From Print to Digital: The Medium Is Only Part of the Message

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Abstract Over the past decade, preschool children have had increasing experience with storybooks in an electronic format. These reading sessions are usually guided by an adult who keeps the child's attention focused as the story unfolds. Occasionally, children are given a tablet or smartphone to operate on their own when the adult is not available to scaffold (e.g., in a car, at a restaurant). Although traditional paper storybooks still dominate the preschooler's reading experience, the growing availability of e-books has opened a debate on the relative effectiveness of these two book formats for children's attention and learning. While it is clear that preschoolers are very attentive to, and engaged in e-books, questions remain about (a) the potential of their interactive features to distract children and diminish learning, (b) the change in the adult-child interaction that occurs during e-book reading compared to traditional book reading, and (c) whether the built-in interactive and multimedia features can replace the traditional role of the adult that occurs in joint reading. The answers to these questions are discussed in relation to three critical variables: the characteristics of the individual child, the content of the e-book material, and the context in which the joint or independent reading occurs.

Keywords Attention · e-Books · Engagement · Executive functioning · Language · Parent-child interaction · Preschoolers · Story comprehension

The market for electronic storybooks for preschoolers is growing steadily as children become increasingly immersed in digital media. A report from *Common Sense Media* (2013) indicated that 72% of children under 8-years of age in a national, United States sample have used a mobile device, up from 38% in 2011. Usage includes playing games, watching videos, communicating, taking pictures, reading

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books and accessing apps and content delivery sites (e.g., YouTube, Netflix). Among children 2 years or younger, 33% had used a touchscreen device. More recently, Kabali et al. (2015) reported even higher rates of ownership (75%) and use (96%) in a large sample of low-income minority children between birth and 4 years of age. Rates in two European samples of very young children were also high; 58% of 5- to 24-month-olds in France (Cristia and Seidl 2015), 52% of 6- to 12-month-olds and 92% of 19- to 36-month-olds in the UK TABLET (Toddler Attentional Behaviors and Learning with Touchscreens) project. However, exactly how effectively these toddlers and young preschoolers used the touchscreen devices is still unclear. It is likely that random touching and tapping the screen to produce any type of effect would developmentally precede deliberate, purposeful activation of a feature or an app to achieve a particular goal (Guernsey and Levine 2015).

Research on the cognitive, motor and social implications of this ubiquitous media exposure for very young children is ongoing. Most of the studies to date have examined the potential impact of e-books compared to traditional paper storybooks on language and literacy outcomes, adult-child communication during reading, and on children's engagement (attentiveness, interest) in the story. Indeed, Rideout (2014) reported that 27% of 2- to 4-year-olds and 39% of 5- to 8-year-olds have read, or been read to from an electronic book (e-book) accessed on a tablet, reader, or smartphone. However, most of the roughly 40 min a day spent reading to preschoolers is still done with traditional paper books (27 min) with less time spent reading on a computer, tablet, or e-reader (13 min). This is consistent with the mixed views that parents report about using e-books with preschoolers, even though e-reading devices are often available in the household (Etta this volume; Kucirkova and Littleton 2016; Richter and Courage 2017; Strouse and Ganea 2017a; Vaala and Takeuchi 2012; Zickuhr 2013). In contrast, there are relatively few studies of preschool children's learning from problem solving, reasoning, or number knowledge apps downloaded onto mobile devices (but see Zimmerman et al. 2016). Given this, the term "e-book" as used here refers to electronic storybook content but also covers the various learning apps for children that are available but that do not have a narrative structure per se. The distinction between "e-books" and "apps" is not always obvious and likely rests more on the intended outcome or goal than on any difference in format or structure.

The growing availability and uptake of e-books for preschool children has raised concerns that in addition to providing more screen time, they will also distract them from the story content and interfere with pre-reading skills and story comprehension (Rideout 2014). There is also evidence that e-books change the nature of the very important parent-child interaction that occurs during reading with traditional print books (Chiong et al. 2012; Krcmar and Cingel 2014; Parish-Morris et al. 2013; Mol and Bus 2011). On the other hand, because e-books are delivered on popular mobile devices, they might engage and motivate children to read more, provide benefit from built-in reading aids, and direct children's attention to important story details that support comprehension (Brueck et al. this volume; Moody et al. 2010). Children who are engaged during reading explore the book more extensively, create conversation, show an interest in the illustrations, and can sustain their attention

throughout the reading. Reading engagement is associated with important positive short- and long-term literacy outcomes (Justice et al. 2003; Whitehurst and Lonigan 1998). The case has also been made that electronic devices are here to stay and that reading from e-books will enhance children's capability with the digital technology that is part of their present and future lives (Bedford et al. 2016; Flynn and Richert 2015; Lauricella et al. 2009; Mol et al. 2014; Roskos et al. 2014).

