Storybook apps as a tool for early literacy development

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Chapter 4

Using electronic storybooks to support word learning in children with Severe Language Impairments

Abstract
Novel word learning is reported to be problematic for children with severe language impairments (SLI). In this study, we tested electronic storybooks as a tool to support vocabulary acquisition in SLI children. In Experiment 1, twenty-nine kindergarten SLI children heard four e-books each four times: 1) two stories were presented as video books with motion pictures, music and sounds; and 2) two stories included only static illustrations without music/sounds. Two other stories served as control condition. Both static and video books were effective in increasing knowledge of unknown words, but static books were most effective. Experiment 2 was designed to examine which elements in video books interfere with word learning: video images or music/sounds. Twenty-three kindergarten SLI children heard 8 storybooks each four times: 1) two static stories without music/sounds; 2) two static stories with music/sounds; 3) two video stories without music/sounds; and 4) two video books with music/sounds. Video images and static illustrations were equally effective, but the presence of music/sounds moderated word learning. In children with severe SLI, background music interfered with learning. Problems with speech perception in noisy conditions may be an underlying factor of SLI and should be considered in selecting teaching aids and learning environments.

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Introduction

Children with severe language impairments (SLI) show late acquisition of first words and by the time of school entry their vocabularies are restricted (Leonard, 2000; Schwartz, 2009). Meta-analyses (Bus, van IJzendoorn, & Pellegrini, 1995; Mol & Bus, 2011; Mol, Bus, de Jong, & Smeets, 2008) corroborate the hypothesis that storybooks play an important role in young children's language development. This research aims at highlighting book features that support language learning in children with SLI. Video storybooks including motion-pictures as well as music and sounds may be of particular interest in promoting word learning for this group of children because of non-verbal support that is known to help in extracting meanings of unknown words (e.g., Smeets & Bus, 2012a; Verhallen, Bus, & de Jong, 2006). On the other hand, due to their delays in understanding the story language, SLI children may prefer visual information to oral text and due to speech perception problems aural elements of video books (music and sounds) may interfere with comprehension of the oral text.

It is estimated that approximately 7% of 5- to 6- year old children can be diagnosed with SLI (Tomblin et al., 1997). It is generally agreed that the SLI population forms a rather heterogeneous group experiencing a broad range of language deficits (Bishop, 1997; Schwartz, 2009; van Weerdenburg, Verhoeven, & van Balkom, 2006). The most common language profile includes weaknesses in syntax and phonology (Leonard, 2000). Lexical-semantic deficits (i.e., limited vocabularies and word finding problems) have been reported with more word production than comprehension problems (Hick, Joseph, Conti-Ramsden, Serratrice, & Faragher, 2002; Gray, 2004; Leonard, 2000; Sheng & McGregor, 2010; Van Weerdenburg et al., 2006). SLI children's ability to learn new words has been a topic of interest for many researchers. A recent meta-analysis by Kan and Windsor (2010) demonstrated that these children score more than half a standard deviation below age matched children on novel word learning, as appeared from comprehension and production measures.

Effects of shared book reading as an effective way to promote vocabulary acquisition have not been examined extensively in SLI children. Most studies delineate language delays compared to typically developing peers. For instance, Kaderavek and colleagues concluded that SLI children experience problems in retelling a narrative using written-like language (Kaderavek & Justice, 2002; Kaderavek & Sulzby, 2000). Rice and colleagues demonstrated that SLI children have a limited ability to understand new words in settings that require 'Quick Incidental Learning (QUIL)', for instance, while watching a video presentation in which unfamiliar words are incorporated into a narrative script (Oetting, Rice, & Swank, 1995; Rice, Buhr, & Nemeth, 1990; Rice, Buhr, & Oetting, 1992). Vocabulary growth may be accelerated when parents or teachers read interactively and pose questions about words and story events (e.g., Crain-Thoreson & Dale, 1999; Dale et al., 1996; van Kleeck, vander Woude, & Hammet, 2006). There is, however, evidence that SLI children do not participate very actively during interactive reading sessions; they might feel overwhelmed by questions due to their language deficits (van Kleeck & Van der Woude, 2003). Similar to language delayed L2 children (Verhallen et al., 2006; Verhallen & Bus, 2010), SLI children may benefit from additional non-verbal information sources to extract meanings of unknown words in the narration. In this light, video storybooks with additional visual information may be beneficial.

Electronic storybooks present illustrations on screen, accompanied by an oral reading of the text. With video techniques, characters and objects can be set into motion to clarify words and phrases that otherwise would be less transparent. For instance, in contrast to the still picture of a butterfly 'hanging' in the air, video storybooks show an animation of the butterfly's fluttering wings. For younger children or children with less developed language skills, seeing the butterfly in action may be more supportive of the meaning of 'fluttering' [dartelen] than looking at a static illustration (Gibbons, Anderson, Smith, Field, & Fischer, 1986). Furthermore, video storybooks use zooming techniques to direct children's attention to details of illustrations that match the narration. By presenting words and images in close temporal proximity (Mayer, 2001) learners are more likely to hold corresponding words/phrases and pictures in working memory (Baddeley, 1998). Experiments so far demonstrated that video stories are more effective in stimulating word learning than the same stories with merely static pictures in both typically developing (Smeets & Bus, 2012a) and in language delayed L2 children (Silverman & Hines, 2009; Verhallen et al., 2006; Verhallen & Bus, 2010). In the current study, we examined whether video storybooks benefit vocabulary acquisition in children who are diagnosed with SLI.

