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Affordances and limitations of electronic storybooks for young children's emergent literacy

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ABSTRACT

Stories presented on phones, tablets and e-readers now offer an alternative to print books. The fundamental challenge has become to specify when and for whom the manner in which children retain information from stories has been changed by electronic storybooks, for better and for worse. We review the effects of digitized presentations of narratives that include oral text as well as multimedia information sources (e.g., animations and other visual and sound effects, background music, hotspots, games, dictionaries) on children's emergent literacy. Research on preschool and kindergarten children has revealed both positive and negative effects of electronic stories conditional upon whether materials are consistent with the way that the human information processing system works. Adding certain information to electronic storybooks can facilitate *multimedia learning*, especially in children at-risk for language or reading difficulty. Animated pictures, sometimes enriched with music and sound, that match the simultaneously presented story text, can help integrate nonverbal information and language and thus promote storage of those in memory. On the other hand, stories enhanced with hypermedia interactive features like games and "hotspots" may lead to poor performance on tests of vocabulary and story comprehension. Using those features necessitates task switching, and like multitasking in general, seems to cause *cognitive overload*. However, in accordance with *differential susceptibility* theory, well-designed technology-enhanced books may be particularly suited

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to improve learning conditions for vulnerable children and turn putative risk groups into successful learners. This new line of research may have far-reaching consequences for the use of technology-enhanced materials in education.

Introduction

Nowadays on-screen activities (i.e., watching television, playing games on computers, tablets and other devices) have come to dominate children's daily lives (Rideout, 2011; Zeijl, Crone, Wiefferink, Keuzenkamp, & Reijneveld, 2005) and they become familiarized with technology at increasingly early ages. An online questionnaire among 1532 Dutch parents in 2012 (Iene Miene Media, 2012) showed that computers and tablets are growing in importance among 3- to 3 ½-year-olds, but not yet among 1- and 2-year-olds (see Rideout, 2011 for similar results in the U.S.). At the same time, the number and availability of electronic storybooks has increased dramatically. The first picture storybook on CD-ROM, *Just Grandma and Me*, appeared in the mid-1990s (Ito, 2009), but this new format has only recently become a widespread alternative to traditional paper book reading for children. According to the Association of American Publishers (Publishers Weekly, 2012), sales of children's electronic books presented on phones, tablets and e-readers went from 7 million dollars in March 2011 to 19.3 million in March 2012. This transition from traditional paper books as the primary source of storybook reading for 3- to 6-year-old children to electronic sources (Burnett, 2010) marks a change in the 'textual landscape' in which young children are growing up. As there has been concern expressed in the media and by parents about the potential negative effects of technological devices on young children (e.g., Spitzer, 2013), there is an urgent need to deepen our understanding of how interacting with digital stories can either support or hinder literacy development in the age range of 3–6 years when most children are not yet conventional readers (Miller & Warschauer, 2013).

We find electronic storybooks to be particularly interesting because these books not only simulate the experience of reading or listening to a story but also provide technological enhancements that make the reading experience qualitatively different from that with traditional paper books. Electronic books usually contain a combination of features, such as animated pictures and background sounds and music that dramatize the text. Most books also include interactive hypermedia elements such as animations that can be activated by the child with a mouse click or screen touch. These "hotspots" may be primarily for entertainment but certain features such as a dictionary function with word definitions can also provide useful on-demand help. Electronic picture storybooks can incorporate a diverse variety of such digital features and there is surprisingly little homogeneity in format across currently available storybook apps (de Jong & Bus, 2003; Guernsey, Levine, Chiong, & Severns, 2012; Korat & Shamir, 2004; Zucker, Moody, & McKenna, 2009).

The overarching theme of the current review is to evaluate whether, and under what conditions technology-enhanced storybooks can be a viable option for the development of emergent literacy. In making explicit when and for whom these books change the manner in which children retain information from stories, we will not discuss the role of co-reading in spite of the importance attributed to adults' participation in the traditional book reading paradigm (Mol, Bus, de Jong, & Smeets, 2008). When electronic books include a limited number of digital enhancements, parental involvement is, just as in print book sharing, an important predictor of children's story understanding (Robb, 2010). However, a recent study by the Joan Ganz Cooney Center (Chiong, Ree, Takeuchi, & Erickson, 2012) indicated that co-reading could be at odds with enhanced electronic books that contain highly interactive features. They found that both parents and children became frustrated when parents attempted to read enhanced stories, thereby interfering in children's interactions with the program. The observations of Chiong et al. demonstrate that the role of the adult in the new era of digital storybooks seems to be a highly complicated issue that needs to be targeted in further reviews.

We will summarize (quasi-) experimental studies in which a wide variety of technology-enhanced books designed for young children are compared and contrasted with more traditional print-like presentations. Although our main focus is on 3- to 6-year-old children, for comparative purposes, we will occasionally refer to research targeting somewhat older pupils. Our minimum definition of an electronic storybook for preschool and kindergarten children requires that it has oral narration instead of, or in addition to written text, and some form of multimedia (e.g., animations and visual effects, sound effects, background music) and/or hypermedia interactive features such as embedded images or activities (Zucker et al., 2009). We evaluate the effects of features that are most typical for technology-enhanced stories – multimedia and hypermedia – and do not consider effects of looking, touching, moving and gesturing behaviors typical for particular devices while interacting with electronic books (Roskos & Burstein, 2013). Although we are aware that several genres of electronic books are available – like concept or information books – we concentrate in this review primarily on narratives and storybooks (Yokota & Teale, 2014). We focus on the effects on *foundational* literacy skills like text comprehension and the understanding of complex grammar and vocabulary; all skills that are strongly related to later reading comprehension and academic performance in school (e.g., Whitehurst & Lonigan, 1998). We do not consider the development of what is sometimes referred to as *new literacies* or *multiliteracies*, that is, a set of skills and strategies related to modes of representation much broader than language alone (e.g., blogging, social media, photo sharing) (e.g., Lankshear & Knobel, 2011; Leu & Kinzer, 2000).

