Annual Review of Developmental Psychology

Children and Screens

Brenna Hassinger-Das,[1] Sarah Brennan,[1] Rebecca A. Dore,[2] Roberta Michnick Golinkoff,[3] and Kathy Hirsh-Pasek[4,5]

[1]Psychology Department, Pace University, New York, NY 10038, USA; email: bhassingerdas@pace.edu

[2]Crane Center for Early Childhood Research and Policy, College of Education and Human Ecology, The Ohio State University, Columbus, Ohio 43201, USA

[3]School of Education, University of Delaware, Newark, Delaware 19716, USA

[4]Department of Psychology, Temple University, Philadelphia, Pennsylvania 19122, USA

[5]The Brookings Institution, Washington, DC 20036, USA

Annu. Rev. Dev. Psychol. 2020. 2:3.1–3.24

The *Annual Review of Developmental Psychology* is online at devpsych.annualreviews.org

https://doi.org/10.1146/annurev-devpsych-060320-095612

Keywords

early childhood, digital media, learning, child development

Abstract

Since the advent of television in the 1950s, parents, educators, researchers, and policy makers have been concerned about the effects of screen time on children's development. Then, when computers became widely used, a new wave of interest in the positive and negative effects of this new medium was generated. Within the past 15 years, the development of the smartphone and tablet have completely changed the landscape of screen time. This review examines the current state of the research regarding the relation between children (from infancy to age 8 years) and screens. Using principles from the Science of Learning as a guide, we invite content creators and researchers to create a new wave of the digital revolution, one in which we need to prompt rather than substitute for social interaction.

Contents

THE SCREEN TIME DEBATE HAS BEEN ALIVE FOR DECADES

We write during the COVID-19 pandemic, when screen time has increased dramatically for everyone—including children, many of whom are receiving school instruction remotely. This fact only increases concerns many scholars have expressed previously over the effects of screen time on children's development. When television debuted in the mid-twentieth century, Western society experienced a crisis around children watching too much television and a potential host of negative outcomes, such as aggressive behavior, substance abuse, childhood obesity, and declining academic performance (Fisch 2004).

The driving force behind these concerns was the displacement hypothesis—the idea that television watching displaces other, more enriching activities like book reading, social activities, and play (Fisch 2004). Yet, research suggested that although television did change how children spent their time, it did not lead to major drops in time spent doing activities like homework or reading books (Schramm et al. 1961). In fact, most research finds no definitive, causal effects of television viewing—either positive or negative—on children's behavioral outcomes (e.g., Barr 2010, Christakis et al. 2004, Foster & Watkins 2010, Huston 1992, Mistry et al. 2007, Schmidt et al. 2009, Stevens & Mulsow 2006, Zimmerman & Christakis 2005, Zimmerman et al. 2007).

One reason that the displacement hypothesis may not be manifested in a straightforward way is that the content of children's media use plays an important role. Specifically, although watching purely entertainment programs seems to be related to lower levels of academic performance (Wright et al. 2001a,b), educational programming can help support learning. Several studies demonstrate the positive impact of watching *Sesame Street* on educational outcomes (e.g., Fisch 2004; Kearney & Levine 2019; Mares & Pan 2013; Rice et al. 1990; Wright et al. 2001a,b). Similarly, a longitudinal study found that children who tuned into *Blue's Clues* for an average of 1 hour and 38 minutes per week for 24 months demonstrated higher levels of cognitive skills in comparison to children who were unable to view the program (Anderson et al. 2000). Richards & Calvert (2017) argued that children's parasocial relationships with media characters—like Blue from *Blue's Clues* or Big Bird from *Sesame Street*—provide a context that supports learning and socioemotional development.

Beyond television, computers and game consoles entered the public arena during the 1980s and 1990s, with products like *Oregon Trail* and *Where in the World Is Carmen Sandiego?* vying for

children's time. In the last 15 years, the second wave of digital media development has altered the landscape even further. Before, there had been designated locations in the house for the television and the computer, and shows aired only at certain times—or you could record and watch them later. Then, the smartphone (2007) and the tablet (2010) entered the market. With mobile devices, digital media are ubiquitous—they are no longer limited by time or location. They are easier for children to use anywhere and available at any time.

In 2016, the American Academy of Pediatrics (AAP) released updated guidelines for children's media use in response to these developments (AAP 2016). The previous recommendation of "no screens under two" transitioned to "no screens (aside from video chat) for 18 months and younger." Recommendations for older children were updated to encourage less than 1 hour of screen time per day, featuring high-quality programming. Ideally, children would also coview any digital media with an adult.

In reality, the latest report from Common Sense Media (Rideout 2017) suggests that US children younger than 8 years spend more than 2 hours per day engaging with various types of screen media. Most of their time continues to be spent watching television (42%), but this percentage has decreased since 2011 in favor of mobile devices (up from 4% to 35%). Similar findings were reported by Ofcom (2020) in the United Kingdom—with children aged 5–15 years increasingly likely to watch programming on mobile devices (43% of total media use). Children are also increasingly likely to live in homes with smart toys (10%) and smart speakers (9%), like Amazon Echo and Google Home (Rideout 2017). And, to the dismay of many child development experts, engaging with digital media is often more of a solo rather than a group activity. Importantly, in this fast-developing landscape, even these statistics are likely outdated, especially as using screens for a range of purposes has exploded during the COVID-19 lockdown.