EXPERIMENT 1

Studies on television viewing in the early eighties reported higher retention of visual information than of audio information which was denoted as the *visual superiority effect*: Children might pay greatest attention to visual aspects of televised presentations and ignore language features (e.g., Hayes & Birnbaum, 1980; Hayes, Chemelski, & Birnbaum, 1981). Few studies in the last three decades corroborate this hypothesis for typically developing children. On the contrary, findings evidence that children's story recall is superior when a narration is accompanied by pictures (Gibbons et al., 1986; Hayes, Kelly, Mandel, 1986; Greenfield & Beagles-Roos, 1988) and video stories support language learning (Smeets & Bus, 2012a; Verhallen et al., 2006; Verhallen & Bus, 2010). However, similar to younger children, SLI children may rely more heavily on nonverbal representations than on their limited language skills (Simcock & Hayne, 2002) and they might 'look and not listen', in line with Hayes and Birnbaum's (1980) visual superiority effect. Because video images are more salient than static pictures, children might pay less attention to the oral text when listening to video books compared to static storybooks.

There are also strong reasons to believe that background music and sounds, another feature of video storybooks, may interfere with processing the narrative text. Among several theories that attempt to account for the language deficits in SLI children is the view that children fail to learn language because they misperceive speech (Joanisse, & Seidenberg, 1998). There is however no consensus that perceptual deficits are the underlying cause of SLI (e.g., Bernstein & Stark, 1985; Coady, Kluender, & Evans, 2005; Tallal et al., 1996). However, researchers might underestimate difficulties in speech perception because speech perception is mostly examined in optimal (i.e., quiet) listening conditions (Ziegler, Pech-Georgel, George, Alario, & Lorenzi, 2005). Some studies evidenced that SLI children's speech perception is especially impaired when background noise is present (e.g., Robertson, Joanisse, Desroches, & Ng, 2009; Vandewalle, Boets, Ghesquière, & Zink, 2012; Vance & Martindale, 2012; Ziegler et al., 2005). In the same vein, we may expect that SLI children experience more difficulties in isolating words from the speech stream when background music and sounds are added to a narration.

In Experiment 1, it was tested whether SLI children a) can learn novel word meanings when they 'read' (i.e., listen to) electronic storybooks without adult support, and b) whether storybooks that include video-effects and music/sounds are more or less beneficial as electronic versions with merely static illustrations without music/sounds.

Method

Subjects

Participants in this study were 29 children with specific language impairment (SLI) aged 60-80 months (M = 69.34, SD = 5.92) following the kindergarten curriculum at 2 Dutch schools for language- and hearing-impaired children called 'cluster 2 schools'. The majority of children in this sample (N = 24) were boys as is typical for this population (Tomblin et al., 1997).

Participating children were diagnosed with SLI by an interdisciplinary team consisting of clinical linguists and school psychologists before they entered the schools. All children showed significant limitations in their language abilities: they scored 1.5 standard deviations or more below the mean in at least two out of four language areas (speech production, speech perception, grammar, or lexical-semantic). Children's non-verbal intelligence was within the normal range (≥85). Furthermore, SLI was diagnosed on exclusion criteria: children experienced no hearing impairments, neurological damage, oral structural anomalies, deficits in oral motor functioning, or communication problems due to an autism-spectrum disorder (Leonard, 2000).

Design

A pretest-posttest within subjects design with three conditions (control, static, video) was used to examine the effectiveness of electronic storybooks and differential effects of static *vs.* video books. Each participant listened to four e-books during the intervention: two electronic stories in a *static* format and two in a *video* format. At pre- and posttest, we tested knowledge of target words from six stories; the two stories that children had not heard during the intervention served as a no-treatment *control* condition. Thus each participant was exposed to all three conditions: video, static and control. Table 4.1 provides an overview of the design.

Table 4.1. Overview of conditions and study design in Experiment 1.

	Static stories	Video books	No-treatment Control
E-book features			
Oral reading of the text	yes	yes	-
Printed text on screen	no	no	-
Background music and sounds	no	yes	-
Illustrations	Static pictures	Video images	-
Study design			
Nr. of stories assigned to condition	2	2	2
Target words pre-and post tested	14 (7 per story)	14 (7 per story)	14 (7 per story)
Frequency of 'reading'	4 times	4 times	0 times

Six stories were assigned to three conditions following a Latin Square Design (Keppel & Wickens, 2004). For instance,

Child A: story 1 and 2 static / story 3 and 4 video / story 5 and 6 control;
Child B: story 2 and 3 static / story 4 and 5 video / story 6 and 1 control;
and so on.

This way, we created unique combinations of stories and conditions for each participant. Importantly, each of the six stories appeared with equal frequency within each condition so that any effect of condition could not be the outcome of differences between stories.

Storybooks

Six Dutch storybooks were digitized: *Tim op de Tegels* (Veldkamp, 2004), *Rokko Krokodil* (de Wijs, 2001), *Bolder en de Boot* (Hoogstad, 2005), *Kleine Kangoeroe* (van Genechten, 2009), *Na-apers* (Veldkamp, 2006), and *Lieve lieve* (Praagman, 2006). For each book two electronic versions were available: a static and a video version. The static version was most similar to the original print format of the story; illustrations of the storybooks were presented on screen accompanied by an oral reading of the storybook text. This way, children could listen to the stories without adult support. The printed text however was not shown on screen in the electronic version. The book automatically turned to the next page when the oral rendition of a page was finished.