The fundamental challenge is to make explicit when and for whom interaction with technology-enhanced picture storybooks changes the manner in which children retain information from narrative text and when and for whom they strengthen or weaken story understanding and language growth. This is a particularly important question now that educators, parents and teachers are faced with the challenge of designing and selecting appropriate software for young children as avenues for teaching and learning literacy skills. The current review is different from previous research syntheses (Miller & Warschauer, 2013; Salmon, 2014; van Daal & Sandvik, 2012; Zucker et al., 2009) in that we were careful to only include studies that represent the typical multimedia and hypermedia features of digital stories. We have also taken the synthesis one step further by making connections between these typical features of technology-enhanced narratives and cognitive information processing theories that include relevant constructs such as dual-coding (Baddeley, 1986; Paivio, 1986), multimedia learning (Mayer, 2005), cognitive load (Sweller, 2005), and differential susceptibility to environmental input (Belsky, Bakermans-Kranenburg, & van IJzendoorn, 2007).

- In the first section of this review we provide rationales for the effects of multimedia storybooks and for whom in particular they may strengthen learning. A fundamental and guiding hypothesis is that instructional materials that are designed to be consistent with the way that the human information processing system works are more likely to foster learning than those that are not.
- In the second section we discuss the potential advantages for children's learning from nonverbal multimedia features such as motion pictures, background sounds, and music to electronic storybooks that match the story text.
- In the third section of this review we focus on the potential effects of common interactive hypermedia features. Apart from games and "hotspots" irrelevant to the text, we discuss on-demand interactive assistance in understanding story content like a dictionary function or a tutor who asks questions and provides feedback to children's responses.
- In the concluding section we will review what we have learned from research about designing digitized storybooks that are developmentally appropriate in form and function for young children. We aim to provide design suggestions for maximizing the potential of electronic storybooks for learning and for minimizing potential negative effects on the development of foundational literacy skills.

Rationales for learning with multimedia storybooks

In interpreting findings of the research on young children's learning from digital storybooks, we made connections between the typical features of technology-enhanced narratives and several key

principles from established theories of human learning and information processing. An evidence-based theoretical framework for multimedia learning was used to make predictions about the way that instructional multimedia messages will be received and interpreted by users of various ages (Mayer, 2005). One prediction is that when stories that are read or heard are accompanied by visual illustrations or other non-verbal information (background sounds and music) that enhance the content of the text, and these information sources are simultaneously available, the text will be understood and retained better than if conveyed by words alone. According to Paivio's (1986) dual-coding theory and Baddeley's (1986) model of working memory, humans process visual and auditory information in separate channels. When incoming sensory information is such that it can be processed in both channels at once, it is learned and retained more effectively than if it is processed in a single channel. One implication of this for multimedia books is that information that targets separate channels should be well integrated and consistent with the core message to be acquired at the same time.

On the other hand, technology-enhanced books may include multimedia features that can interfere with learning. When they are not directly related to the story text and children have to switch from processing one kind of information to another without being able to integrate them, these features can exceed capacity and children may experience cognitive overload (Sweller, 2005). Both children and adults have a limited capacity to process information at any one point in time (Kahneman, 1973). When we try to both comprehend the story text and the content of animations that are only indirectly related to the story content there is a threshold for how much information we can successfully attend to and manage. The constraints on processing capacity require a "central executive" (Baddeley, 1986) to deploy metacognitive strategies to select what we should focus on and how the selected information should be processed. Without such a mechanism, children may fail to select the relevant information that is needed to understand the story in the presence of distractors. Research has shown that task switching is especially difficult for young children whose executive functions are immature and who might predictably retain less from an electronic than a paper book format (e.g., Garon, Bryson, & Smith, 2008). One implication of this for hypermedia books may be that if multimedia additions are inconsistent with the core message to be acquired they may interfere with children's story understanding. When children switch their attention among the text and such interactive features of electronic storybooks while trying to retain the details of the story, they are engaging in an approximation to "everyday" multitasking, which may cause cognitive overload.

In testing the effects of multimedia in technology-enhanced storybooks we also used the concept of differential susceptibility to predict individual variation in responses to multimedia books (Belsky et al., 2007). In the developmental psychopathology literature there is growing evidence for the hypothesis that not all children are uniformly susceptible to the quality of educational input. The basic idea rests on the evolutionary-inspired proposition that depending on certain neurobiological, temperamental or genetic characteristics, some children seem to suffer more from poor guidance but also appear to benefit more from individualized scaffolding than others do. Building on this proposition, it is expected that not all children will be equally susceptible to the qualities of technology-enhanced materials. Intensive, closely monitored, and individualized scaffolding as can be offered by multimedia features, more so than is available in traditional learning settings. These features direct putatively vulnerable children's attention and motivation toward the tasks at hand while solving problems. As a result, children who lag behind when they do not have a chance to practice with optimally designed technology-enhanced materials might outperform their peers when receiving such materials. Books with built-in multimedia features that match the story text may thus offer a better starting point for the development of language and literacy skills and turn a "risk" group into a successful group. We expect that technology, given that particular conditions are fulfilled, may thus open up new learning opportunities for vulnerable children.

The potential of animation, background sounds and music in storybooks to support emergent literacy

We expected from previous research that multimedia learning might play an important role in emergent literacy and that electronic books equipped with motion pictures, background sounds and music might be especially supportive of this development (e.g., Verhallen, Bus, & de Jong, 2006). Within the

multimedia learning framework (Mayer, 2005), there is reason to expect that young children will learn more effectively from presentations that include words combined with pictures than from words alone (Schnotz, 2005). For example, there is evidence that children are more successful in understanding and retaining unfamiliar words (Paivio, 1986; Sadoski & Paivio, 1994) and the story meaning (Guttman, Levin, & Pressley, 1977; Sharp et al., 1995), when the story is processed through both the visual and verbal channels rather than through a single channel. These findings are consistent with Paivio's dual-process theory, in which a verbal system specialized in dealing directly with language and a nonverbal system specialized for dealing with nonlinguistic information are integral. Drawing on both channels simultaneously, nonverbal information can help young children to comprehend language including unfamiliar words and complex grammar. Vice versa, verbal information may help children to comprehend difficult or unfamiliar images. In addition to the effect of dual-channel processing per se, when there is close temporal proximity of words and images, integration of verbal and nonverbal information is facilitated thus enhancing memory traces that connect details of pictures with phrases in the narrative (Paivio, 2008; Wickens, Kramer, Vanasse, & Donchin, 1983).