The increased use of screen media—not originally present when the displacement hypothesis was offered—has again raised the question of whether the displacement hypothesis is operating (Przybylski 2019). We now have screens that we carry everywhere, and they may be more likely to displace parent–child interaction or simply children's time being bored and finding ways to entertain themselves. Findings are mixed regarding whether screen time negatively affects child outcomes by interrupting other developmental processes and opportunities. Stiglic & Viner (2019) completed a systematic review of 940 abstracts and 12 other research reviews and found associations between screen time and an unhealthy diet, less sleep, cyberbullying, and poorer mental health for children and adolescents. However, if studies do not take socioeconomic status or parent education into consideration, it is difficult to evaluate these findings and their significance. These correlations do not necessarily represent causal links between screen time and negative outcomes. Furthermore, inconclusive results across many studies led the authors to conclude that a causal relationship cannot—as of yet—be established. The AAP (2016) recommendations along with the current state of research, as evidenced by reviews such as one by Stiglic & Viner (2019), support the idea that digital media technology per se is not a problem but rather that the problem lies in how that technology is used (Guernsey & Levine 2016).

Of utmost concern is the mismatch between the goals of content developers and child development researchers in developing new digital media. Researchers suggest that content developers are prioritizing the marketing of digital media over quality development (Hiniker et al. 2019), paralleling prior criticisms about television production. Confounding the creation of excellent digital media is the difficulty developmental scientists and media developers have in communicating; the concerns of each camp differ, and there must be close coordination between them (Dore et al. 2018b). One main issue has been the call to make digital media more social. It is not enough to take noninteractive media and simply morph them into a social format; a great deal of research has focused on how to make digital media truly socially interactive (Bus et al. 2020, Calvert et al.

2019, Myers et al. 2017, O'Doherty et al. 2011, Tsuji et al. 2020, Zack & Barr 2016). In the next wave of the digital revolution, the challenge for industry and developmental researchers will be how to engage more humans as well as artificial intelligence in these interactions to create social partners.

The landscape of children's screen time has changed dramatically since the advent of television in the 1950s. To understand the effects screen time has on development and whether these effects differ across ages, we need to consider its content and the contexts in which it is used (see also Guernsey & Levine 2016, Shapiro 2018). In other words, there is no one-size-fits-all evaluation; just as with television, content, context, and frequency matter. It is less about the dichotomy between screens versus no screens than about how screens can be used to support healthy development and learning (Guernsey & Levine 2016, Shapiro 2018).

This review examines the state of the literature on children (from infancy to 8 years) and screens in terms of their learning and development. Yet, as described throughout, outcomes and recommendations cannot be made uniformly for the entire early childhood age range. Across media types, it appears that infants and toddlers likely benefit the most from social interactivity, but children throughout the age range addressed here demonstrate higher levels of word learning (Kuhl et al. 2003, Myers et al. 2017, O'Doherty et al. 2011), comprehension of content (Fisch et al. 2008, Parish-Morris et al. 2013, Salomon 1977), and attention (Barr et al. 2008, Nussenbaum & Amso 2016) when engaging with others around digital media. Other research suggests that distracting elements of digital media may be more problematic for younger children (<5 years of age) in comparison to older children (>5 years of age) (Parish-Morris et al. 2013). Throughout this review, we draw attention to potential developmental differences in how children can benefit from digital media on the basis of age and other characteristics.

RESEARCH ON CHILDREN AND SCREENS

What We Have Learned from Research on Television, Videos, E-Books, and Apps

Children learn best when educational digital media are designed in a manner grounded in the Science of Learning (Hirsh-Pasek et al. 2015b). The Science of Learning is relatively new—a burgeoning field that began roughly 20 years ago to examine how children learn and how this knowledge can contribute to practices in classrooms, at home, and in digital media (Bransford et al. 1999, Sawyer 2006). Four psychological pillars derived from the literature demonstrate that children can best master tasks when they are cognitively active, when they are engaged, when learning experiences are meaningful, and when there is social interaction (**Figure 1**) (Hirsh-Pasek et al. 2015b). It is important to note that many of the studies discussed here entail multiple pillars—even when one salient pillar is highlighted. The pillars do not operate independently; they are interconnected. Given that these conditions are consistent with how children learn, applications and programs that incorporate aspects of the four pillars are more likely to result in learning that can be generalized beyond any one particular screen experience. In this section, we examine the research addressing each pillar for television and video as well as e-books and apps, keeping in mind that frequent turnover in the type of devices, children's level of access to technology, and changes in norms of use keep the literature very fluid and often changing.