Research findings in which preschoolers' language and literacy outcomes have been compared across electronic and paper formats have been inconclusive. Some have indicated that e-books facilitate learning (Herman and Ciampa this volume; Ihmeideh 2014; Korat 2010; Smeets and Bus 2012), produce outcomes similar to that from paper books (de Jong and Bus 2004; Lauricella et al. 2014; Neuman et al. 2017; Willoughby et al. 2015), or diminish comprehension and learning (de Jong and Bus 2002; Krcmar and Cingel 2014; Parish-Morris et al. 2013). Factors that underlie the lack of agreement include: (1) the diversity of methods, procedures, materials, and dependent measures that have been used to study the outcome measures of interest, (2) the wide range in the number, type, and quality of the interactive features embedded in the e-books makes them difficult to compare with each other or with paper books, and (3) that individual differences in the maturity of preschoolers' executive functioning and language proficiency have not been considered in relation to literacy outcomes. Although these variables are strongly correlated with age, there are also individual differences that potentially relate to learning outcomes (Carlson et al. 2016).

1 The Cognitive Theory of Multimedia Learning: An Integrative Perspective

Some of the uncertainty about learning from e-books versus paper books can be resolved by considering well-established principles of human cognition. For example, Mayer (2005) proposed a cognitive theory of multimedia learning (CTML) in which he argued that effective instructional materials in any medium must be consistent with the way that the human information processing system works. Three principles guide the theory. The first, based on dual-coding theory (Paivio 1986), is that when incoming information can be processed in both visual and auditory channels at the same time it is learned and retained more effectively than if it is processed in a single channel. Second, there is a limit to the amount of information that can be processed in working memory at any one time (Baddeley and Hitch 1974; Kahneman 1973). Third, learning is most effective when individuals are actively engaged in its processing (e.g., paying attention, integrating new information into existing knowledge) (Gopnik and Meltzoff 1997).

Although the CTML was developed to enhance multimedia learning for older students, much of it can be adapted to the design and evaluation of paper and electronic storybooks for younger children. Both formats support dual processing

(visual image, narration), though the multimedia features added to e-books might enhance or perhaps diminish the effect compared to the same paper book. Likewise, either format might tax working memory; e-books with too many features, or paper books with too few features that require more interaction with long term memory. Both formats permit active learning; e-books through story compatible interactive features and paper books through conversation with the adult during joint reading. Ultimately, the effectiveness of any application of these principles will depend on the cognitive load that the medium and the story content jointly impose on young children, whose executive functions are immature (Diamond 2013; Garon et al. 2008). Indeed, Fisch (2000) proposed a capacity model of children's comprehension of educational television content that is relevant. The basic idea was that young children have limited cognitive resources available to process and comprehend both the narrative and instructional contents that require them to follow the story (e.g., understanding goals, making inferences) and at the same time retain and use the elements targeted for learning (e.g., new words, facts, numbers) to support comprehension. All of these requirements consume resources. When capacity is exceeded, comprehension and learning are reduced. Cognitive load could be further increased if extra resources are needed to control and process the interactive features and to carry out the operation (e.g., swipe, drag and drop) of the electronic device itself. Alternatively, if the sources of narrative and instructional information are cohesive, load could be reduced, and resources enhanced.

2 Predicting the Learning Potential of e-Books and Learning Apps

Like many complex questions about early child development, the truth lies in considering a multitude of factors as well as the interactions among them. It is important to note that many of the current questions and concerns about interactive mobile devices (including e-books) were asked and answered about the effects of television viewing on cognitive and social development in young children over the past several decades (Guernsey 2012; Pecora et al. 2007). However, there is a critical difference between television and e-books and other mobile devices. Television is a passive medium as children simply sit and watch and do not take an active role in the learning process. In contrast, e-books and other apps are interactive and engage the child directly and often require verbal responses or actions as the story unfolds. Consistent with the CTML, it is this interactivity that makes the e-book and apps potentially more effective platforms for learning than is television. This possibility was recognized by the American Academy of Pediatrics (AAP) in their revised, more flexible recommendations on screen time for children (Chassiakos et al. 2016). These recommendations have also been endorsed by the Canadian Pediatric Society (2017). That being said, a consensus from the literature on the efficacy of e-books compared to paper books indicates that, as is also the case for television viewing, the answer

depends on (a) factors within the *child* (e.g., age, executive functioning, language proficiency), (b) the *content* of the e-book or app itself (e.g., age appropriateness, comprehensibility, the quantity and quality of the interactive and multimedia features it includes), and (c) the *context* in which the reading activity takes place (e.g., alone or with a supportive adult; with or without dialogic prompts; presentation format such as electronic, paper, face-to-face) (Barr and Linebarger 2017; Guernsey and Levine 2015; Lerner and Barr 2015).