Video versions included the same read-aloud of the narration as the static version. Just as static stories, video versions of the storybooks did not present printed text on screen. In both e-book versions, backgrounds and story characters looked exactly the same. The video version, however, included additional visual and audio effects (see also Table 4.1). For example, in 'Tim op de Tegels' (Veldkamp, 2004), the voice-over reads that "a truck driver wants to lift Tim off the paving stones". In synchrony with the narration, we see an animation of how the truck driver reaches his arms in Tim's direction. Zoom-effects are often used to guide children's attention to focal details of the illustration. For instance, when a baby crocodile appears from its egg in 'Rokko Krokodil' (de Wijs, 2001), the camera zooms in on one of many eggs, after which video images show how it breaks open and how a crocodile appears (see Figure 4.1).

Unlike animation films (e.g., cartoons), motion pictures in the video versions of the stories are designed to focus children's attention on elements that are highlighted in the oral text. Background music was added to video books to emphasize suspense, sadness or happiness. Mixed with music are sound effects. For instance, you can hear someone knocking on a door (*Lieve Lieve*), hear birds whistle (*Kleine Kangoeroe*), or hear a motor humming (*Bolder en de boot*). These sounds are added to highlight elements in the oral text; we hear the motor humming when Bolder is on the verge of leaving the harbor. All motion pictures, sounds, and music appeared automatically in the video books and were not under control of the children. There were no interactive features included in the e-books utilized in this experiment.

Tests

PPVT. The Peabody Picture Vocabulary Test (PPVT-III-NL; Schlichting, 2005) was used to assess children's level of general receptive vocabulary.

Target vocabulary test. Effects of the e-books on word learning were tested by a target vocabulary test that was especially designed for this study. As we intended to examine novel word learning, we selected words that would be unknown to the majority of children. We selected 7 low-frequency words per story (42 words in total). According to Schrooten and Vermeer's (1994) analyses, kindergarten children rarely encounter this selection of words in verbal contexts such as storybook reading and teacher-child talk. An overview of all target words per story is provided in Appendix B. The number of verbs, nouns, adjectives and adverbs was not exactly the same for each story but across conditions about half were nouns and half were other word types.

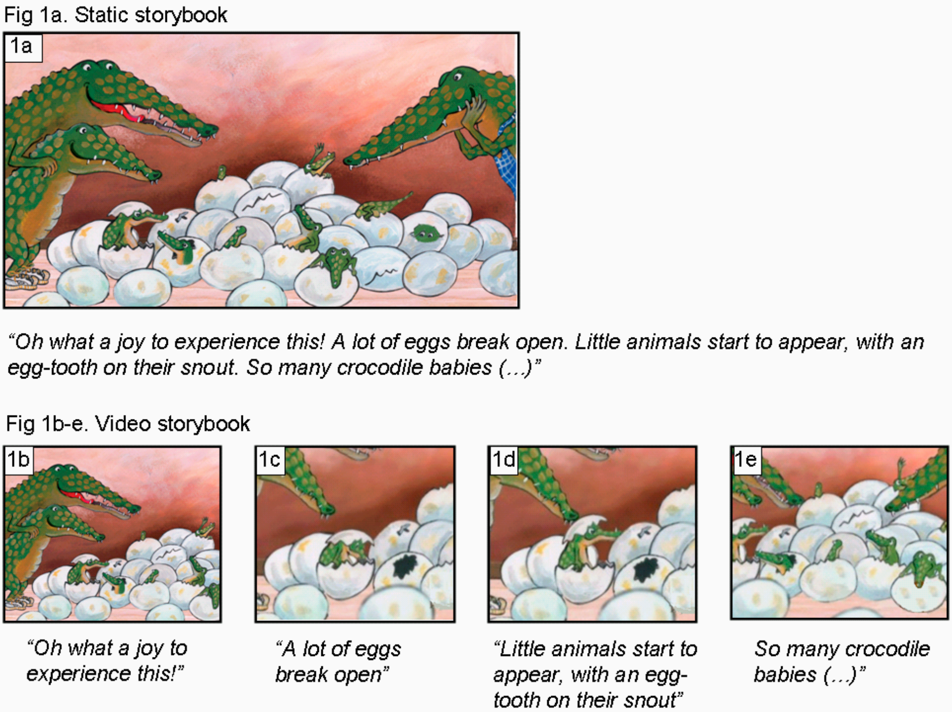

Figure 4.1. A scene from ‘Rokko krokodil’ [Rokko the crocodile] in which his siblings ‘appear’. Figure 1a presents an example from the static storybook: a static picture is presented on screen while the story text (here printed below the picture) is read aloud. Figures 1b-e are successive screenshots from the video version of the same scene. With help of zoom-effects and motion pictures, children’s attention is focused on details in the illustration in synchrony with the narration. For instance, in Figure 1c, the camera zooms in on one egg showing that is cracked open. The animation in Figure 1d shows how the baby crocodile appears. In Figure 1e, the camera zooms out to show that the other siblings follow.

Note. On the website of the Dutch e-book provider ‘Bereslim’ other examples of video books can be found: *http://web.bereslim.nl/bereslim/bereslimme-boeken/demo-bereslimme-boeken.html*. Note that we did not use the interactive versions in this study.

Children's knowledge of all 42 target words was tested with a sentence-completion task which revealed neither ceiling nor bottom effects in prior research (Verhallen et al., 2006; Verhallen & Bus, 2010; Smeets & Bus, 2012a; Smeets & Bus, 2012b). In this task, children were asked to complete sentences while pictures of the scene of the story were presented on screen. For example, in the story 'Kleine Kangaroe' (van Genechten, 2009), the story tells that "mother kangaroo was carrying around little kangaroo all day in her pouch". In the sentence-completion task, a picture of little kangaroo in mama's pouch was presented. Children were asked to complete the following sentence: "Little kangaroo has jumped into mama's …?". The stimulus sentences always differed from the story text to prevent that children merely repeated memorized text. When children completed sentences with a word that was less specific than the target word (e.g., 'tummy' or 'belly' instead of pouch), responses were coded as incorrect. Mispronunciations were only coded as correct when the child made the same error systematically (e.g., pronouncing /r/ as /l/).