Active Pillar

The idea that children learn through active exploration and mental manipulation is not novel. From Vygotsky to Piaget, the founding fathers of cognitive development stressed the role of

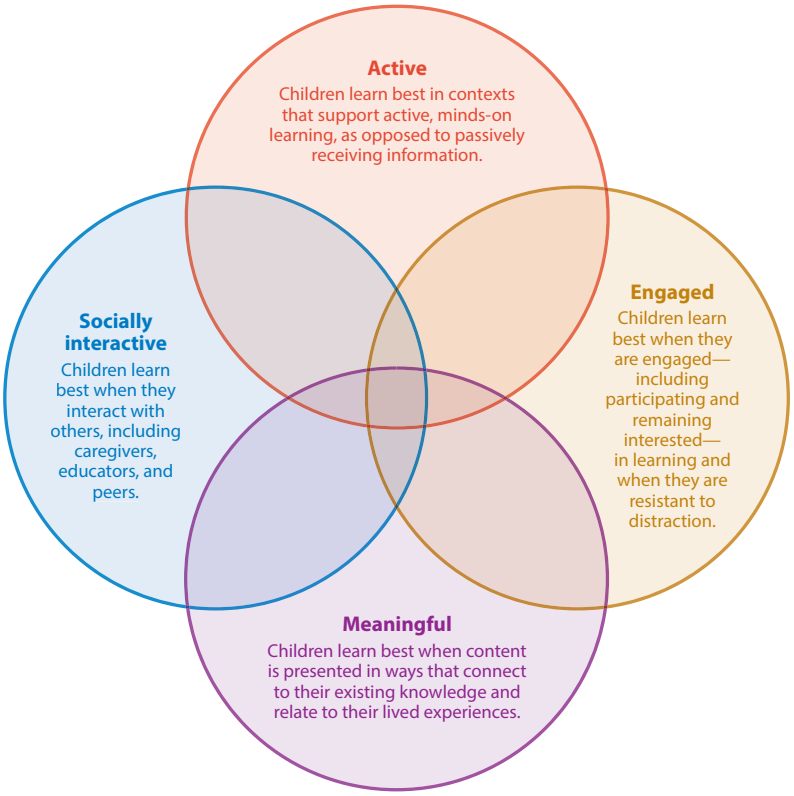

Figure 1

The four pillars of learning—active, engaged, meaningful, and socially interactive—as described by Hirsh-Pasek et al. (2015b).

children's own exploration and discovery in learning, with Piaget (1964) emphasizing cognition and Vygotsky (1976) focusing on the social domain. The active pillar broadly encompasses a range of different sorts of cognitive processes or behaviors, such as exploration, attending, participating, making connections, and processing across multiple modalities, which we explore in this section.

However, active learning can be challenging to measure, because active learning means minds-on learning, whether the child is physically active or not. And swiping or touching is not necessarily sufficient; something can be digitally interactive but not involve minds-on interaction with the content. Active learning entails both solo and collaborative activities that encourage learners to engage in the process of "building and reshaping understanding as a natural consequence of their experiences and interactions within learning environments that authentically reflect the world around them" (Grabinger & Dunlap 1995, p. 5).

Television and video. When young children simply sit down and passively watch a program, they do not demonstrate learning—even after multiple exposures (Richert et al. 2010, Robb et al. 2009). For children to learn from television, they must first attend to the program, as demonstrated by findings showing that children are better able to comprehend educational programming when they actively attend to the program and remain on task while watching (Lorch et al. 1979). For example, active participation while watching *Blue's Clues* transferred to other programs

that preschool-aged children watched (Anderson et al. 2000). Similarly, when watching *Sesame Street*, young children are asked to participate as partners in the active learning taking place on screen. Characters call for the viewer to repeat letters and numbers, actively respond to questions, and think critically about the content. Children who respond to such prompts from characters are more likely to understand the programming compared with children who merely observe (Calvert et al. 2007). These results indicate that children learn more from screens when the experience incorporates interactive elements to facilitate links between the screen and children's real-life experiences (Lauricella et al. 2010). Additionally, prior naturalistic experience with interactive rather than noninteractive media is predictive of toddlers' ability to learn from screens, perhaps because children learn that media can be interactive and responsive (Kirkorian & Choi 2017).

E-books and apps. To learn and retain information from e-books and apps, children need to consider various outcomes, demonstrate comprehension that moves beyond the words, focus on the narrative arc, incorporate their own experiences and knowledge to predict what comes next, and maintain information they have already read as the story progresses. The processes that facilitate learning during e-book reading are the same that unfold during dialogic reading—having a back-and-forth conversation during shared book reading with a caregiver (Whitehurst et al. 1994). The CROWD strategy of dialogic reading includes sentence completion prompts, information recall prompts, open-ended (recalling information in children's own words) prompts, *wh*-word prompts (who, what, when, where), and distancing (applying book content to other contexts) prompts (Whitehurst et al. 1994). A meta-analysis of caregiver shared book reading interventions found that these interventions resulted in marked improvements in children's language skills (Dowdall et al. 2020). Dialogic reading is a prime example of generating the minds-on thinking so central to active learning.