Although these three sets of factors provide a convenient organizational framework in which to review the literature on the effectiveness of digital media, it is important to note that it is the nature of the interactions among them that will primarily affect learning and literacy outcomes from all formats. In particular, it can be difficult to separate the effects of the content of any medium on outcomes from the effects of the affordances (e.g., amount of interactivity) provided by the medium itself (e.g. e-book, paper book). In any case, individually and collectively, the three sets of factors are a good fit with the guiding principles of the CTML. The literature on the roles of the child, content, and context in relation to screen media will be considered next. Where relevant, comparative data from research on the effects of television on attention and learning will be also described.

2.1 The Individual Child

Perhaps the most obvious individual child characteristic is age. Older preschoolers and school aged children can learn from television or e-books more effectively than can younger preschoolers, toddlers, or infants. However, age itself is only a proxy for the many domain general and domain specific developments that co-occur with it. As children age, the prefrontal cortical regions of their brains become better articulated and more specialized, they acquire conventional language proficiency, and they master the narrative skills with which to interpret and comprehend a story. They also have a richer knowledge base about the world, better learning strategies, have come to understand the symbolic nature of screen media, and have more mature executive functions (Garon et al. 2008).

Executive functions are of particular importance in understanding digital technologies as they enable self-regulation or cognitive control of one's thoughts, feelings, and behavior in a wide range of daily activities. Broadly speaking, there are three core (but interrelated) executive functions (a) inhibition; the ability to resist making a dominant but incorrect response in favor of a subdominant but correct response, (b) working memory; the limited capacity mental workspace essential for thinking and reasoning (e.g., reading, mental arithmetic, conversation), and (c) attention control; the mental flexibility that enables one to maintain focus or shift attention from one task to another appropriately. Executive functions are poorly developed in infants and toddlers but mature rapidly across the preschool years and continue to fine-tune into adolescence (Diamond 2013; Garon et al. 2008).

There is a growing research interest in the development of executive functions as their importance to a range of cognitive and social outcomes that require self-regulation is recognized (Lawson and Farah 2015). Consistent with the limited capacity principle of the CTML, for both e-books and paper books, more mature executive functions will enable children to keep more information in mind, sustain their attention to the story, and to resist distraction (Diamond 2013; Johansson et al. 2015). However, the additional distractions from the animations and interactive e-book features and the operation of the touchscreens themselves might further tax the young child's executive functions and diminish learning. In contrast, older children have sufficient resources to adapt to the additional cognitive load and still benefit from the interactive and multimedia features. Although advances in executive functioning are typically related to age across the preschool years, there are also marked individual differences within age that result from neurobiological, genetic, and social factors (e.g., prefrontal cortex, child temperament, parenting) (Bell and Cuevas 2016; Benson et al. 2013; Bernier et al. 2010). Indeed, Richter and Courage (2017) found that executive functioning was a better predictor of preschool children's attention and story comprehension of both an e-book and a matched paper book than was age or language comprehension alone. Finally, there is evidence that viewing certain types of screen media content seem to diminish executive functioning, at least in the short term (Huber et al. 2018).

The maturity of children's language development is another factor that will affect what and how they learn from storybooks. Specifically, more mature language facilitates story comprehension and recall. Strong receptive language provides the child with a richer knowledge base with which to interpret, comprehend, and retain the story content. Likewise, having strong productive language enables effective story retelling that not only serves as a rehearsal mechanism that supports retention of story information, but also reflects good story comprehension regardless of book format (Dunst et al. 2012). e-Books for preschool children often have additional features that support language development, including word pronunciations, explanations, repetitions, and highlighted text. Older children and those with more mature executive functions and language may not need those supports and will therefore have additional resources to devote to processing the story for comprehension. For example, Strouse and Ganea (2016) found that 4-year-olds who had stronger language skills were better able to learn a new concept provided in an e-book format than those with weaker language skill. Although the familiar language milestones unfold in a predictable order that is strongly related to age, there are also well documented individual differences in all aspects of language development, from first words to grammar, that originate from a host of biogenic and environmental influences (Bates et al. 1995; Richter and Courage 2017).