Procedure

Testing and intervention took place in a separate room at the children's school that was not in use for other activities during the experiment. Preceding the intervention, two sessions of about 10 minutes were preserved for administering the PPVT and target vocabulary test, respectively. The next four weeks were reserved for the intervention. During eight sessions (two per week) children listened to four different stories and each story was repeated four times. Two stories were presented in a static format and two in a video format. With the restriction that each of the four stories was presented once a week, the order of the four stories presented within a week was randomized. Children could thus either listen to two stories of the same or different format within one intervention session. Children always wore headphones for listening to the reading of the stories. An experimenter was present in the same room for starting up the stories, but she did not interfere with the reading during the session. Directly after the last reading session, the target vocabulary test was administered again as posttest.

Results

One of the children refused to complete the target vocabulary posttest. Therefore, analyses were performed on 28 participants. Differences in PPVT or target vocabulary pretest scores between the two schools were not found.

First, we conducted a RM ANOVA on target vocabulary knowledge using time (pre *vs.* post) and condition (control, static, video) as within-subjects factors. The effect of time was significant, $F(1, 27) = 74.224$, $p<.001$, $\eta_p^2 = .733$, $d = 2.16$. Effects of condition were examined by testing two a priori contrasts: 1) pooled experimental conditions (static and video) *vs.* control; and 2) video *vs.* static (Keppel & Wickens, 2004). The significant interaction Contrast 1 X Time showed that children learned more words in experimental conditions compared to the control condition, $F(1, 27) = 42.235$, $p<.001$, $\eta_p^2 = .61$, $d = 1.54$. The interaction Contrast 2 X Time was also significant, $F(1, 27) = 8.169$, $p<.01$, $\eta_p^2 = .232$, $d = .48$; as can be seen in Table 4.2, static storybooks revealed the highest vocabulary gains.

Table 4.2. Means (and sd's) for target vocabulary in Experiment 1.

	N	Control	Static	Video
Pre	28	1.29 (1.33)	1.11 (1.37)	1.82 (1.70)
Post	28	2.04 (1.86)	5.14 (2.35)	4.43 (3.18)

Note. Maximum scores equaled 14 in each condition.

Overall, general vocabulary knowledge as measured by the PPVT was positively correlated with target vocabulary learning. After correction for knowledge of target words on pretest, correlations between PPVT and target vocabulary posttest scores equaled .29 ($p<.05$) for video and .44 ($p<.05$) for static books. These results suggest that word learning increased more with higher scores on general vocabulary, yet correlations were only moderate (Cohen, 1992). Follow-up analyses to examine whether the PPVT score moderated intervention effects did not reveal significant results.

Discussion

Results show that electronic storybooks (regardless of their format) are effective ways to increase SLI children's expressive vocabulary even when there is no adult support. In total, children learned about 23% of target words (7 out of 28) after four storybooks were heard each four times (about 80 minutes in total). In typically developing children, vocabulary gains of about 35% have been reported after four (Smeets & Bus, 2012a) and 18% after two readings (Smeets & Bus, 2012b). SLI children will probably need more exposures to accomplish similar learning effects (Rice, Oetting, Marquis, Bode, & Pae, 1994). Since electronic storybooks are easy to implement in schools and do not require much of the teacher's investment, e-books can be a valuable tool to increase SLI children's encounters with storybooks.

The most interesting result was that highest gains were accomplished when reading static storybooks. In contrast to typically developing children (Smeets & Bus, 2012a) and L2 students with language delays (Verhallen et al., 2006; Verhallen & Bus, 2010), SLI children benefited significantly less from video than from static books. Although video-effects were designed to support learning, visual stimuli in the video books may have been so attractive that children paid less attention to the narration as the visual-superiority effect predicts (Hayes & Birnbaum, 1980). Likewise, music and sounds may have interfered with processing the story language. However because effects of video and music/sound were confounded in the 'all-inclusive' video books that were used in this experiment, we cannot conclude which of these features interfered with word learning.

EXPERIMENT 2

Experiment 2 was designed as a follow-up study to explain Experiment 1's finding of decreased word learning for video *vs.* static stories. The main goal of Experiment 2 was to differentiate between effects of video and music/sounds. We hypothesized that the visual superiority effect (Hayes & Birnbaum, 1980) may explain the lower success rate for video books in the first study. On the other hand, background music and sounds may interfere with word learning as they may deteriorate speech perception, similar to the effect of noise (e.g., Robertson et al., 2009; Ziegler et al., 2005). In Experiment 2, children heard four types of e-books: video books with and without music/sounds *vs.* static books with and without music/sounds. If results will be similar to Experiment 1, that is, highest gains for static books without music/sounds and smallest gains for 'all-inclusive' books with video and music/sounds, we must conclude that video images as well as background music and sounds interfere with learning. However if video alone is detrimental for learning, we expect superior word learning in the two static conditions (both with and without music/sounds). If only music and sounds interfere with vocabulary acquisition, gains will be superior in the two conditions without music/sounds (both static and video stories).