Even when children are not engaging with an adult in dialogic reading, e-book features can promote their use of minds-on thinking to increase learning during independent reading. These features can be beneficial when they focus children on information central to the story, aid in defining and presenting new words, and increase children's attention to the story (Courage 2019).

Interactive hot spots in e-books and apps present opportunities for both learning and potential stumbling blocks. The inclusion of hot spots—or touch-based pop-up activities—designed to define target words increased kindergarten children's learning of vocabulary compared to an e-book without hot spots (Smeets & Bus 2014). Similarly, other multimedia features, like animated pictures, music, and sound effects, can support word learning by drawing attention to the word's meaning or providing additional information about the definition (Bus et al. 2015, Takacs et al. 2015). For instance, a story featuring the word "galloping" might include an animated clip of a horse galloping alongside a drawing of the same action. By providing the same information in two modalities, learning is reinforced. This is one way in which e-books have the potential to promote comprehension and learning beyond what could be provided in a noninteractive medium.

An active application can also foster parental involvement. For instance, if a book application is designed to be interactive, it can promote parent and child dialogue to increase children's reading comprehension (Parish-Morris et al. 2013). A caveat is that the activities must be designed in such a way as to foster learning rather than simply promoting conversation about how to push buttons and work the app.

Another important active aspect of learning through screens is control. Essentially, applications that provide children with the appropriate amount of control and independence based on their developmental stage facilitate attention maintenance (Hirsh-Pasek et al. 2015b). By varying the amount of control children have over the reading process, e-books can facilitate both children's interest and attentiveness to content (Calvert et al. 2005).

Yet, some research with apps suggests that more interactivity is not always better. Aladé et al. (2016) investigated a tablet game for preschoolers focused on measurement. Both children who played the tablet game and those who watched a noninteractive video showed knowledge transfer. Touchscreen interactivity—like dragging objects across the screen to measure the height of a giraffe—improved children's near transfer performance. Conversely, watching a noninteractive video helped children perform better on far transfer tasks. The authors suggest that interactivity may cause children to tie their learning too closely to the context of the tablet, which leads to difficulty applying it to a novel setting (Aladé et al. 2016).

Engaged Pillar

We define engagement as both "the heightened, simultaneous experience of concentration, interest, and enjoyment" (Shernoff et al. 2016, p. 53) and the lack of distraction. Research suggests that engagement is linked to academic performance and learning (Ladd & Dinella 2009). Beginning in early childhood, identifying and building on children's interests are critical ways to encourage engagement and minimize distraction (Hirsh-Pasek et al. 2015b). When interest is triggered, engagement is a natural consequence (Renninger & Bachrach 2015). By removing distractions and increasing engagement, children's learning can be optimized.

Television and video. Interactive experiences with screens facilitate links between what children see on the screen and their real-life experiences (Lauricella et al. 2010). Additionally, when children engage with screen content through either verbal interactions or physical movement, comprehension increases (Calvert et al. 2007). One way to promote engagement is to ensure that the content is the right balance of challenging and accessible. This Goldilocks approach seeks to have the media experience at just the right level for the child—neither too simple nor too difficult—which differs according to age and other developmental considerations. Children may cease to engage if the material is too simple and familiar, yet the same problem can occur if the material is too difficult and novel (Wright & Huston 1983). When television programming is at the right developmental level and the content is appealing (e.g., including animation, children's voices, and humor), children are more likely to engage (Wright & Huston 1983). Also, when material is repeated multiple times during a single program or across episodes, children are better able to learn and transfer content to new situations (Fisch & Truglio 2001).

However, sometimes engagement with television is not the intent. Television is often left on as background noise, which disrupts young children's play (Schmidt et al. 2008). Indeed, high levels of exposure to adult television programs during early childhood are related to lower levels of executive functioning skills at age 4 years (Barr et al. 2010). Also, Kirkorian et al. (2009) demonstrated that the quality and quantity of caregiver–child interaction decreased in the presence of background television noise, indicating that the distraction of background television works against social engagement.

E-books and apps. E-books present many opportunities for fostering learning, but one downside is their potential to promote distraction. Reich et al. (2016) reviewed the state of the literature and found that for infants through preschoolers, interactive e-book features lead to distraction when they are not specifically targeted to the content being taught. For instance, while children read *The Princess Knight* (Funke 2004) as an e-book, the following activity hot spot pops up, interrupting the book reading: "Harold and hearty start with H. Find three more things that start with H." Children must then select the correct images before the story begins again. Directing children's attention away from the main storyline is more distracting than enriching.

Yet, when hot spots are designed to focus on the book content, such as defining target words, children's learning increased in comparison to an e-book without hot spots (Smeets & Bus 2014).