These multimedia learning principles can explain why young children's recall of the story line and story details improve when a narration is lavishly illustrated, as is typical of most paper and electronic storybooks for young children (Greenfield & Beagles-Roos, 1988; Hayes, Kelly, & Mandel, 1986). According to the dual-channel assumption, the advantage of books that include images in addition to text is that children thus have a chance to match verbal information with corresponding images because they are presented at the same time. This match with non-verbal information may result in more understanding of story text due to better comprehension of story events and stronger encoding of the verbal material. There is some research showing that young children naturally try to match verbal information with images. Their looking behavior while listening to the story text seems to promote close temporal contiguity of word and image. Using a remote eye-tracking system to register which details in a still illustration were fixated on while listening to the story text (Verhallen & Bus, 2011), we found that the text limited where in the illustration children fixated. They looked more often and for a longer time inside the areas in the illustrations that the text highlighted, than outside these areas. As a matter of fact, children's visual attention seemed to be directed by the content of the oral text. To further test the importance of close temporal contiguity of word and image in picture storybooks, we also carried out an experimental study in which we compared the effects of simultaneous with successive presentation of oral text and illustration. We found evidence for the hypothesis that, especially when the text is complex, simultaneous presentation is more effective for learning story information than is the sequential presentation of oral text followed by the corresponding illustration, such as what children often experience at story time in school (Takacs & Bus, 2013, April).

The special effects generated by technology-enhanced storybooks can reinforce multimedia learning and promote comprehension. The new formats allow simultaneous presentation of images and text in ways that are not possible in print books (Ito, 2009). Consistent with the cognitive theory of multimedia learning, we expected that electronic book features could bolster story and text comprehension in ways that listening to a typical read-aloud of a picture storybook does not. In listening to the words read from printed picture storybooks, children may not readily connect the visual images in the storybooks to the (oral) text, even when both are presented simultaneously (Verhallen & Bus, 2011). This may be especially likely when the child is at risk for language delay (e.g., low SES; second language learning) or the material is complex. Moreover, as the amount of information that can be processed in each channel at one time is limited, children can hold only portions of an image in a picture storybook in working memory (Baddeley, 1986). Likewise, they can only hold a few words from the narration to which they are simultaneously listening. We hypothesized therefore that children might often fail to match the narration with the illustration (Verhallen et al., 2006). However, electronic books that include animated pictures can provide guidance to the learner, more so than printed books, in integrating images and language and cementing these associations firmly in memory. In animated pictures, visual elements that are normally presented as a single very detailed static illustration can be split into several smaller portions that are highlighted or zoomed in on, each representing one element of the narration. By thus synchronizing phrases in the narration with portions of the relevant picture there is a higher probability that connections will be made between words and images and that children can 'concretize' the narration without much effort (see exemplary pictures from print books as

compared with screen shots from the digitized versions of the same scenes in Smeets & Bus, 2012, 2014). The material thus assists the learner in constructing a coherent mental representation of visual and verbal input.

To illustrate this issue, it is not easy to connect an image in *Winnie the Witch* (Thomas & Gorky, 1996) that depicts the witch with her wand and her green cat with the events in the narration that successively explains how the black cat was turned to a green cat by waving the magic wand and reciting a magic spell. The electronic version of this picture storybook with animated pictures, by contrast, may facilitate the association between text and image. This version of the book is more informative about the event by showing, in this order, how Winnie picks up her wand, waves it, uses the spell, and turns the cat from black to green, thereby exactly matching the images with events in the narration. Improving temporal proximity of text and images by zooming in on details in pictures or adding motion that attracts children's attention to a particular element may help the child to understand the story events and may strengthen recall and retention of unfamiliar words. Motion in particular seems to direct children's attention to important details of animated illustrations thereby facilitating integration of the verbal and non-verbal information (Takacs & Bus, 2014). We expected that, in this way, animated electronic books might facilitate the learner's understanding of the scene and of complex expressions like "wand" or "wave" (Smeets & Bus, 2012, 2014).

Recent storybook apps often include, along with animated visual images, auditory information (background sound and nonverbal music), which may be an additional advantage for multimedia learning. According to Schnotz's (2005) integrative model of text and picture comprehension, pictorial information is not necessarily associated with the visual modality alone, but can also be conveyed by other sensory modalities such as sound images. Background sound – the sound of knocking on a door, birds whistling, or an engine running – are also processed in the visual/pictorial channel. This may enrich nonverbal coding and thus help concretize scenes and words' meanings just as images. When background sounds are contingent with the oral text, this may also enable simultaneous processing of verbal and nonverbal material, thereby facilitating language comprehension. Moreover, storybook apps often include nonverbal music that may lend support to text comprehension by illustrating the characters' moods (e.g., fear, sadness or happiness). For instance, when Winnie the Witch is furious because she stumbled again over her black cat in her black house and turns the cat into a colorful cat to make him visible, the happy tune stops and turns into atonal sounds. Although images and sounds are functionally independent, both information sources may facilitate the learner's understanding of the scene and of the grammar and abstract expressions by concretizing the narration (Thompson & Paivio, 1994), especially when phrases in the narration are synchronized with non-verbal information in storybook apps (Schnotz & Rasch, 2005).

Evidence for the efficacy of multimedia storybooks enriched with animated pictures, music and sounds

In early studies conducted into television as a medium for young children, the potential negative effects of animated stories were often emphasized. For instance, it was concluded that students invest less mental effort when activities are perceived as entertaining (Salomon, 1984). In line with this argument, watching animated stories on various devices may be less effective for learning than listening to an oral text while looking simultaneously at illustrations in print books. It was also hypothesized that children might pay the greatest attention to the visual aspects of animated pictures, thereby ignoring language features. Only a few early studies on television viewing in the early 1980s (Hayes & Birnbaum, 1980; Hayes, Chemelski, & Birnbaum, 1981) found higher retention of visual information than of audio information, a phenomenon denoted as the *visual superiority effect*. However, based on the dual channel assumption of multimedia learning (Mayer, 2005), we might expect that books that optimally enable dual-coding by including congruent animated pictures and nonverbal sounds and music with the text would offer more comprehensive support than print books that only contain still pictures. So previous results that supported the visual superiority effect may be an artifact of a set of stimulus materials that were not closely matched and thus did not support dual coding.

