled the gap that less evidence reported the effects of enhancements, such as animation and music and sounds, on children's learning, especially examined 3-4 years old children and 5-6 years old children's learning outcomes. The current study disclosed that digital enhancements are more beneficial for both groups of children than the static picture format. Children viewed and listened to either animation or music and sounds version benefitted more compared with those who viewed and listened to the combined animation and music and sounds version. The same information presented by multiple sources imposed 3-6 years old children's cognitive load, this aligned with the redundancy principle (Mayer, 2009). The findings suggested that too much nonverbal information presented to these age groups of children interfered with their learning. The findings also suggested that the quality enhancements were matched with narration better supported children's learning, this aligned with the temporal contiguity principle (Mayer, 2009).

Another significant finding emphasized that preschool children improved story comprehension with the enhancements support. The enhancements, either animation or music and sounds, guided children's attention to deeper understand the meaning of the story scenarios along with listening to the narration. The consistent presentations between the enhancements and narration scaffolded the children to build the mental connections between verbal and visual information (Paivio, 2007), thus they learned the meanings of the story and comprehended vocabulary words.

Finally, enhancements were superior to the static version for 5-6 years old children learning vocabulary words. Animated pictures are a favorable technique to support this age

group of children acquiring expressive vocabulary words. The findings suggested that well-designed e-books can making the meaning of the story events and promoted 5-6 years old children's vocabulary learning, especially in their expressive vocabulary acquisition with repeated viewing and listening to the digital story.

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Appendix A

Instrument Samples

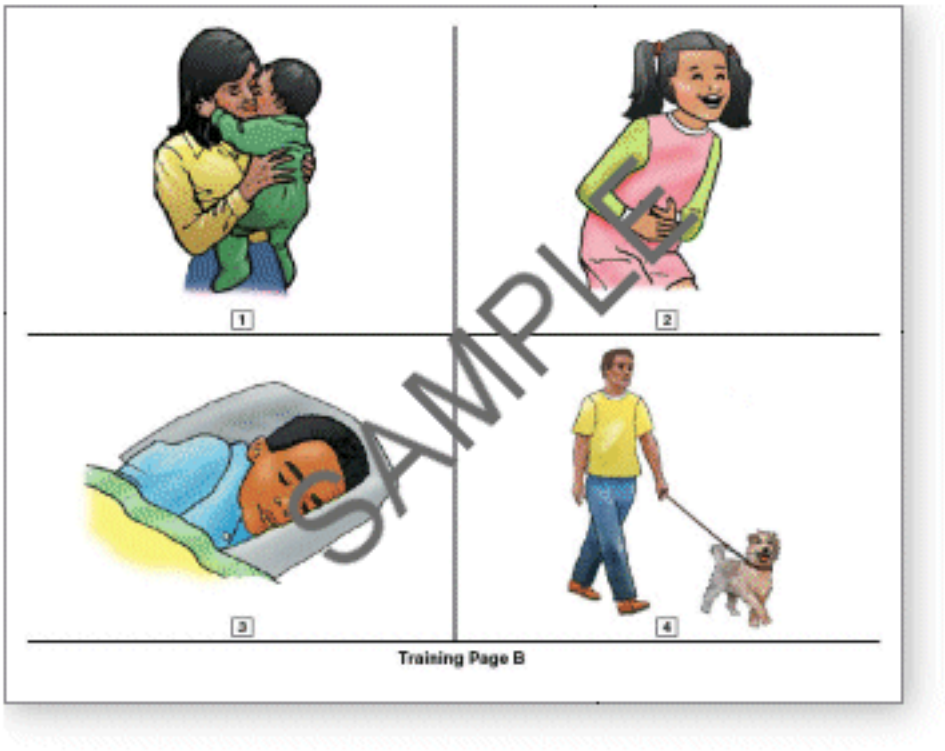

Figure A1. PPVT-4 Training Page B [Online image]. Retrieved from http://images.pearsonclinical.com/images/pa/ppvt4item.gif