2.2 The Content of e-Books and Digital Screen Media

There is little doubt that reading to children from traditional paper storybooks is the "gold standard" activity that provides educational advantages and predicts a range of positive developmental outcomes for children of all ages. Among the most important advantages for preschool children are improvements in language (expressive, receptive) and in emergent literacy (e.g., print awareness, vocabulary acquisition, letter knowledge, phonological awareness) that are fundamental to learning to read, engagement in reading, and achievement in school (Fletcher and Reese 2005; Mol and Bus 2011; Mol et al. 2009; Whitehurst and Lonigan 1998). Storybook reading also supports the development of attention, memory, narrative, and learning more generally (Greenhoot et al. 2014; Lever and Senechal 2011; Whitehurst and Lonigan 1998). These important gains from early exposure to books are robust and persist beyond early childhood and continue into adolescence and young adulthood (Mol and Bus 2011). It is also clear that the content of the storybook, or indeed any learning medium, must be developmentally appropriate in order to optimize learning. The content must be matched to the child's level of cognitive development, including their language proficiency, their knowledge of the world, and the narrative understanding that will make the story comprehensible. Presumably, these basic requirements also apply to learning from stories and other types of content presented on electronic media. Whether these have been considered and included in the roughly 80,000 commercially available, "educational" e-books and apps for children is unclear, in part because the claims of educational content remain largely untested and unregulated (Hirsh-Pasek et al. 2015).

Television Many of the early studies of television related the amount of viewing to the outcome measure of interest. Subsequently, researchers discovered that while the amount of television viewing is not unimportant (e.g., Pagani et al. 2013), "watching television" is not a single activity that in and of itself can support or interfere with learning and child development. Rather, the content of the television material being viewed is far more important. Indeed, several studies that showed negative associations between the amount of television viewing and a particular developmental outcome (e.g., poor language, aggression) disappeared when the content of the television program was considered (Christakis et al. 2004).

Perhaps one of the most thoroughly documented examples of the benefits that educational content can provide is *Sesame Street* (e.g., Anderson and Hanson 2010; Mares and Han 2013). A meta-analysis of 24 studies done on *Sesame Street* in 15 countries that included 10,000 children from all social classes and income levels,

showed strong positive effects of regular viewing on cognitive outcomes (literacy, numeracy); knowledge about the world, social reasoning and attitudes to minority groups (Mares and Han 2013). Other research groups have also shown the positive effects that certain well-designed television programs can have on language (e.g., Linebarger and Piotrowski 2010; Linebarger and Vaala 2010) and social (e.g., Anderson and Hanson 2010) development. That being said, educational content is not sufficient on its own to support learning. Linebarger and Walker (2005) examined the relationship between television exposure, and vocabulary knowledge and expressive language in toddlers' who regularly viewed several popular children's educational programs. The results varied by the program and in particular, the language strategies that were incorporated into the content of each one (see Linebarger and Piotrowski 2010). It should also be noted that just as children can learn from good positive content, they can also learn from negative content. The relation between viewing violent content and aggressive behavior and attitudes in some children is well known (Anderson and Hanson 2010; Pecora et al. 2007).

The Transfer Deficit A significant limitation to what young children can learn from video content is the fact that until about 3 years of age they have a "transfer" deficit. This refers to the fact that infants and toddlers do not readily imitate action sequences viewed on video, although they will imitate the same actions when viewed by a "live" model (Anderson and Pempek 2005; Barr 2010, 2013). This transfer deficit is not limited to action sequences but also occurs with object-retrieval, word-learning, and language-recognition tasks (Kirkorian et al. 2016; Krcmar et al. 2007; Kuhl et al. 2003; Troseth 2010). Research has shown that this deficit originates from the specificity of infant and toddler learning whereby the characteristics of the encoding (e.g., video) and retrieval (e.g., real world) contexts must match exactly for learning to occur and be transferable (Hayne 2009; Rovee-Collier 1999). Over their second year, infants develop greater "representational flexibility" and only then are they able to tolerate mismatches between encoding and retrieval contexts and to transfer learned information to new objects and situations. However, the transfer deficit is usually not fully resolved until late in the second year (Barr 2013; Hayne 2009). Notably, it has also been observed in toddlers' learning from picture book content (Barr 2013).

Research on the transfer deficit showed that mismatches can arise from immaturities in several perceptual, cognitive, and social processes. These include (1) the difficulties in equating information obtained from the 2-D video with the corresponding 3-D live source, and vice versa (Barr 2010, 2013), (2) understanding the symbolic nature of the medium; that the video is something in its own right and also represents the same information in the real world (DeLoache et al. 2010; Troseth 2010), and (3) the fact that their usual experience with responsive, contingent others tells them that the non-contingent video source is not real or directed to them personally and therefore not useful (Troseth 2010; Stouse and Troseth 2014). Mitigation of these factors (e.g., by repetition of the material, experience with closed-circuit

video, embedded verbal prompting cues) improved performance (e.g., Barr et al. 2007, 2008) but did not eliminate the advantage of live learning. Finally, very young children have limited understanding of the medium and the conventions of television itself; the form and function of its formal features, the size, movement and trajectory of the objects and characters, the format (narrative or expository) of the content delivery, or its interactional quality (non-contingency). Following experience with television and with coincident advances in language, cognition, and social awareness, these limitations become resolved, and learning and transfer from video begin to occur (Anderson and Hanson 2010; Barr 2010).