For a critical test of multimedia effects we selected (quasi-) experiments from the literature in which additional non-verbal information was included in electronic stories. We assessed whether these features actually improved the manner in which children learned and retained information from storybooks

and for whom those additions were most effective. The seminal study by Sharp et al. (1995) was among the first to test whether what they called 'dynamic video information' aided children's understanding of short stories. The study showed that, in a group of 5- and 6-year-olds, a learning context with silent video that illustrated the entire story accelerated story comprehension more than did a silent video in which only one video event from the story was shown. More recent studies have also revealed positive effects of animated books that included animated pictures, background sound, and nonverbal music when compared with the same or similar books that included static images. Most experiments focused on children aged 5 and 6 years with a limited Dutch or English background for whom the scenes were complex and the narrations included difficult language (Kamil, Intrator, & Kim, 2000). From these randomized controlled trials it appeared that electronic multimedia books were more appropriately tailored to meet the needs of these children than still versions of the same books that contained only static images (Smeets & Bus, 2014; Verhallen & Bus, 2010; Verhallen et al., 2006). For instance, after 20 minutes, the time it takes to hear the computer voice read the story about *Winnie the Witch* four times, second language learners' vocabulary gained six out of the 42 words selected from the focal story (Verhallen et al., 2006). Children's word knowledge also improved as a result of spending the same amount of time reading a still version of the same book – a condition that seems analogous to a print-book reading sessions – but growth was less substantial. Stories with animated pictures were also more beneficial for story understanding (Verhallen et al., 2006). After hearing the oral narration four times while looking at static pictures on the screen children understood only part of the story. Their retellings were far from complete and included on average slightly less than 40% of the story elements. In the multimedia condition, children's retellings covered on average 55% of all story elements. Effects were most pronounced for understanding the goals, intentions, motivations, and feelings of story characters. Children in the static condition understood that *Winnie the Witch* kept stumbling over the cat (action) and that she changed the cat into a green cat (action) but they did not mention the fact that *Winnie the Witch* got angry when she had fallen once again and decided to do something about it (implied). Retellings of a story after being exposed to the multimedia book, on the contrary, did not just contain actions but implied elements as well. These children also named states of minds of main characters ("sees," "is furious," or "decides").

The results of these studies were consistent with the hypothesis that nonverbal information does not necessarily "use up" the capacity for storing language in working memory but rather enables children to figure out the meaning of unknown words and store those in long-term memory (Paivio, 2008; Wickens et al., 1983). None of the experiments with animated storybooks that included motion pictures, sound and music supported the visual superiority hypothesis that these books were so overwhelming that children failed to listen to the story text and just focused on the animations. The multimedia effect may not, however, be the only explanation for the finding that children learned more from such books compared with print books. Alternatively, animated storybooks may be more effective in attracting children's attention than static books, especially when children repeatedly listen to the same story. Evidence for this comes from a study in which we found that children's level of arousal as indicated by skin conductance while listening to a story was higher during the animated version than while listening to the static version, especially when the book was repeated for the third or fourth time (Verhallen & Bus, 2009). A balanced set of motion pictures enriched with music and sound may help young children to stay attentive while listening to the story, thereby enjoying books more and becoming more motivated to reread stories more than once.

Not all multimedia features facilitate children's emergent literacy

Not all experimental results supported the positive effect of animated stories on learning in young and language-delayed groups of children. Unlike the above-mentioned studies, Korat and Shamir (2007) and Silverman (2013) did not find positive effects of animated stories on story comprehension and vocabulary learning. However, the materials in these studies may not have been designed in a way that non-verbal information provided guidance to the learner for understanding the narration. For instance, Korat and Shamir (2007) used scanned illustrations that included automatic dynamic visuals to dramatize the story, but the animations were not created to attract attention to the particular details that matched the story text. Motion was added to make the scene more realistic (e.g., trees moving

in the wind), but not to attract children's attention to relevant story elements in the illustrations and thus optimize temporal congruity of text and illustrations, and dual coding. Where the visualization is not intended to focus attention on particular details, but rather includes purely 'decorative' or incidental animations, electronic books may not benefit literacy skills. Silverman (2013) used children's television programs as a medium for vocabulary instruction and contrasted those with print versions that were made by selecting screenshots from the videos, "chosen to be optimally representative of the theme". The text was created by incorporating dialogue from the script verbatim into the books. The videos showed the whole scene but were not created to make complex narrative story language understandable by zooming in on or turning critical details (e.g., bear's red face due to being shy) or typical behaviors (e.g., a fluttering butterfly) in motion.

We predict, therefore, that positive effects for multimedia additions to stories will be observed only if images that attract the most attention are semantically related to the words and if they are presented closely together in space or in time (Kamil et al., 2000; Moody, Justice, & Cabell, 2010). The "crowdedness" of animated presentations may become problematic if the result requires children to process information simultaneously through multiple modalities that do not match. This might cause overload of children's working memory and reduce learning about the story language, rather than making the most efficient use of limited cognitive resources. Likewise, the integration of commercial movie footage with written text, as in so-called 'vooks' (an amalgamation of video and books), may not fulfill the minimum requirement of temporal contiguity and therefore not support language development. Given the discrepancies in the extant research base on how static and animated media compare as contexts for vocabulary learning and text comprehension, more research is required. We need to specify the ways that different media should be harnessed to improve learning; that is, under what conditions does information presented through multiple versus single modalities bootstrap the development of literacy skills.

Differential effects of additional information resources

Even though detailed pictures make storybooks particularly suitable for extracting meaning and deriving unknown words from the book context (Carney & Levin, 2002; Greenfield & Beagles-Roos, 1988; Hayes et al., 1986), they may not always be needed or helpful because some readers are able to create mental images of story events from the words alone (Guttman et al., 1977). With age, easy-to-follow texts that are highly concrete and engaging (e.g., interesting narrative passages) may readily elicit visual imagery (Carney & Levin, 2002). We therefore expected that not all children would benefit from multimedia stories that use a broader range of symbolic elements to carry meaning. The inclusion of additional information sources – images, music and sounds – in addition to text may be primarily helpful for children who experience problems in understanding story events and learning new words (Reinking, 2005). Nonverbal support for story and text comprehension may be important because these children have fewer words with which to comprehend new words through verbal communication alone (Silverman & Hines, 2009). Consistent with this reasoning, Kamil et al. (2000) predicted the strongest effects of the application of multimedia features for children who find it hard to understand narration based on language alone: second-language learners, other groups at risk for language delay (e.g., low SES), and very young children.