Caregivers and children are more likely to make behavioral comments like "Touch there" or "Turn the page" when reading an e-book, whereas during print book reading they are more likely to make comments related to the content of the story (Parish-Morris et al. 2013). These distractions may also result in lower levels of story comprehension for younger children (3 years of age) versus older children (5 years of age) (Parish-Morris et al. 2013). Distractions are more likely when significant time is spent discussing how to operate the device or directing the child's attention. When activities and behavioral intervention interrupt the flow of book reading, they can lead to lower levels of story comprehension (Krcmar & Cingel 2014), but this finding is not consistent across studies (see Lauricella et al. 2014).

At the same time, e-books may foster greater child engagement than traditional books. Several studies have demonstrated that children are more engaged when reading an e-book than a paper book (Chiong et al. 2012, Richter & Courage 2017, Strouse & Ganea 2017). While print books may be more successful in facilitating the coreading process, e-books better facilitate children's engagement and encourage physical interaction, especially enhanced e-books featuring pop-ups and hot spots (Chiong et al. 2012). Etta & Kirkorian (2019) found that vocabulary learning and story comprehension were similar between e-books that included relevant and irrelevant interactive features, suggesting that irrelevant hot spots might not significantly affect children's learning. Less is known about which factors allow children to look past the distractions and focus on the story.

Beyond interactive activities, caregivers have a large role to play in children's engagement with e-books. When examining independent e-book reading versus reading with a caregiver, Dore et al. (2018a) found that children who read most often with their caregivers were able to perform best in a condition involving independent reading without audio narration. This finding suggests that children were able to attend more to the book perhaps because of their previous book reading experiences that they then transfer to novel reading situations.

For children to learn from e-books and applications, they must successfully avoid the many distractions that often arise. Calvert et al. (2007) found that when preschool children engaged with a story either verbally or physically through controlling features of an application, their learning was better facilitated than when they read a static book. Children's engagement is also stronger when they are provided with immediate feedback, which fosters motivation (Hirsh-Pasek et al. 2015b).

In a study comparing the delivery of spatial training to preschool children in person or using a digital app, C.A. Bower, L. Zimmermann, B.N. Verdine, C. Pritulsky, R.M. Golinkoff & K. Hirsh-Pasek (manuscript in review) found that both types of training supported children's concrete spatial assembly skills in comparison to a control group. Children engaged equally with both training types and demonstrated similar learning as a result—suggesting that a well-designed app that features immediate feedback and scaffolding can facilitate learning as well as an in-person learning experience.

Applications can incorporate aspects that harness children's intrinsic motivation for engagement, which may be critical to their long-term development. For instance, so-called sandbox apps like Toca Builders are designed in an open-ended manner, as with an actual sandbox. Toca Builders allows children to create their own worlds using blocks on the screen. It allows the child to harness their unique abilities, personal interests, and creativity. Across the various types of digital media, both design choices and caregiver engagement can combat distraction and encourage child engagement and learning.

Meaningful Pillar

To learn, children must store knowledge in long-term memory for later retrieval and transfer to new situations (Carrier & Pashler 1992, Kirschner et al. 2006, Mayer 2004). Learning can be made meaningful in a variety of ways: learning with a specific purpose in mind, connecting information to prior knowledge, and learning new information that is personally relevant (Chi 2009). People who take new information and build upon their past experiences and prior knowledge are more likely to master a topic (Brown et al. 2014). These factors differentiate meaningful learning from rote learning (Ausubel 1968). Rote learning does not encourage the learner to find ways to link to older information. However, when learning is linked to previous knowledge or personal experiences, it fosters a higher level of understanding (Novak 2002). The creation of this type of conceptual framework in which to incorporate new knowledge is key to knowledge transfer (Bransford et al. 1999).

Rote learning often lacks depth, and children may learn facts but not understand the context in which their new learning applies. For instance, a caregiver might share the acronym HOMES to teach the names of the Great Lakes (Huron, Ontario, Michigan, Erie, Superior), but if children memorize those names, it does not mean that they know where the lakes are located, how they affect trade, and so forth. Indeed, children are more likely to remember information when it is couched in a familiar narrative, such as relating the wildlife of the Great Lakes to a field trip to a local stream (Hudson & Nelson 1983). When individuals store knowledge in long-term memory, they can retrieve it and can transfer that knowledge to new contexts (Kirschner et al. 2006)—such as applying their knowledge of the Great Lakes to understand how the lake in their local park drains into another body of water.

But how does meaningful content get encoded into memory? Levels-of-processing theory suggests that items are remembered differentially depending on the level at which they were mentally processed (Craik & Tulving 1975). In word learning, new vocabulary that is semantically connected to other words, as in "The chicken went to sleep in his *coop*," is learned more deeply than words only presented with phonemic attributes, including, "cooper, coo, *coop*" (Hadley et al. 2016). Most good literacy instruction relies on enhancement of background knowledge as a precursor to strong reading (Dickinson et al. 2006, Neuman & Dwyer 2011).