Experiment 2 also aimed at extending existing knowledge on novel word learning in SLI by exploring two potential moderator variables: phonological working memory capacity and language skills. One major theoretical account regarding the origin of SLI proposes that the disorder is caused by a phonological processing deficit (Joanisse & Seidenberg, 1998). In line with this view, SLI children's poor performance on non-word repetition (NWR) tasks coincides with decreased performance when repeating multiple-syllable non-words (e.g., De Bree, Rispens, & Gerrits, 2007; Dollaghan & Campbell, 1998; Ellis Weismer et al., 2000). Likewise, SLI children's sentence comprehension deteriorates with longer sentences (Montgomery, 1995, 2003). Positive relations between phonological working memory and word learning have been reported for typically developing children (e.g., Gathercole & Baddeley, 1990a; Gathercole et al., 1992) but results for the SLI population are mixed (e.g., Edwards & Lahey, 1998; Gray, 2003; Montgomery, 1995, 2003). In the current study, we tested whether children with 'greater' phonological working memory capacity learned more words than children with 'smaller' capacity.

It is reported that the severity of children's impairments is predictive of the persistence of language problems (Catts, Fey, Tomblin, & Zhang, 2002). Thus we expect that acquiring new word meanings will be most difficult for children with lowest scores on general language tests. In Experiment 1, PPVT was not strongly related to intervention outcomes, which has been reported before in the SLI population (e.g., Kiernan & Gray, 1998; Rice et al., 1990; Rice et al., 1992). Considering the heterogeneity of children's language deficits, it may be necessary to assess a range of language skills as possible moderators. In Experiment 2 we assessed a battery of language tests not only including indicators of receptive language skills but also expressive measures and a test for phoneme awareness.

Method

Subjects

Twenty-three kindergarten children (13 boys) between 60 and 90 months old (*M*=71.56, *SD*=7.15) participated in the second experiment. All children were selected from 3 Dutch cluster 2 schools. All children were diagnosed with SLI by experts according to the same criteria as in Experiment 1. None of the children in Experiment 2 had participated in Experiment 1.

Design

We used a 2 (static *vs.* video) x 2 (no music/sounds *vs.* music/sounds) within subjects design resulting in four conditions: 1) static books without background music/sounds; 2) static books with background music/sounds; 3) video books without background music/sounds; and 4) video books with background music/sounds. An overview of the differences and similarities between the four conditions is provided in Table 4.3. All children heard two stories in each of the four conditions and were pre- and posttested on their target vocabulary knowledge.

Table 4.3. Overview of conditions and study design in Experiment 2.

	Static - no music/ sounds	Static – with music/ sounds	Video – no music/ sounds	Video – with music/ sounds
E-book features				
Oral reading of the text	yes	yes	yes	yes
Printed text on screen	no	no	no	no
Background music and sounds	no	yes	no	yes
Illustrations	Static pictures	Static pictures	Video images	Video images
Study design				
Nr. of stories assigned to condition	2	2	2	2
Target words pre-and post tested	18 (9 per story)	18 (9 per story)	18 (9 per story)	18 (9 per story)
Frequency of 'reading'	4 times	4 times	4 times	4 times

The intervention was split into two periods (see Table 4.4). We created two sets of four stories so that half of all children could listen to set A in the first period and set B in the second; vice versa for the other half of the children. During each period, four stories were presented each in a different format: one static story without music/sounds, one static story with music/sounds, one video story without music/sounds, and one video story with music/sounds. About 3 to 4 days after the last story exposure, we posttested target vocabulary of the stories that children heard in this period. About 1 week later, just before a new intervention period started, the target vocabulary for the other four stories was pretested. Children then listen to the other four stories four times following the same procedure as in the first period, after which target knowledge was posttested again. By carrying out the intervention in two periods, time between first, second, third, and fourth reading of a specific story was similar to the procedure in Experiment 1. Furthermore, time between the first reading and post test was also comparable. Table 4.4 provides an overview of the time line.

Similar to Experiment 1, stories were balanced across conditions following a Latin Square Design (Keppel & Wickens, 2004). For all 23 participants we created unique combinations of stories and conditions; overall each story was presented as often in all four formats.

Table 4.4. Overview of intervention periods in Experiment 2.

Testing phase	Week 1-3	Assessing language and working memory skills
Intervention period 1	Week 4	Pretest stories 1-4
	Week 4-7	'Reading' stories 1-4
		
		- one story per condition
		- each story was heard 4 times
	Week 7	Posttest stories 1-4
Intervention period 2	Week 9	Pretest stories 5-8
	Week 9-12	'Reading' stories 5-8
		
		- one story per condition
		- each story was heard 4 times
	Week 12	Posttest stories 5-8

Note. This overview applies to half of the participants. The other half read stories 5-8 in the first intervention period, and stories 1-4 in the second.

Storybooks

In Experiment 2, eight electronic storybooks were used including the same six stories that were used in Experiment 1, and two additional stories: *Beer is op Vlinder* (van Haeringen, 2004) and *Lieve Stoute Beer Baboen* (Westera, 2002). Each of the eight stories was available in four different formats: static with and without background music/sounds, and video with and without background music/sounds.

To compose four formats of every story, we first created two files with 1) static illustrations or 2) motion pictures (video). To each file, we added one of two audio files including either a) the narration (oral reading of the text, without background music/sounds) or b) both the narration and background music/sounds. Sound effects (e.g., the motor that is humming in 'Bolder en de boot', or birds that whistle in 'Kleine kangoeroe') are embedded in the background music. The oral text was exactly the same in the two audio files. Combining these files resulted in four formats of the same story differing in sources of visual and aural information (see Table 4.3).