Smeets and Bus (2014) did not find effects of multimedia compared with static storybooks on story comprehension in a normative sample of 4- and 5-year-olds who were first language learners with average scores on language proficiency. Yet Smeets and Bus (2014) found that animated electronic storybooks provided more opportunities for vocabulary growth and resulted in an additional 6% increase in word learning in this group compared with stories presented on the computer with static pictures alone. Other studies that included children from elementary schools indicated that for these older students with normal language skills (Beagles-Roos & Gat, 1983; Gazella & Stockman, 2003; Neuman, 1989, 1992), providing animated pictures was not as helpful in promoting story comprehension as it was for younger groups. This was probably because hearing the text content directly elicited useful images in older and more advanced students but not in younger students. In so far as these findings concern students in higher grades of education, they are consistent with the "expertise reversal effect", in which instructional techniques that are effective for less experienced learners might

not be useful for more experienced learners because the redundant additional information can distract the experienced learner and increase cognitive load (Kalyuga, 2007; Kalyuga, Chandler, & Sweller, 2004).

A study targeting kindergarten children diagnosed with Severe Language Impairment (SLI) showed that symbolic elements used to carry meaning such as background sounds and nonverbal music are not always helpful for young children who experience problems in understanding and retaining the story language. In those cases, music and sound added to electronic stories contributed negatively to learning new language (Smeets, van Dijken, & Bus, 2014), just as adding music and sounds to general learning tasks seemed to do in young toddlers (Barr, Shuck, Salerno, Atkinson, & Linebarger, 2010). According to Schnotz's (2005) integrative model of text and picture comprehension, information enters working memory from the outside world through sensory channels. During the first step in processing information that enters through the ears, the learner makes exact auditory images of words for a very brief time period in an auditory sensory memory. Children with SLI may experience problems with creating these exact images because of the presence of background sounds and music. The SLI children in the Smeets et al. study also failed to repeat novel non-words when background noise was present (c.f., Robertson, Joanisse, Desroches, & Ng, 2009; Vance & Martindale, 2012; vande walle, Boets, Ghesquiere, & Zink, 2012), which may indicate that they had problems creating auditory images of words in the sensory registers. As a result, they may have failed to create, in the next step of processing verbal information, a verbal representation of selected words or phrases in the verbal working memory thus interfering with learning unfamiliar words (Schnotz, 2005). It is also possible that children with SLI experience problems in identifying basic emotions from music (Spackman, Fujiki, Brinton, Nelson, & Allen, 2006). This might interfere with processes that take place when non-verbal information is integrated in working memory in order to create a mental model of non-verbal information. Even though music and sounds are present only in the background and provided to supplement images, they attract attention (Barr et al., 2010) and might have caused cognitive overload for these children when they were organizing visual and auditory information into a mental representation.

Whatever the exact nature of the interference of music and sounds may be, an important message of the Smeets et al. (2014) study is that adding these to stories might diminish rather than enhance the learning potential of multimedia storybooks for children who have problems with verbal processing (Courage, Bakhtiar, Fitzpatrick, Kenny, & Brandeau, 2015). In those cases, it might often be best to present oral text alone, without any music or sound effects. The finding that music and sounds can be detrimental for learning has far-reaching implications in a world that is dominated by storybook apps that mostly include background sounds and music (Smeets & Bus, 2013). In many apps, the volume of the soundtrack is loud and not adjustable. In examining the current offerings in app stores, we found many that typically are too loud. For example in Disney's *Cars 2*, the narration can barely be heard over the exciting background music and sound effects of racecars driving by. The storybook app *Magic Gold Fish* by Yasmin Studios includes hotspots with sound effects (e.g., a fish splashing in the water) that are very loud in comparison with the narration. Interestingly, for example, the apps *Pansjo Tummy* developed by ThenQ, *PopOut! The Tale of Peter Rabbit* (Loud Crow Interactive) or *The Fantastic Flying Books of Mr. Morris Lessmore* (Moonbot Studios) include an option for turning off background music and narration separately; such a feature makes an animated multimedia book more adaptive to support learning in different target groups.

Effects of interactive features in hypermedia storybooks

Most first generation electronic storybooks included interactive features, as was evident from content analyses of Dutch (de Jong & Bus, 2003) and Israeli e-books (Korat & Shamir, 2004). Since the first books on CD-ROM appeared, researchers have studied the effectiveness of hotspots in these stories. One of the first interactive electronic storybook that came out in The Netherlands in the late '90s was based on the stories by German author-illustrator Janosch. A scene from one of the stories shows Dr. Cornelis Frog examining Tiger because he did not feel well. After the events were dramatized, the screen was frozen and it was possible to click on about five details in the illustration such as the light bulb, the little duck on the floor, or Tiger, whereupon visual and/or sound effects were activated. Doctor Frog may, for instance, take a bite from the light bulb hanging above his head. Hotspots in the early

electronic storybooks were rarely supplemental and intended to help to understand story events. A content analysis carried out in The Netherlands (de Jong & Bus, 2003) and replicated in Israel (Korat & Shamir, 2004) indicated that in most first generation digitized books, almost all interactive hotspots were incidental (more than 90%). As a result of the increased popularity of touch screen devices, hypermedia stories for the youngest children usually include a large number of increasingly fancy but incidental hotspots. For example, in the app *PopOut! The Tale of Peter Rabbit* (Loud Crow Interactive) children have small games on every screen utilizing the advanced features of the device. By touching and moving leaves, berries and other objects pop up and fall down the screen; at the bottom they can be moved to and fro by physically moving the device as marbles in a box can be moved. All of the games are surprising and amusing but irrelevant to the story. In another app *The Three Little Pigs* (Game Collage), in addition to the option to make parts of the illustrations pop up, there is a feature included on every page that allows children to put on an x-ray view showing the mechanics of those pop-ups. Such incidental features that do not enhance the story line are typical for many books developed for the youngest children. In electronic stories for 9- and 10-year-olds, the 'menu' may allow the child to visit the different planets, listen to the characters, play a game, keep a diary, and find out about the life of the author (Grimshaw, Dungworth, McKnight, & Morris, 2007).

However amusing those interactive features might be, there is concern for the educational quality of these electronic storybooks (e.g., de Jong & Bus, 2003; Korat & Shamir, 2004; Roskos, Brueck, & Widman, 2009; Zucker et al., 2009). Kamil et al. (2000) described electronic books that are loaded with extraneous information as more like a game than a book reading experience. Although playful additions are designed to be interactive, motivating, and self-paced (e.g., Ricci & Beal, 2002), adding 'bells-and-whistles' to a multimedia presentation may distract children from the main activity – story comprehension – or interfere with extracting meaning from the main message (Mayer, 2001). As the human information processing system has a limited capacity (Baddeley, 1986; Sweller, 2005), sharing resources among various tasks (e.g., memorizing and integrating story events in between playing games) may come at a cost for performance (Kahneman, 1973). In his review of the educational potential of electronic story texts, McKenna (1998) noted that interactivity in electronic texts for literacy learning makes great intuitive sense but that interactivity can also take forms that interfere with story comprehension. Preschool children's learning may suffer especially from task switching between game-like features and story understanding, as their executive functions are immature (Garon et al., 2008). We shall now review the available research that examines common forms of interactivity in storybook apps for preschool age children.