e-Books and e-Learning Apps Notwithstanding the transfer deficit, the content of e-book stories is critical to their effectiveness as a learning platform. However, unlike television, the content of the current genre of e-books are interactive and engage the child directly as a participant as the story unfolds. Importantly, well-designed e-books incorporate some of the features that mitigate the transfer deficit (e.g., repetition, contingency) that occurs when passively viewing television. However, as with television, the e-book content must be both engaging and age appropriate for learning to occur. The results of several recent studies have shown that children were generally more engaged during the reading of an age appropriate e-book than a matched paper book (Parish-Morris et al. 2013; Richter and Courage 2017; Strouse and Ganea 2017a). It is also important to note that e-book technology has evolved dramatically over the past decade. The early versions were standard storybooks available on CD-ROM for presentation on a computer and operated by a mouse. Others were available on game-like reading consoles. Currently, many e-books are downloaded on hand-held devices with touchscreen operation. Moreover, e-book software has become highly sophisticated in the features that they can provide to illustrate and enhance the stories. In addition to storybook content, e-learning apps now include a range of other types of material (e.g., word learning, concept acquisition, number knowledge).

How Engaging Features Enhance Content The number and type of built-in features that are contained in an e-book can have a powerful effect on learning. Consistent with principles of the CTML, these must also be carefully placed and integrated into the story if they are to focus the child's attention and support learning rather than being a distraction. e-Book features can be highly effective if they direct the child's focus to important story information, provide explanation of new words, and motivate them to sustain their attention until the story is finished (Bus et al. this volume). In a recent meta-analysis, Takacs et al. (2015) distinguished between two general types of e-book features, multimedia and interactive. Multimedia features are those that include story congruent animations, sounds, voices, or music that are presented simultaneously with the text as the child hears or reads the e-book (e.g., the sound of a splash as a baby bird falls into the water). In contrast, interactive features, often called "hot spots", include built-in games or activities that require

children to shift their attention away from the story content and toward the particular feature (e.g., tapping a hot spot to change the color of Cinderella's dress). The results revealed a significant benefit from e-book reading for story comprehension for those that included multimedia features, while no additional benefit was found for stories with interactive features. Likewise, Strouse and Ganea (2017b) reported that 17- to 26-month-olds who were read an electronic or paper book were more attentive and engaged during e-book reading, produced more content related comments, and showed more recognition of newly labeled object. The authors noted that the e-book was quite simple and contained multimedia but no distracting interactive features.

These findings are consistent with a large literature showing that attention or task switching in both older children and adults almost always results in a response cost in terms of increased errors or a response delay (Courage et al. 2015; Kiesel et al. 2010). Given this, there may be a trade off in the effectiveness of story congruent hotspots whereby they might provide additional relevant information but also divide children's attention and produce a response cost. In fact, the results of recent studies with preschool children who were read to from an e-book on a touchscreen device and a matched paper book showed that in spite of greater engagement in the e-book, there was no difference in the recall of story comprehension by format (Richter and Courage 2017; Willoughby et al. 2015).

In contrast, older preschoolers and school-aged children can learn readily from well designed, age appropriate content, regardless of the book format (Jones and Brown 2011; Moody 2010; Takacs et al. 2015; Zucker et al. 2009). They can (or are beginning to) read independently, making the transition from "learning to read" to "reading to learn" (Miller and Warschauer 2014). They no longer need as much parent or teacher oversight, and the interactive and multimedia features (e.g., built in dictionaries, word pronunciations, highlight text, drag and drop options, tapping for special effects, feedback, repetition) can serve to engage and motivate them to read more often. However, as with younger children, too many or incongruent hot spots (e.g., games, puzzles, activities), can also distract them and reduce the learning potential (Bus et al. 2015.)

e-Books in School Building on this evidence from older children, several large-scale studies of e-reading programs confirm the effectiveness of well-designed e-books in the classroom (e.g., Korat 2010). A particular strength of including e-books in school curricula is that they can support individual differences in children's ability, including those who are at risk for language delay, who are socially disadvantaged, whose learning processes are atypical, or who are learning English as a second language (Bus et al. 2015; Korat and Shamir 2007; Verhallen et al. 2006). The most effective e-book features for these special populations are self-pacing (e.g., pausing the story, turning the page at will) repetition (e.g., going back to read a page or activate a feature again), immediate feedback (e.g., the narrator will respond to the child's actions), and the incorporation of dialogic questioning and prompts to which the child can respond (e.g., What color was Cinderella's ball gown?). It is clear that good, well-designed content presented on interactive digital

media devices can enhance reading, language, science and social skills, and teach factual information about the world for all school aged children (Blumberg and Brooks 2017). However, incorporating technologies into classroom pedagogy has been a challenge (Roskos et al. 2009). To be optimally effective, they should be systematically integrated into the curriculum such that the content of the application and the teaching and learning goals are clear and consistent. That balance can be difficult, as diverse expertise in curriculum and software development are required. As with any new technology, teachers must adapt the way they teach in order to successfully accommodate e-books into the classroom.