Tests

Phonological working memory

NWR. A Dutch non-word repetition task (NWR) was designed to measure children's phonological working memory. In this paradigm, children heard pre-recorded non-words through a loudspeaker and were asked to repeat the words. Comparable to De Bree and colleagues' procedure (2010), pictures of fantasy animals were presented and children were told that these animals had funny names (i.e., the non-words). For each of five syllable lengths (1-5) we created 4 nonsense words totaling up to 20 items (Cronbach's alpha = .79). Non-words were based on items in the non-word reading task of the 'dyslexia screening test' (Dyslexie Screening Test; DST-NL; Kort et al., 2005). The test started with the shortest, one-syllable items and ended with the longest, five-syllable non-words. Two coders independently rewarded each item with a score of 0 (incorrect) or 1 (correct, i.e., whole word was repeated without any errors). Total scores could range between 0 and 20. For 12 of the 20 items, the Kappa statistic ranged between .65 and 1.00 indicating a substantial to high inter-rater reliability (Landis & Koch, 1977). For 5 items, the Kappa statistic was moderate (range: .52 to .59) and on 3 items fair (range .28 to .39). To award a final score, disagreements between raters were resolved through discussion.

Digit Span (forward). We assessed a digit span task (subtest of the CELF-4-NL; Kort, Schittekatte, & Compaan, 2008) in which children were asked to repeat a sequence of numbers that the experimenter had read aloud. Forward recall provides a measurement of basic storage capacity of the phonological loop, whereas backward recall taps working memory (Bull, Espy, & Wiebe, 2008). Scores on the forward span demonstrated sufficient variation yet backward recall was too difficult for these young SLI children. For analyses, we could only use the digit span forward.

Language skills.

CELF-4-NL. To assess children's general language skills, we administered a series of subtests of the Dutch version of the Clinical Evaluation of Language Fundamentals (CELF-4-NL; Kort et al., 2008). To attain an indication of children's receptive language abilities, we administered the subtest '*understanding sentences*' (zinnen begrijpen). In this task, the experimenter reads a sentence aloud and the child selects the correct image out of four pictures (e.g., the boy has a ball; the girl let go of her balloon). In the subtest '*word categories*' (woordcategorieën) children had to name the two pictures (out of 3 or 4) that "belong together" (e.g., apple, banana, egg). Next, children were asked to explain why the two pictures belong together (e.g., because apple and banana are both fruit). The first score is coded as indicator of receptive language skills and the second as indicator of expressive language skills. '*Expressive vocabulary*' (actieve woordenschat) was tested by a picture naming task. Finally, children completed several *phoneme awareness* (foneembewustzijn) tasks among which phoneme identification, deletion and substitution, and clapping out the number of syllables of a word.

Target vocabulary knowledge

Target vocabulary test. Target vocabulary was assessed the same way as in Experiment 1: The experimenter asked children to complete stimulus sentences (e.g., "Here you can see that Bear is…."?) while corresponding pictures from the stories (e.g., Bear feeling *broken-hearted*) were shown on screen. Appendix B presents which low frequency words were assessed per story (9 per story, 18 words per condition, 72 words in total).

Procedure

Testing and intervention took place in a separate room at the children's school that was not in use for other activities during the experiment. Preceding the intervention, we reserved 2 to 3 weeks (about 5 sessions) for assessing general language skills and working memory. The order of the tests was the same for all children. Next, intervention was carried out in two periods (see Table 4.4). Each intervention period lasted 4 weeks. In eight sessions (two per week), children heard four stories, each four times: a static story without music/sounds, a static story with music/sounds, a video book without music/sounds, and a video book with music/sounds. With the restriction that children read each of the four stories once a week, the order of the four stories presented within a week was randomized. Children wore headphones and experimenters did not interfere while children were listening and watching. Knowledge of target words was tested 3 to 4 days after the last intervention session.

Results

In the sample of Experiment 2, almost 45% of participants were girls, which is atypical for the SLI population (Tomblin et al., 1997). Differences between boys and girls were not found on any of the variables, so effects of gender are not reported in the results section. Children from the three schools did not differ on any of the variables assessed.

Language skills and phonological working memory

Table 4.5 presents an overview of children's scores on the language and working memory tests. Mean scores on the subtests fit the pattern of the most commonly reported deficits in SLI (Leonard, 2000): Children attained higher scores on receptive than expressive tasks, and they scored low on the phoneme awareness test. Low scores can also be observed on the NWR and, as expected (e.g., Dollaghan & Campbell, 1998; Ellis Weismer et al., 2000), children experienced more difficulties when non-words contained more syllables.

Table 4.5. Descriptive statistics for language and working memory tests in Experiment 2.

	Mean (*SD*)	Range	Max. score	*N*
Non-word repetition (NWR)				
total	06.36 (03.59)	1-12	20	22
1 syllable	02.27 (01.12)	0-4	4	22
2 syllables	01.95 (01.33)	0-4	4	22
3 syllables	01.18 (01.01)	0-3	4	22
4 syllables	00.59 (00.85)	0-3	4	22
5 syllables	00.36 (00.49)	0-1	4	22
Digit span (forward)				
Raw score	03.52 (01.53)	0-8	16	23
Percentile score	01.40 (03.10)	0.1-16	100	
Phoneme awareness				
Raw score	10.91 (08.99)	1-37	45	23
Percentile score	09.70 (14.41)	0.1-63	100	
Expressive vocabulary				
Raw score	10.43 (05.75)	2-24	56	23
Percentile score	04.43 (05.83)	0.1-25	100	
Understanding sentences				
Raw score	13.48 (04.79)	6-25	27	23
Percentile score	06.24 (15.54)	0.1-75	100	
Word categories – receptive				
Raw score	13.65 (03.51)	5-18	19	23
Percentile score	15.44 (15.68)	0.1-63	100	
Word categories – expressive				
Raw score	05.70 (03.72)	0-12	19	23
Percentile score	05.56 (3.70)	0.1-16	100	

Table 4.6 presents correlations between language and working memory tests. A principal component analysis (PCA) on all tests revealed two separate components. The first component explained 46% of the variance and the second added another 25% summing up to 71%. The five language tests loaded high on the first component (.60-.88) and low on the second (.03-.40). The two working memory tests loaded high on the second (.79-91) and low on the first component (.05-.31).