Effects of games or "hotspots" that are incidental to story content

Clicks on hotspots that activate links to animation, sound, or music – mostly incidental to the narration – may attract the viewers' attention and increase arousal, motivation, and engagement (Smith, 2012). Moody et al. (2010), for instance, reported higher levels of persistence during the adult-led storybook with hotspots compared with the adult-led print book reading. That is, the children were more problem-oriented and more able to complete and maintain participation with hotspot-enriched storybooks (cf. James, 1999). However, there are more studies indicating that switching among divergent tasks within a window places the younger user at risk for cognitive overload. Rather than enhancing learning outcomes as intended, carrying out game-like activities during the story reading session interrupts the processing of the story line and results in interference, distraction, and ultimately errors and diminished performance (Courage et al., 2015).

Although the twenty 8-year-old children in a seminal study (Okolo & Hayes, 1996) enjoyed the animations (clicks on an element of the picture revealed a written label, spoken out loud and sometimes accompanied by sound effects), the extensive animation sequences often misled children into drawing wrong conclusions about the text and diminished their ability to make sense of a story. Similar results were reported for 10-year-old students (Trushell, Maitlend, & Burrell, 2003). Children in the *Let me play* group condition that contained visual distractions that lured attention away from text, scored lower on story recall measures than students in the *Read to me* group without distractions. When incidental hotspots were included, children's recollections of the story were lacking in detail and also contained distortions.

In a case study, Labbo and Kuhn (2000) compared retellings of two books, one with incidental interactive features incongruent with the text and the other with congruent, supplemental features. The study involved a Spanish-speaking child practicing with books written in English in the classroom. Their observations indicated that storybooks on CD-ROM with supplemental interactive features supported this child's understanding and retelling of the story. However, CD-ROM stories with many incidental effects resulted in the child's inability to retell the story in a cohesive way. In other words, when given two tasks to perform concurrently – understanding the story while resisting distraction from interactive features – it was difficult for this child to construct a coherent mental representation of the story. The authors concluded that kindergarten children could fail to understand stories especially when special effects in the storybook apps were frequent and inconsistent with the story.

De Jong and Bus (2004) replicated the negative result of incidental interactive features in a larger group of kindergarten children. The children in their experiment were native speakers and therefore not as delayed in language as was the Spanish-speaking boy. The CD-ROMs used in this experiment included many incidental interactive features. On average each screen included five animations that could be activated after listening to the story text read to them by a computer voice. More than 90% of the animations were incongruent with the story. All children were attracted to the embedded effects and activated about 20 animations in each 15-minute session. After listening to the story, children were able to retell it but did so in much less detail than without having had access to the embedded animations. This suggested that children were unsuccessful in coordinating simultaneous task demands and, perhaps due to a higher cognitive load involved in multitasking, their comprehension was diminished (Mayer & Moreno, 2003).

A likely explanation for the negative effects of incidental interactive features inconsistent with the story is that task switching (or multitasking) is particularly difficult for young children. They are typically unsuccessful in carrying out simultaneous activities that require different cognitive processes at the same time or alternating between activities that consume processing resources. According to the research, preschool and kindergarten children fail to attend to all of the relevant information that is needed to understand the story while resisting distraction from animations that are interesting but less relevant. These negative outcomes – distortions and less detailed retellings – may be the result of immature executive functions such as working memory, attention shifting, and inhibition (Kegel & Bus, 2014). They may also reflect a "switch cost" (Courage et al., 2015): When attention is divided or switched among two or more tasks, some degree of dual-task inference or switch cost may result in poorer performance. However, not all studies show negative effects of children's access to irrelevant interactive hotspots and games on story memory (Homer et al., 2014; Ricci & Beal, 2002; Robb, 2010). The kinds of interactivity offered by the device in those studies may have been limited enough that children were able to focus on the story line. In other words, the success of hypermedia electronic storybooks may depend critically on a variety of pedagogical and design factors as well as on the maturity of executive functions and comprehension skills that the child possesses.

Nowadays apps are available that, more than the first generation of electronic stories, include playful interactive features that must be activated by the reader in order to advance the story. The programs that we examined, however, showed that this type of design can be effective but mostly at the expense of the story's complexity and language. In the app *The Birthday* by Sylvia van Ommen, for instance, a mouse brings written invitations for his birthday to all his friends. By dragging the letter to a friend or the letterbox of a friend the child continues the story. The activities may not place the young user at risk for cognitive overload but the result is, unavoidably, an extremely simple story told in colloquial language with phrases like: "hi", "did you read it?", "cool", which is rather limited even for 2- and 3-year-olds. The activities might be entertaining because they are game-like, but the medium may develop children's visual and motor capabilities at the expense of story understanding and language processing (Greenfield, 2009).

Efficacy of on-demand and automatic support for story comprehension

In one of the first prize-winning digitized picture storybooks released on CD-ROM in The Netherlands, *P. B. Bear's Birthday Party* (Davis, 1994), several different activities took place across the windows but, unlike the storybooks described above, the on-demand sources within a window were not only

meant to be amusing but to provide support in understanding the story text. As the story text was read aloud by clicking on an icon at the beginning of the text, children could, for instance, activate the illustration to dramatize the story text or use a dictionary. Clicking on pictures replacing words in the story text revealed animations or sounds to explain the words' meaning. Furthermore, they could listen for a second or a third time to the oral text read by the computer voice or return to a previous screen for a repeated reading of the story text. One study tested whether such on-demand sources for understanding the story were used effectively by young children to support story comprehension. A randomized controlled trial (de Jong & Bus, 2002) revealed that 4- and 5-year-old participants did not recall the story line as well as children who listened to an adult read the same story to them. It seemed that young children who explored the electronic story were unsuccessful in dividing their attention across reading and using the on-demand resources in all six 15-minute sessions. Most children completely ignored the oral text and just played games and activated the animations. In so far as they listened to the story text, they did not listen to the pages in order. They spent more than half of the available time (about 2 hours in total) on the attractive animations and games, and the rest of the time was alternated between animations and a film about the story that was presented without (oral) text. They rarely listened to the story text and if this occurred they focused on text fragments after clicking on a sentence probably because they liked the motorial activity. As a result, most children heard the story text in a seemingly random order that was disconnected from the visualizations.