2.3 The Viewing and Reading Contexts

The importance of the context in which learning occurs should not be underestimated. When new information is presented for learning it is encoded, but so too are the proximal and distal characteristics of the context (e.g., place, persons, time of day, season) in which the learning occurs (Tulving and Thomson 1973). These contextual cues structure the learning situation and can serve to facilitate retrieval of the information at a later time. The bond between content and context is extremely strong in human infants such that if they learn an operant response (e.g., that a foot kick moves an overhead mobile) while lying in a crib with a patterned surround, they will not emit the kick if the surround is changed to a different pattern at retention. Over the first few years of life, the bond gradually becomes more flexible (Hayne 2009; Rovee-Collier 1999) and the young child can transfer the learning in a different context. This inflexible learning is at the core of the transfer deficit whereby young children only gradually come to understand the symbolic nature of screen media. Although context dependency is reduced across early childhood, it remains an integral support to learning and retention across the lifespan.

There are two key aspects of the context in which children's learning occurs that should be considered: (a) the learning medium itself (i.e., television, e-books and apps, traditional paper book), and (b) the presence of an adult who scaffolds children's attention and learning. Concerning (a), as has been noted, it is difficult to disentangle the content of a learning medium from the affordances that it provides. For example, a paper storybook and an e-book with identical content will provide different contexts (e.g., with or without enhanced features) in which the content is experienced. The research on those contextual factors has been considered in the previous section on the content of screen media.

Concerning (b), a critical question for screen media research in general is whether parent-child interactions during video viewing might become part of the context that structures and facilitates learning just as they do for learning from traditional storybooks. Many of the positive outcomes from storybook reading are mediated by verbal exchanges that occur during the reading experience (Fletcher and Reese 2005). Adults talk to children in more complex ways during reading than they do in other contexts. They typically use a "dialogic" strategy (Whitehurst and Lonigan 1998)

in which they direct children's attention to key elements of the story, engage them in conversation, ask distancing questions, and provide repetitions, recasts, expansions, and explanations of the story content. These shared reading experiences underlie the literacy outcomes, school readiness, and interest in independent reading that have been observed (Mol et al. 2009; Whitehurst and Lonigan 1998). They not only serve to focus the child's attention, but also promote active involvement in the learning process, an important guiding principle of the CTML.

The Parent as Context: Attention and Word Learning from Video Barr et al. (2008) showed that toddlers who viewed baby videos with their parents looked longer at the videos, and were more responsive (e.g., vocalizing, pointing) to them when the parents provided scaffolding (e.g., descriptions, labelling, pointing) during viewing. Even when parents' verbal scaffolding was controlled, infants between 18 and 21 months of age were more likely to look towards a baby video (and to look longer at it) during free-play immediately following a parent's look toward the video than to do so spontaneously (Demers et al. 2012). Such interactions that direct the child's attention to important content could potentially increase comprehension and learning (Barr et al. 2007).

The results of several other studies showed that parent-child verbal interactions can have a positive impact on word learning from video. In one study, adult scaffolding and contingent responsiveness facilitated 3-year-olds' learning of novel object names from video, and it was especially effective if the intervention included dialogic questioning (Strouse et al. 2013). Similarly, when 30- to 42-month-olds were taught action verbs either by video alone or through a combination of video and a live interaction with an adult about the video content, only the children older than 36 months learned verbs in the video alone condition (Roseberry et al. 2009). In another study, 2- to 3-year-olds viewed a picture of an object several times on a screen while hearing a voice-over label the object. Children were then able to point to the target object from among several distractors and to transfer their learning to a real 3D version of the target (Allen and Scofield 2010). Stouse and Troseth (2014) reported that 2-year-olds showed reliable transfer of a novel word learned from video to the real object, but only when the parent pointed out that the real object and the video image were "the same". Similarly, Roseberry et al. (2014) showed that 24–30-month-olds who took part of a simulated video "chat" in which they were taught novel verbs, were successful only when the video partner interacted contingently with them. O'Doherty et al. (2011) showed that 2.5-year-old onlookers could learn a novel word from viewing a shared interaction between two adults on video though they did not learn words from the adults in a passive labelling condition without engagement.