Table 4.6. Correlations between language and working memory tests assessed in Experiment 2.

	1	2	3	4	5	6	7
1. Phoneme awareness	1	.53**	.69***	.45*	.67***	.25	.49**
2. Expressive vocabulary		1	.62**	.36†	.60**	-.03	.19
3. Understanding sentences			1	.41†	.72***	-.05	.38†
4. Word categories - receptive				1	.53**	.15	.25
5. Word categories - expressive					1	.05	.30
6. Digit span (forward)						1	.50*
7. Non-word repetition (total)							1

Notes. *$p < .05$ level (2-tailed); **$p < .01$ level (2-tailed); ***$p < .001$ level (2-tailed); †$p < .1$(2-tailed).

A PCA on the five language tests resulted in one component explaining 66% of the variance with loadings ranging between .67 and .88. For analyses we used this aggregate measure (Cronbach's alpha = .82) that was distributed normally; higher scores indicated better language skills. PCA on the two working memory tasks revealed one component with high loadings (NWR = .79; digit span: .91) explaining 76% of the variance. Higher scores indicated greater phonological working memory capacity.

Intervention effects

An overview of pre- and posttest scores is provided in Table 4.7. For two children, there were too many missing scores (due to illness) for either language or working memory tests, or target vocabulary. Therefore, analyses on pre- to posttest gains were conducted on 21 participants (11 boys).

Table 4.7. Means (and sd's) for target vocabulary in Experiment 2.

	Static		Video		Total[2]
	No music & sounds[1]	With music & sounds[1]	No music & sounds[1]	With music & sounds[1]	
Pre	0.29 (0.72)	0.81 (1.17)	0.62 (1.32)	0.48 (0.68)	02.19 (2.60)
Post	3.67 (2.56)	4.14 (3.21)	3.76 (2.86)	3.86 (2.89)	15.43 (10.41)

Note. [1]Maximum scores per condition equaled 18. [2]Total score was calculated as the sum of four conditions with a maximum score of 72.

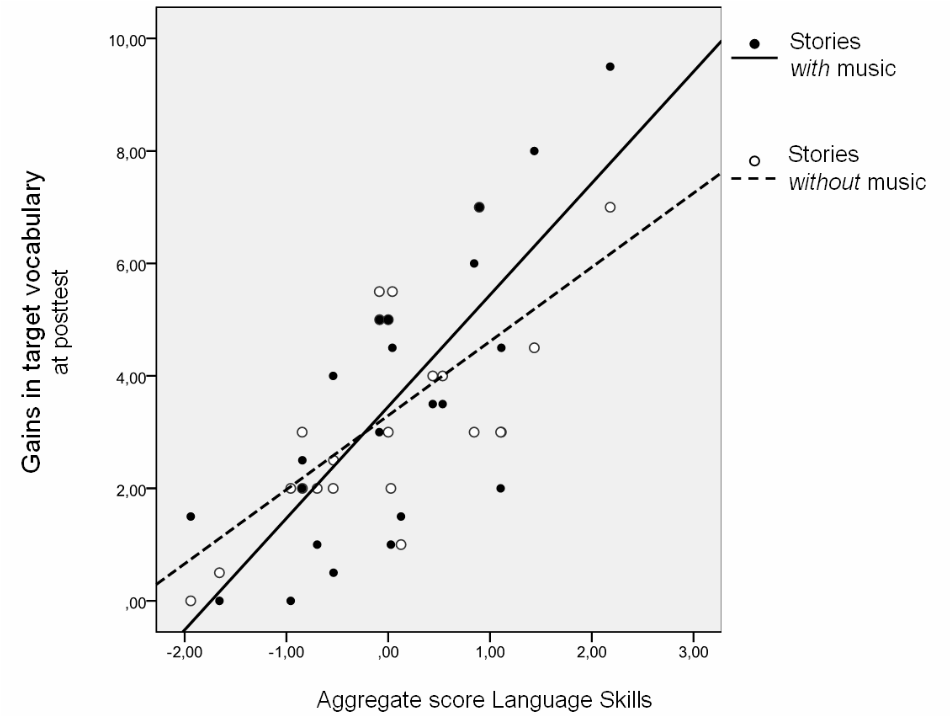

Figure 4.2. Gain scores for target vocabulary at posttest (calculated as posttest - pretest) as a function of language skills, displayed for stories with and without music/sounds. Because no effect for video was found, the conditions with/without music reflect the mean of both static and video stories.

We examined the effect of video and music/sounds on target vocabulary knowledge by a RM ANOVA with 3 within subjects-factors: time (pre *vs.* post), illustrations (static *vs.* video), and music/sounds (with *vs.* without music/sounds). Aggregate measures for language skills and phonological working memory capacity were included as covariates. A main effect of time was found indicating growth in vocabulary for all children, $F\ (1, 18) = 114.602$, $p<.001$, $\eta_p^2 = .864$, $d = 3.37$. The aggregate score of language skills was a significant covariate, $F\ (1, 18) = 48.470$, $p<.001$, $\eta_p^2 = .729$, $d = 2.13$, and the significant interaction Time x Language skills, $F\ (1, 18) = 30.135$, $p<.001$, $\eta_p^2 = .626$, $d = 1.62$, indicated that children with more advanced language skills learned more words. Main intervention effects for illustrations or music/sounds were not found, neither were two- or three-way interactions with time significant. However, the significant interaction of Time x Music/sounds x Language skills, $F\ (1, 18) = 4.526$, $p<.05$, $\eta_p^2 = .201$, $d = 0.43$, indicated that language skills moderated effects of music/sounds. As can be seen in Figure 4.2, more severe SLI children learned less with music/sounds, regardless of the illustrations being static or video. The effect in the subgroup with more severe SLI is similar to the finding in Experiment 1 that 'all-inclusive' video stories with music/sounds were inferior to static stories without music/sound. No effect for phonological working memory was found.