Television and video. As the dialogic reading method successfully fosters meaningfulness during shared book reading, coviewing should similarly enhance children's learning from television. Indeed, Lemish & Rice (1986) found similarities between television coviewing and caregiver–child book reading behaviors. When coviewing, a caregiver can make comments about the content of the show and help children make meaningful connections to their prior knowledge and experiences. Yet, research examining coviewing demonstrates mixed findings. Some studies suggest that coviewing can increase infants' attention (Barr et al. 2008) as well as older children's comprehension of content (Fisch et al. 2008, Salomon 1977). Strouse et al. (2013) found that when caregivers ask children questions about coviewed video in a dialogic style, learning is enhanced.

Yet, other research shows that coviewing might not be effective and that children who coview with caregivers spend more time overall watching television (Bleakley et al. 2013). DeLoache et al. (2010) noted that toddlers did not learn new words from video, even when caregivers coviewed. Coviewing is also related to the availability of caregivers' time as well as gender, age, and socioeconomic status (Connell et al. 2015); caregivers with more time and financial resources have more opportunities to coview.

Further studies suggest that young children often have trouble connecting what they view on screen to their daily lives. Infants and toddlers learn best when combining watching a character

on screen with physically playing with the same character (Gola et al. 2013). They face difficulty when attempting to transfer the knowledge they have learned from the screen to the real world, especially when videos do not connect to their lives or interests (Lauricella et al. 2011). For an on-screen character to have social relevance, there must be meaning for the child—such as the character being familiar—or back-and-forth interactions. For example, young children often have toys based on media characters, and they are incorporated into their everyday life. This builds a connection from the on-screen world to the real world.

When children are familiar with certain characters, like Blue from *Blue's Clues*, they have greater problem-solving skills, flexible thinking, pattern perception, and social behavior versus when children are unfamiliar with these characters (Gola et al. 2013). Children's working memory is also taxed when attempting to process a new on-screen character's actions. They focus on who the character is instead of what they are doing.

Television shows try to rectify this unfamiliarity by providing prior knowledge about a character to reduce the working memory load (Lauricella et al. 2011). Research suggests that children may be wary of learning from video, because it does not foster immediate feedback and the characters are unfamiliar (Troseth et al. 2006). Krcmar (2010) explained this observation in terms of social meaningfulness—when characters on screen are seen as both familiar and meaningful, like a parent or other caregiver. When a person on screen is familiar—mother versus a stranger—young children learned to imitate behaviors more effectively (Krcmar 2010).

Repetition can also help create social meaningfulness. At the beginning of its television run, *Blue's Clues* used research suggesting that children interact more with a program once they understand the material to support airing the same episode every day for a week (Crawley et al. 2002). By watching a show multiple times, children can master new content and then transfer that content to new situations (Fisch & Truglio 2001). For example, on *Dora the Explorer*, each episode involves an adventure. An animated map shows the children the places that lie along the way to the end location. Children need to remember the various locations, and the show repeats these four times each. Then, Dora asks the children what places she needs to visit on the way to her destination. By repeating the material, children should be better able to integrate the information into their conceptual framework and then apply the ideas to using maps in other contexts.

E-books and apps. Repetition also assists in learning from apps. Pila et al. (2019) used the Daisy the Dinosaur and Kodable apps to teach preschoolers coding skills. After a week of repeated game play, children demonstrated an improved understanding of how to use the specific commands within each game to be successful.

Additionally, caregiver talk and other reading behaviors may have the ability to make e-book content more meaningful for children (Troseth & Strouse 2017). More so than apps, caregivers draw on children's previous knowledge and experiences to make adjustments during shared book reading to target the experience to the child, which improves learning (Kucirkova et al. 2014). While studies suggest that computers and tablets might provide individualized education (de Jong & Bus 2003, Moody 2010) in the context of storybook reading, it seems that, regardless of book format, the key to an optimal reading experience may be the meaningful connections between stories and children's lives that adults help foster. Hassinger-Das et al. (2016) found that children whose caregivers connected the story to the children's lives demonstrated better comprehension than children whose caregivers did not—regardless of the type of book (print or e-book) they read. This type of conversation helps children relate stories to their own lives as well as infer information not contained in the text (Van Kleeck 2008). A caregiver may note that the bicycle in the book is just like the child's own bicycle. This type of talk makes the content of the story more meaningful for the child and supports learning.

As a further example, Troseth et al. (2020) and Strouse et al. (2017) demonstrate the use of dialogic reading to help children make meaningful connections with their own experiences. In the Read with Me, Talk with Me program, the Ramone character from *Peg + Cat* provides dialogic reading support during book reading. Caregivers stated that Ramone helped them better understand how to use dialogic reading to make the story more meaningful for their children by connecting the book to children's lived experiences (see Revelle et al. 2019 for a review).

Yet, Bus et al. (2019) note that caregivers do not always employ dialogic reading practices. They recommend supplementing books with additional elements—like a camera zooming and panning over illustrations—that can encourage the types of book reading behaviors that support increased learning. For example, the authors describe a page in a story where the text describes a child going to "the weather school" while the page zooms in on a picture of the school. They argue that this kind of augmentation can direct children's attention and help caregivers focus their conversation on relevant topics.