Collectively, these studies show that beginning at about 24–30 months, children are able to learn some new words from video and that this is most likely to occur in the presence of an engaging, contingent, supportive adult who provides verbal and nonverbal structure as well as social cues (e.g., using the child's name). However, this early learning did not come easily, nor was it robust. In any case, it seems that only when parents co-view, talk to children about the story, scaffold their attention,

and use a dialogic approach will young toddlers learn some language from video. It is important to note that these optimal conditions are unlikely to occur when a child views "real" video content at home as parents report co-viewing with their children only about 50% of the time.

In contrast, there is little evidence that children younger than 2 years learn much language from video, even with parent-child interaction (e.g., Krcmar 2014; Krcmar et al. 2007; Richert et al. 2010). Video viewing in these very young children is still dominated by the transfer deficit, and the minimal learning they can show is often more readily learned from a live source (Barr 2010; DeLoache et al. 2010; Richert et al. 2010; Roseberry et al. 2014). On the other hand, older children, from about 4 or 5 years of age can learn language from well-designed educational video without difficulty (e.g., Sesame Street; Blue's Clues; Dora the Explorer). With their more mature executive functions and the onset of conventional reading, adult scaffolding is not as essential, though it still plays an important role.

Parents as Context for e-Book Learning Contextual support and scaffolding are equally important for e-book reading. Preschool and kindergarten children learned more language from an e-book supported by an adult's scaffolding than from one read without scaffolding (Segal-Drori et al. 2010; Strouse et al. 2013). In addition, a sample of toddlers aged 17–23 months learned novel labels for unfamiliar objects from either an adult-led e-book or print book. However, only those who read the traditional format book generalized and transferred the label to another context. An older group of toddlers aged 24–30 months were able to learn and transfer the label from the electronic book (Strouse and Ganea 2017b). In a study on the quality of parent interactional style, Zack and Barr (2016) found that 15-month-old toddlers could learn and transfer a button press from a 3D object to a 2D touchscreen and vise versa when parents provided a high quality (i.e., diverse) compared to a lower quality (i.e., repetitive) interactional style.

It is clear that language exchanges are the heart of the valuable parent-child interactions during storybook reading. However, recent reports of spontaneous communications between parent-child dyads during e-book and paper book reading showed that both parties talked less during the e-book than the paper book session (Chiong et al. 2012; Krcmar and Cingel 2014; Lauricella et al. 2014; Parish-Morris et al. 2013; Richter and Courage 2017). Moreover, the utterances that even the most verbal children produced were primarily about the device and its operation during the e-book and mostly included labeling and comments about the story content during the paper book session. One implication of the prominence of technology talk during e-book reading is the corresponding reduction in the dialogic exchanges that have been so important to preschoolers' language and literacy outcomes more generally (Fletcher and Reese 2005).

Can e-Books and Learning App Software Provide Effective Scaffolding? A fundamental question in that regard is whether the interactive e-book features that are intended to support learning in well-designed books can replace the scaffolding provided by a parent or teacher. Typically, e-book stories include an oral narration

or Read-to-Me option making it possible for children to "read" storybooks by themselves. Based on the research to date, a logical expectation might be that the effect of adult support during storybook reading would be greater than the benefits provided by multimedia features in the story content. However, well-designed e-books now include many built-in features that simulate parent scaffolding with the expectation that these will facilitate literacy outcomes in the same way that parents do. In addition to story consistent multimedia features, these include dialogic questioning, definitions and prompts provided by the story narrator or one of the characters, or suggested activities that enhance the memorability of the story information (e.g., use drag and drop to help Red Riding Hood pack the basket of food for Grandma). In addition, other features, such as motion and zooming-in, are commonly used techniques in e-books that direct children's attention to a particular detail of the illustration just as an adult might do when pointing out a detail and providing comments or explanations in a traditional book (Bus et al. 2015). With the inclusion of these design features that provide active involvement in the material, e-books may be just as effective in supporting story and language comprehension as an interaction with an adult who explains the meanings of the story and novel or complex words in the narration. This might be especially likely for older kindergarten and first grade children who are beginning to become independent readers. Younger children, whose executive functions are still fragile, might still have difficulty in sustaining their attention and become distracted before the story is complete (Richter and Courage 2017). Recently, Strouse and Ganea (2016) reported that 4-year-olds learned a biological concept (camouflage) from an e-book with electronic prompts as effectively as from an adult prompting from a paper book or face-to-face. Similarly, Kwok et al. (2016) reported that 4- to 8-year-olds learned information about animals equally well from interactive media or from face to face instruction.