Discussion

In Experiment 1, 'all-inclusive' e-books with both video-images and background music and sounds were inferior to simple static versions. Experiment 2 replicated this finding. A subgroup of participants, namely children with more severe SLI (lowest scores on language tests) benefited less from all inclusive e-books. Disentangling effects of video and music/sounds by presenting variations of e-books enabled us to specify the cause of negative outcomes. In contrast to what the visual superiority hypothesis predicts (Hayes & Birnbaum, 1980), the presence of additional visual information sources did not interfere with word learning by distracting SLI children's attention from the language. However, background music and sounds interfered with learning new words from books. To explain why children with severe SLI have difficulties in familiarizing with unknown words when background music and sounds were present we assume that SLI children have problems with speech perception in noisy conditions (e.g., Robertson et al., 2009; Vandewalle et al., 2012). It seems plausible that similar problems occur in other contexts, which might explain SLI children's overall language delay. Being susceptible for the presence of background noise may indicate that SLI children experience speech perception problems which could be an underlying factor of SLI (Ziegler et al., 2005).

There is no support for the hypothesis that phonological working memory capacity plays a central role in disordered language development (Gathercole & Baddely, 1990b). In accordance with several other studies that failed to demonstrate a correlation between phonological working memory tasks and language skills (e.g., Edwards & Lahey, 1998; Montgomery, 2003; Ellis Weismer et al., 1999), working memory was not found to moderate word learning in this study. This suggests that difficulties in speech perception are independent of phonological working memory skills. However given the relatively small number of participants and small variation in skills we must be cautious with such a conclusion.

General Discussion

The current experiments show that storybook reading can be an effective language intervention for SLI children. This study was focused on reading electronic storybooks without any adult support; SLI children benefited from independent e-book reading but to a lesser extent than typically developing children. Prior research has demonstrated vocabulary gains of 35% for typically developing children after four readings of the same book (Smeets & Bus, 2012a) whereas SLI children on average learned 23% after four readings. SLI children seem to be especially susceptible to manipulations of the speech signal as is found in studies testing Tallal's hypothesis (e.g., Tallal & Piercy, 1974) that SLI children benefit from slowing down the speech signal (Ellis, Weismer, & Hesketh, 1996; Gillam et al., 2008; Segers & Verhoeven, 2002). In the same vein, our experiments demonstrated that background noise may interfere with understanding an orally presented text. Instead of supporting text comprehension by emphasizing suspense and stress moods such as happiness or sadness, the addition of music and sounds may have complicated perception of speech. Alternatively, even though music and sounds are only present in the background, they form an active component of attention (Barr et al., 2010) and might have caused cognitive overload when children experience problems in identifying basic emotions from music as is found for SLI children (Spackman, Fujiki, Brinton, Nelson, & Allen, 2006).

Our finding that some SLI children suffered more from background music and sounds than others is in line with suggestions that there are clusters of children with different language profiles within the SLI population (e.g., van Weerdenburg et al., 2006). On the other hand, in the current study word learning was moderated by an aggregate score composed of several language tests. Children who scored low on the aggregate performed poorly on all language tests, thus differential effectiveness of intervention may very well be dependent on the severity of SLI rather than the nature of the impairment.

Limitations

This study is not without limitations, one of which concerns the vocabulary test that we used. Just as in previous studies that used a sentence-completion test (e.g., Smeets & Bus, 2012a, 2012b; Verhallen et al., 2006) this measure effectively detected growth in knowledge of target words. However the test is limited in that it may not tap into a level of deeper semantic word knowledge that enables children to provide a definition for the word or use it in new contexts (Ouellette, 2006). Although the ability to complete sentences does not merely tap knowledge at the lowest end of the word learning continuum (Nagy & Scott, 2000) like for instance pointing out a word's visual referent, the test probably reveals partial word knowledge only. Using multiple tests at various levels of word knowledge would therefore be preferable which however has the disadvantage that repeated exposure to target words could explain outcomes (Biemiller & Boote, 2006; Verhallen & Bus, 2010).

The finding that phonological working memory was not related to word learning in the current study may raise some doubts whether working memory capacity is an underlying cause of SLI. However we must also acknowledge that the tests that we used for measuring the construct, a non-word repetition task and digit span forward, may have measured short term memory rather than working memory capacity. In neither of these tasks, children had to manipulate the information that was presented, which is supposed to be a crucial element of working memory (Baddeley, 1998).

Summary and Conclusions

Considering the rapid increase in technology including the use of e-books in schools, current findings provide valuable information for educators and speech-language pathologists for evaluating and designing interventions for SLI children. The current study shows that time on the computer can be well spent reading e-books; even without adult support SLI children familiarize with difficult words such as 'jealous', 'whistle', 'pouch', or 'broken-hearted'. However, speech perception problems should be considered in selecting e-books. Background music and sounds can interfere with processing the oral story text and may restrict learning. It seems best to present oral text in its purest form, without any background noises, music or sound effects. This is an important finding in a world that is dominated by media such as television and music and also has implications for children's learning in classrooms: as good as a teacher may be, noises in a crowded classroom may cause problems for at least a subgroup of SLI children.