For apps, coplay (like television coviewing) varies greatly among families, and research suggests that it influences caregiver–child relationship closeness and communication (Wang et al. 2018). Apps that are successful in teaching require children to solve problems or become competent in an area that is built into the narrative. Kirkorian et al. (2016) found that toddlers learned object labels from a tablet when they were prompted to touch and manipulate that object on the screen—making the object more real for them.

Bedtime Math—an app featuring short mathematics story problems—provides another example of how meaningfulness can affect learning from screens. For example, one problem presents a short story about how pizza is made and asks children to find triangle (pizza slice–shaped) objects in their room. In so doing, children connect their personal experiences to the math content. Previous research has demonstrated that, when combined with guidance from an adult, the use of manipulatives helps children engage with mathematical ideas by encouraging their integration into a larger conceptual framework of previous knowledge (Clements 1999). When first-graders used the Bedtime Math app throughout a school year, Berkowitz et al. (2015) found that they improved their math achievement significantly over a control group.

Socially Interactive Pillar

Children's first teachers are the social cues of adults around them—a "natural pedagogy" of sorts (Csibra & Gergely 2009). Mere hours after being born, infants will imitate another person's act of sticking out their tongue (Meltzoff & Moore 1983). At 12 months of age, infants will follow the gaze of both a human and a robot, but they will demonstrate increased learning about an object only in relation to the human gaze (Okumura et al. 2013).

This finding hints at the importance of social contingency—or serve-and-return interactions—for child learning. Parenting in which adults respond to children's contributions strongly predicts children's later cognitive and social development (Shonkoff & Phillips 2000). Think of a child in the kitchen pointing and saying, "Banana!" Her father also points to the banana and says, "Yes, you are right. That is a banana! Remember how we saw monkeys eating bananas at the zoo last week?" The father is fostering contingency by responding to the child's bid for attention promptly and relevantly. The importance of contingency for language learning is well established (Cartmill et al. 2013, Goldin-Meadow 2015, Hirsh-Pasek et al. 2015a, Tamis-LeMonda et al. 2014). Kuhl (2007) argues that this type of social interaction facilitates language processing. Indeed, the fluency and connectedness between mothers and children at 2 years of age accounted for 27% of the variance in children's expressive vocabulary at 3 years of age (Hirsh-Pasek et al. 2015a). These types of interactions predicted vocabulary over and above the quantity of

mothers' words per minute as well as general maternal sensitivity and children's earlier language ability.

Learning from and with others continues to remain important throughout the life span. Socially interactive learning occurs when there high-quality interactions occur that are both contingent and adaptable to the child (Hirsh-Pasek et al. 2015b). Such interactions can involve a knowledgeable social partner, a collaborative learning situation (Tamis-LeMonda et al. 2014), and even a nonhuman virtual agent (Tsuji et al. 2020).

Television and video. Research suggests that children under 2.5 years of age are less able to learn from video than from live interactions, known as the video deficit (Anderson & Pempek 2005). Kuhl et al. (2003) found that 9-month-olds who experienced in-person exposure to Mandarin Chinese as a second language discriminated Mandarin phonemes not found in English, whereas video and audio recordings did not elicit the same learning. Similarly, Lytle et al. (2018) demonstrated that infants, when using touchscreens to control the viewing of the same Mandarin-language videos from Kuhl and colleagues' study, learned better from a screen in the presence of another infant. They argued that the addition of a social partner enhanced learning—even on a touchscreen. Children learn from conversation both in person and over video, but they learn best from conversations when engaging in reciprocal social interactions (O'Doherty et al. 2011).

Myers et al. (2017) demonstrated similar results. In their study, 17- to 25-month-olds watched either a FaceTime conversation or a noninteractive video of the same adult. After a delay, children in the FaceTime condition recognized their adult video partner and remembered the words and patterns taught over FaceTime, whereas children in the noninteractive video condition did not. Similarly, visual attention and word learning were specifically tested by teaching preschoolers words in Swahili with four varying degrees of social engagement and interactivity (Nussenbaum & Amso 2016). The results indicated that, across conditions, children learned novel words from the programming, but younger children learned words better with social interactivity.

Roseberry et al. (2009) examined the ability of children between the ages of 30 and 42 months to learn verbs through video. Results indicated that children between 30 and 35 months old learned verbs from a video recording that was supplemented with social interaction provided by interactive teaching with a live experimenter. However, live social interaction was more effective for children under 3 years of age, while children older than 3 demonstrated some ability to learn verbs from just viewing the video (Roseberry et al. 2009). The results of this study further demonstrate the importance of developmental considerations when determining how to engage children in learning from screens.

In a follow-up study, Roseberry et al. (2014) examined the mechanism that supports word learning by comparing language learning during live interaction, socially contingent video chats, and noncontingent videos. The results indicated that children between 24 and 30 months old learned novel verbs only when they were engaged in socially contingent interactions either live or over video chat. These various studies demonstrate a difference in children's ability to learn from television and video—with contingent interactions being most important for the youngest children.