There is also a trend for schools to adopt electronic formats to tutor and instruct young children (Kucirkova 2014; Rideout 2014; Takacs et al. 2014). The implications of these new reading contexts are unclear, but given the importance of parent-child communication for development, should be a focus of future research. In a recent evaluation of this question, Takacs et al. (2014) conducted a meta-analysis that included 29 studies and 1272 preschool, kindergarten, and elementary school children. The results showed that stories with multimedia features were more beneficial for story comprehension and vocabulary than reading sessions with traditional paper books that did not include the adult's scaffolding. However, no significant differences were found between the learning outcomes of multimedia stories and reading with traditional paper book stories with scaffolding from an adult. These analyses suggest that multimedia features like animations, background music and sound effects, and parent scaffolding simulations can provide similar support and facilitation for children's story comprehension and word learning as can a "live" adult, at least for older children who are becoming independent readers.

3 Conclusion

Although these three sets of variables concerning the child, the content of the media and the reading or viewing context have been considered separately, it would be misleading not to consider their conjoint effects. That being said, it is generally the case that older children who typically have more advanced cognitive skills and executive functions, will be better able to comprehend and retain story information that they read or hear from any medium – electronic or paper. Conversely, younger preschool children who typically have more limited information processing capacity and more fragile executive functions will comprehend and retain less story information from either medium. However, a child's age cannot meaningfully be considered in isolation from the content of the material in question and the context in which it is presented. What this means is that, consistent with the guiding principles of the cognitive theory of multimedia learning (CTML), children of all ages (and perhaps some adolescents) could benefit from the skillful inclusion of certain multimedia enhancements that engage their attention, get them actively involved in the learning process, and highlight novel words and concepts and reinforce the most important story information. Beyond this, as older children have larger working memory capacity and better attention control they will have sufficient cognitive resources to avail of multimedia and story consistent interactive features while continuing to operate the device and follow the sequence of events and the information in the story. Although interactive hot spots will divide their attention and likely result in some response cost (e.g., longer completion times), they will be less distracted by them and be better to resume the basic story reading than will younger children (Courage et al. 2015). Most older preschoolers (as well as those with advanced executive functioning or language) and school aged children who have begun to read independently do not need constant parental scaffolding to structure their learning. In addition, the built-in multimedia supports that are included in well-designed e-books and apps will serve a comparable "parent-like" role in supporting children's retention and comprehension for those who do still need some scaffolding. It is also the case however, that the excessive or story incongruent though engaging features that are common in many commercially available e-books, will lead even the mature reader to become involved in significant task switching that could distract them and diminish learning (Hirsh-Pasek et al. 2015; Miller and Warschauer 2014).

In contrast, younger children who have less working memory capacity and more difficulties with directing and maintaining their attention on task will likely be distracted from the story content by the touch-activated interactive features or "hotspots" that many e-books typically provide (Chiong et al. 2012). As their general knowledge base and language competency are more limited, their story comprehension will be compromised, especially when the content of the story is unfamiliar.

Younger preschoolers also depend strongly on parental scaffolding to direct their attention during traditional reading. However, when the e-book software scaffolding techniques are embedded in the story, it is possible for comparable learning to occur (Takacs et al. 2014). Finally, when younger children have to use a mouse or finger to activate hotspots and turn pages, they have to allocate some of their limited cognitive resources to point, click, and swipe while still following the narrative (Guernsey and Levine 2015; Lauricella et al. 2009). This also places them at risk for cognitive overload and poorer learning outcomes (Fisch 2000). There is little evidence that children under 2 years of age can benefit from e-books without traditional scaffolding from a parent. Their very limited cognitive resources, language, and executive functions will make it unlikely that e-books will be as effective as paper books for these very young children. However, Strouse and Ganea (2016) did show that toddlers between 17 and 24 months were able to learn new word labels from an e-book read by a "live" adult. Without that structure, their limited attention control and working memory would have made learning less likely. However, this remains an empirical question. Older toddlers from 24 to 28 months were able to learn and transfer the new words.

In sum, children of all ages can learn new information from well-designed e-books with story consistent multimedia features if the content is age appropriate and comprehensible for them and if parental or electronic supports are in place to scaffold learning as needed. Effective e-books and other digital apps for any age child should be designed based on the "science of learning" in which the principles of multimedia learning are integral to the material to be learned; it is active, engaging, meaningful and social and that cognitive load is appropriate to the available resources (Hirsh-Pasek et al. 2015). It appears that print-based resources and e-books are not mutually exclusive, nor is technology a substitute for print. Rather, traditional print books and e-books seem to play different roles in the literacy process, and eliminating this false dichotomy offers children more opportunity for diverse types of literacy experiences.

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