In general, the basic goal of this first generation electronic storybook, to provide additional information sources (e.g., explaining words, visualizing the story events, rereading the story text) to promote (oral) text comprehension, was not effective for young children. Both playing and reading can occur in parallel but the children preferred playing with animations and games to listening to the story text, maybe because distributing limited mental resources differentially among them was too taxing. Resources were redistributed in a graded fashion (e.g., mainly ignoring the most complex task – understanding the story text) to maximally enjoy the games. Probably because of the group's limited text comprehension skills, children gave priority to animations and games at the expense of oral text, and the animations and the visualization of story events were used on their own and not as tools to improve story understanding. The extra material in this interactive storybook seemed to distract young children from the story, even though most additions were relevant for story comprehension. Although the story was designed to be interactive, motivating, and self-paced, it placed the young user at risk for cognitive overload rather than enhanced learning outcomes. We hypothesized that due to young children's inability to divide and deploy attentional resources effectively across the various subtasks, this interactive story supported a game-playing approach rather than engagement in the story.

On the other hand, there is evidence indicating that young children can benefit from explanations of difficult words when those are automatically presented during story reading and interruptions are limited to a few times per book. For instance, in *Bear Is in Love With Butterfly* (van Haeringen, 2004), a definition of words that are often unknown to 4- and 5-year-old children (heartbroken, shy, wharf, imitate) were audio-recorded and linked to a hotspot in the illustration. After the screen freezes a green circle appears around one element, for instance Bear's red face, and the voiceover explains Bear's mindset: "Bear is shy, his cheeks have turned red." When word meanings were thus defined children gained, after four encounters with the same story, an extra 8% of word meanings beyond encounters with words in the text alone (Smeets & Bus, 2014). Similar results were reported for other studies with a 'dictionary option' that automatically defined words (e.g., Korat, Levin, Atishkin, & Turgeman, 2013; Korat & Shamir, 2008; Shamir & Korat, 2009; Shamir, Korat, & Shlafer, 2011) or presented word definitions as games (e.g., asking a child to click on a target object in the picture; Segers & Verhoeven, 2002, 2003). These hypermedia features may be effective because children are safeguarded from having to coordinate simultaneous task demands and also receive help in dividing attention across reading and on-demand sources.

Somewhat older, conventional readers seem more able to use on-demand help in understanding the story events and language probably because they have more mature executive functions and can multitask more effectively. For instance, the online dictionary providing on-demand word definitions and synonyms was accessed by 18 of the 26 9- and 10-year-olds while only one child accessed a printed copy of the Oxford Primary Dictionary once while reading from the printed version of the same text (Grinshaw et al., 2007). However, there was no strong evidence for the effects of a

dictionary or other supplement information on story comprehension in this young age group. Although students utilized additional reading resources when engaged with digital text, Wright, Fugett, and Caputo (2013) reported similar comprehension scores for print and electronic storybooks.

Questions and comments modeled on co-reading with adults can stimulate learning

In accordance with engagement theory, the hypothesis that students must be meaningfully engaged in learning activities through interaction with others for optimal learning to occur (Kearsley & Schneiderman, 1999), developers have begun to model questions and feedback about complex words or important story points on adult supports that occur during book reading sessions. Children who read an interactive book with a parent get tailored support from the parent, as well as access to desirable interactive features. Comparable verbal support from a computer tutor might encourage children's continued, positive engagement in the task just as it does in co-reading sessions. When adults prompt children with questions pertaining to the text, label object, and encourage them to discuss the book content in terms of their experiences and interests, this elicits increased motivation and verbalization by the child and can improve literacy development (e.g., Biemiller & Boote, 2006; Blewitt, Rump, Shealy, & Cook, 2009; Brabham & Lynch-Brown, 2002; Collins, 2010). The promptness and contingency of responsiveness might help ensure that the child remains focused on the computer task. In this line of argument, we expect that a tutor modeled after an adult would facilitate children's understanding of complex word explanations. In fact, there is evidence that a story incorporating an on-screen dialogic questioner modeled on parent-led questioning enhanced children's story comprehension at age 3 (Strouse, O'Doherty, & Troseth, 2013). The storybook pages included very light animation and there was a voiceover of an adult reading the story. Each page also included a small picture-in-picture in the corner of the main story image. An actress on the pre-taped video asked dialogic questions but could not respond contingently to the viewing child. Consistent with this, the results of a randomized controlled trial study (Smeets & Bus, 2012) indicated that children who learned by answering multiple-choice questions outperformed those who received identical information in a non-interactive message. When Bear in the story *Bear Is in Love With Butterfly* (van Haeringen, 2004) is fanning the fire, the story is interrupted for a question by the computer assistant: "Bear is fanning the fire. In which picture can you see that?" To answer questions about difficult words or important story points, children can click on one of three pictures that appear on screen (the correct image among two distractors). The tutor gives feedback regarding the correctness of the response and provides clues in the cases of incorrect responses that become more specific as children continue to make errors (van der Kooy-Hofland, Kegel, & Bus, 2011).

The pattern of results suggests that the inclusion of a tutor using dialogic questioning within electronic stories modeled on co-reading with adults, although probably not as effective as true social contingency, might be useful in increasing what young children can learn from electronic books. We have therefore begun testing the hypothesis that, for susceptible children (i.e., whose performance depends more strongly on the quality of educational input than for others; Belsky et al., 2007), multimedia books that provide intensive, closely monitored, and individualized scaffolding may be especially effective in turning a putative "risk" group into a successful group. The experiment (Plak, Kegel, & Bus, 2014) was carried out at 82 Dutch schools. All 5-year-olds who belonged to the lowest quartile of a national standard literacy test were eligible to participate in this experiment. The experimental group used the books twice a week for 3 months while a control group played games not related to literacy during the same time. By analogy with findings in developmental psychopathology, we assumed that some children would be more susceptible to environmental input than others (van IJzendoorn & Bakermans-Kranenburg, 2012). In this study we focused on children's genetic make-up as marker for differential susceptibility and tested whether carriers of the long variant of the DRD4 genotype may also be a susceptible group in the cognitive domain. It is assumed that transmission of electric signals, especially in the prefrontal cortex monitoring impulses from the limbic system, is less efficient in this group. Consequently, these children may be easily distracted by irrelevant elements in the learning environment and experience more problems in canalizing stress elicited by school tasks, with poor achievement as a result. An engaging learning environment, on the other hand, might influence these children more positively than it affects their peers. The first experimental results indicated

that only carriers of the long variant of the DRD4 genotype benefited from an intervention in which they read multimedia books on their own. In this susceptible group (about one-third of all participants), the electronic books program caused a moderately strong effect on a national standard literacy test (effect size $d = 0.56$), whereas the program did not affect the other children ($d = -0.09$). Further studies are required to test why carriers of the long variant of the DRD4 genotype in particular lag behind without multimedia book reading but outperform their peers with such experiences in addition to the common core curriculum in kindergarten. Guidance and feedback provided by the tutor may make the multimedia books especially effective in susceptible groups. It is also possible that attractive multimedia including motion pictures, sound and music help young vulnerable children to stay engaged and control stress while reading books (Kegel & Bus, 2012).