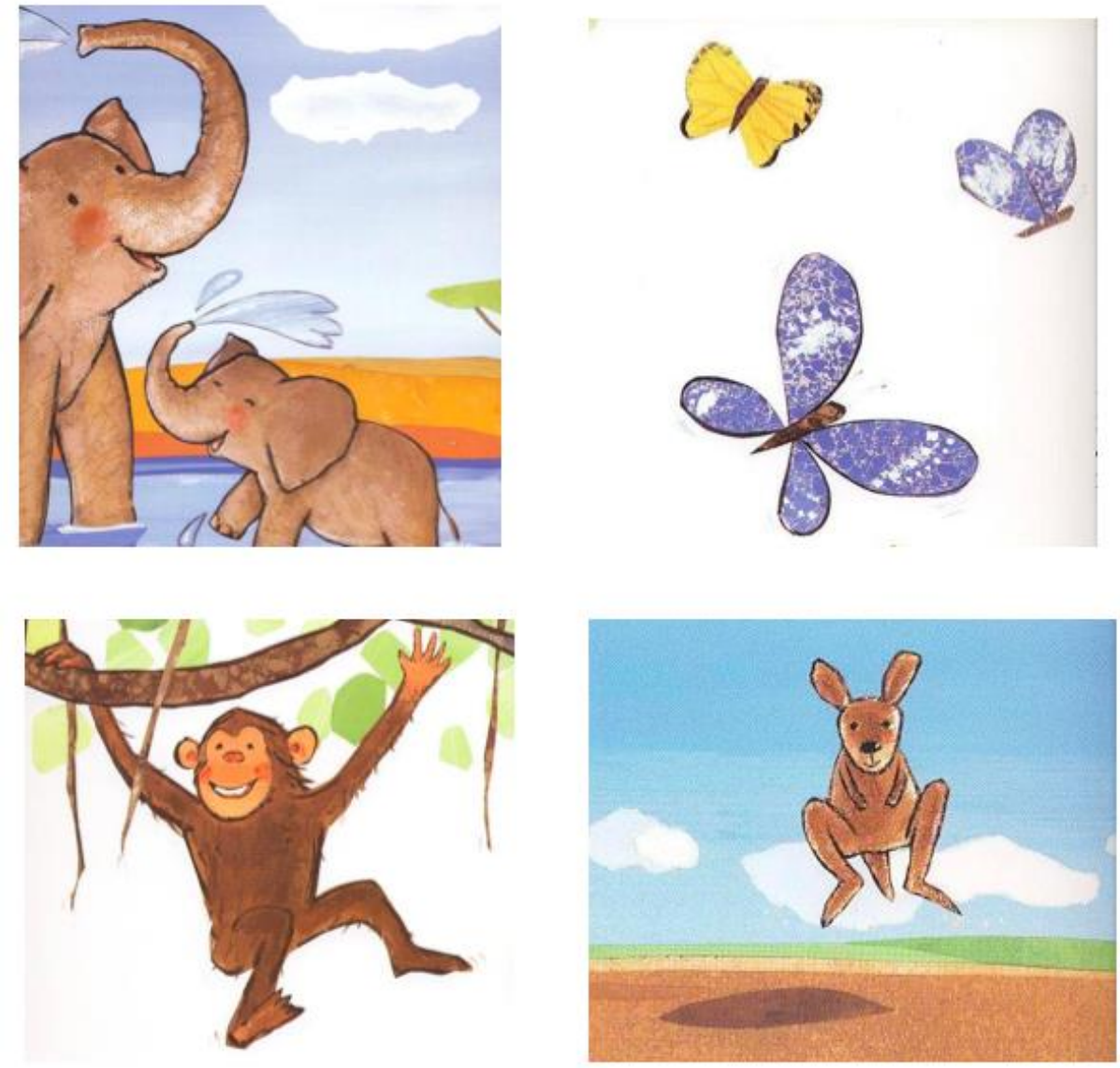

Figure A2. Receptive Vocabulary Word Test Sample

Figure A3. Expressive Vocabulary Word Test Sample

Who are the two Kangaroos in this story?

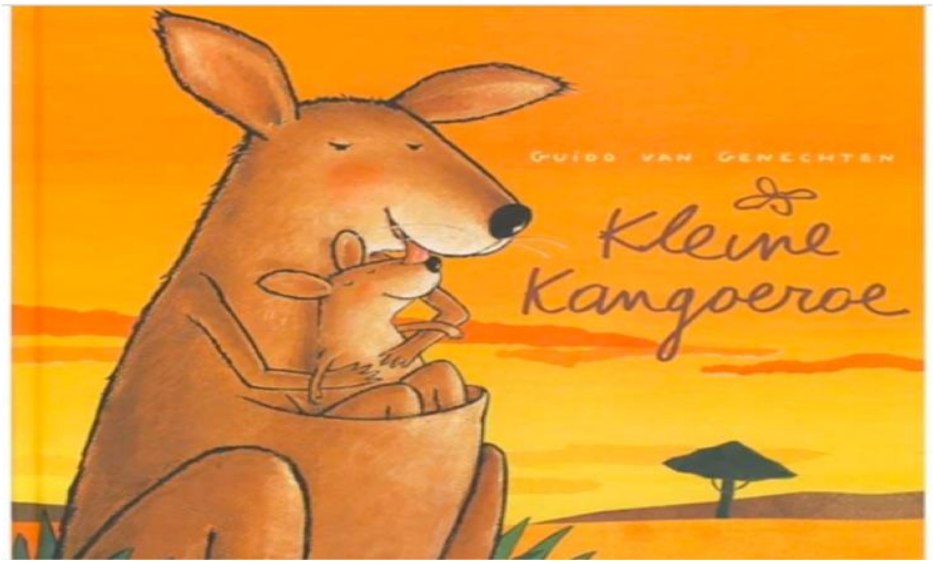

Figure A4. Story Comprehension Test Sample