Conclusions: what we have learned about designing digitized storybooks that are developmentally appropriate in form and function

Digital storybooks, including those designed for recent devices like phones and tablets, contain a combination of enhancements (Horney & Anderson-Inman, 1999) that will change children's early experiences with books. The research synthesis provided here indicates that additional enhancements can improve the manner in which children as young as 3 years of age comprehend and retain information from stories. As one '*working' principle* for app developers, it seems important to promote dual-coding by facilitating the matching of nonverbal information sources with the oral text. When there is close congruency and temporal proximity between narration and non-verbal information, electronic storybooks can offer new opportunities to promote story and text comprehension. Research findings indicate that animated pictures can reduce the amount of effort that is required for matching nonverbal information with story language, which can then facilitate word learning and story comprehension (Schnotz & Rasch, 2005). Animated pictures may be especially promising for very young children and language-delayed learners. We found evidence for the importance of strong congruency between the verbal and nonverbal modalities for those children. However, additional irrelevant visualizations may hamper learning when they deplete information processing resources. For instance, where the visualization is not designed and intended to focus attention on particular details, but is simply frivolous live action video that does not match the story text, the storybook app may hamper instead of stimulate story and language comprehension. Such visualizations may attract children's attention to details of the illustration that are irrelevant to the text. There is also evidence that music and sounds can easily lead to interference and diminished performance when these nonverbal additions compete for limited auditory or visual resources, especially in children with language impairments. By offering more options in electronic storybooks, software could be designed to enable adults to tailor electronic stories to the needs of children. For example, the option of turning the sound effects and background music off could be helpful for children experiencing problems with verbal processing.

Hypermedia features easily interfere with optimal learning conditions

Hypermedia features are a popular addition to storybook apps because of their potential to enhance the effect of book exposure by creating electronic storybooks with automatic or on-demand interactive features. Similar to first generation CD-ROMs, apps that are now available for new devices include an extensive number of embedded features that are increasingly novel. Retailers prefer to offer apps that include a maximum number of embedded features. However, these may lure children's attention away from the narration and turn the activity into a game instead of a reading experience. The evidence presented in this review suggests that app developers should consider, as a second vital *working principle*, that the youngest children cannot distribute their limited mental resources differentially between story comprehension and on-demand forms of assistance such as dictionary or word pronunciation features. Several studies showed unambiguously that the presence of games and hotspots, incidental to the story line, diminish children's performance in story and language comprehension. If they have a choice, children prefer playing with animations and games to listening to the story. Moreover, we found that young children will likely not develop language and literacy skills when stories

include task switching between the story text and embedded features, whether supportive or frivolous. Task switching, or multitasking, requires executive functions and most young children are not yet able to control and deploy their attentional resources effectively. Consequently, they enjoy playing with the programs but the activities may no longer support and expand literacy skills and experiences. The studies that were discussed here underscore the problems that can arise when children lack a purpose or focus for reading, rendering them easy prey to "eye-candy" (Trushell et al., 2003). The book reading experience will only support literacy development when the program safeguards children from having to coordinate simultaneous task demands and they receive support in dividing attention across reading and embedded features. Suggestions for improvements of electronic storybooks generally call for greater balance between making use of the exceptional capabilities of technology and the careful selection of features that support literacy and language development in order not to overwhelm the child.

Technology currently provides one of the most important sources of literacy development for children of all ages but without a balanced set of hypermedia, there is a serious risk of a downward reading spiral in the long-term. Considering the numerous distractors in popular apps, we suspect that the many hours spent with screen media cannot replace the time spent sharing print books with parents and teachers. As a result, children may develop lags in a whole range of literacy skills (Mol & Bus, 2011). Already at 15 months, rarely-read-to infants lag behind regularly-read-to peers in vocabulary and thereby in their ability to understand and enjoy books (van den Berg & Bus, 2014). We urge therefore the development of optimally designed and evidence-based story apps that will foster young children's foundational literacy skills.

Engineering and assessing new electronic stories: new roads for the future

The multimedia and interactive stories for children targeted in research projects are rather heterogeneous making it difficult to disentangle the effects of the many different design features on children's learning. Moreover, the electronic stories available on the market are changing rapidly, including new features, new platforms and eventually quite novel reading experiences (e.g., movement-based devices like the Microsoft Kinect in Homer et al., 2014). Additional well-controlled studies on the effectiveness of the new wave of available apps that ostensibly present stories to toddlers and preschoolers are urgently needed to test the effects of these formats and their content on emerging literacy skills.

Furthermore, research to date supports the hypothesis that technology-enhanced books can be particularly helpful for children with a high susceptibility to environmental input and help them to make optimal use of their learning abilities. We reported some preliminary findings demonstrating that multimedia storybooks that also provide positive feedback in response to children's answers to embedded questions about complex words or the story content can boost learning for susceptible children. An explanation for these findings may be that technology-enhanced materials can help easily distracted children to stay engaged while solving tasks and may enable them to control stress elicited by the task. As a further test of technology-enhanced materials, and in particular digitized books for young susceptible children, we need to identify the key components that make these enriched multimedia books most effective. To achieve this, we also need more variety in digitized book formats than is now available. Dutch publishers are aware of the shift that is taking place toward digitized reading in kindergarten and primary education and are looking for ways of making optimal use of the digitized format. On the other hand, they are unlikely to invest in new book designs without data to support their economic viability. As researchers, it is incumbent upon us to provide that data as technology may open up new opportunities for vulnerable children and turn putative "risk" groups into successful groups.

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