In addition to connecting with live people, children can develop parasocial relationships with characters they see on television, and they may even perceive themselves to be engaging in a meaningful interaction with the characters despite a lack of direct response (Calvert 2017). Children learn better from a socially meaningful character than from a disembodied voice (Calvert et al. 2019). Indeed, a review of the literature suggests that a major component of children's ability to learn from television is the establishment of social relationships with on-screen characters (Richert et al. 2011). Lauricella et al. (2011) compared learning from socially meaningful characters with learning from less socially meaningful characters through video viewing with children

under the age of 2 years. Even toddlers learn from a video in which socially meaningful characters demonstrate a task; when characters are unfamiliar, they are more likely to take the child off task and information is not learned as well (Lauricella et al. 2011). Children learn more effectively from television when a meaningful relationship with the character is established, and as children get older, they can learn more complex information when learning is facilitated by a meaningful character.

E-books and apps. Research supports the idea that a special bond forms when children and caregivers read together and that this bond can be interrupted by electronic reading media. Neumann & Neumann (2014) reviewed the literature and concluded that caregiver support during book reading, as well as the availability and quality of literacy apps, determined the effectiveness of apps for supporting children's literacy outcomes.

C. Gaudreau, Y.A. King, R.A. Dore, H. Puttre, D. Nichols, et al. (manuscript in review) found additional support for the importance of caregiver–child interactions in a study comparing dialogic reading over video chat with live and prerecorded book reading for fostering story comprehension and vocabulary learning. While their findings suggested that children comprehended and learned new words from the story similarly across all three conditions, children were more responsive to the prompts in the two contingent conditions than in the prerecorded condition. This observation suggested that children did notice the difference in the ability of the platforms to support back-and-forth interactions. In the domain of apps, Eisen & Lillard (2020) found that an in-person lesson with physical materials led to better geography learning than solo app use after one session, but that when an experimenter gave a lesson using the app, differences disappeared, highlighting the importance of social interaction for learning.

Similarly, Yuill & Martin (2016) found that caregiver–child warmth was lower during e-book reading. Indeed, research indicates that for children reading with a caregiver is a different emotional experience than reading an e-book alone, featuring greater physiological arousal and more positive child emotion (Dore et al. 2019a). Yet, Ross et al. (2016) showed that when dyads read a highly interactive e-book, they demonstrate high levels of positive emotional engagement like smiling and laughing together.

Note that a social partner does not need to be a caregiver—or even a human being at all. Some reports suggest that by 2022 50% of US households will have a smart speaker—like Amazon Echo or Google Home (Abramovich 2018)—through which family members can ask questions, make purchases, and listen to music. Lovato et al. (2019) conducted a qualitative study of 5–6-year-olds' interactions with smart speakers and recommended adapting the technology so that the devices provide more individualized feedback, like recognizing children's voices and providing child-friendly answers. This type of adaptation would allow the smart speaker to provide more responsive feedback.

When technology is more responsive, outcomes improve, as demonstrated by Tsuji et al. (2020). They found that a virtual agent demonstrating gaze contingency taught 12-month-olds new words more effectively than a nonhuman agent that did not demonstrate contingent behaviors. Other research has examined how to develop conversational agents (CAs) as reading partners by engaging children in story-related conversations similar to dialogic reading with an adult. Xu & Warschauer (2020) developed a CA that asked children questions and provided immediate feedback while reading. They suggested not that CAs should not replace caregiver–child shared book reading but rather that CAs can act as an additional support for children's learning. Yet, it is not clear whether this recommendation will be heeded as CAs become more popular and even better attuned to children's talk and attention. The research is clear—for caregivers, on-screen characters, and nonhuman agents, contingency is key for supporting children's learning through digital media.

A GROWING CHALLENGE TO CAREGIVER–CHILD INTERACTION: TECHNOFERENCE

The research examined above focuses on children's social interaction with other children, adults, or virtual agents but not on the so-called technoference that occurs when everyday interactions are interrupted by the presence and use of technology (McDaniel 2019, McDaniel & Radesky 2018, McDaniel et al. 2018, Myruski et al. 2017, Zimmerle 2019). If social interaction is key, then interrupting social interactions should sidetrack children's ability to engage and learn. Indeed, caregivers express concern about the effects of their technology use—both on themselves and on their children (Radesky et al. 2016)—and caregiver screen time is the top predictor of children's own screen use (Lauricella et al. 2015). Research describing observations of caregiver–child interactions suggests that parents' use of mobile devices is related to lower levels of responsiveness and verbal interaction with their children (Radesky et al. 2014, 2015). Research also suggests a relation between children's problem behaviors and caregivers' technoference (McDaniel & Radesky 2018). Mothers' interactions interrupted by technology predicted both mothers' and fathers' assessments of child problem behaviors, such as whining, sulking, hyperactivity, and temper tantrums.

One thread of inquiry has examined how breaks in contingent caregiver–child interactions driven by the use of mobile devices affects children's language learning. Reed et al. (2017) demonstrated that when caregivers of 2-year-olds were interrupted by a cell phone call while teaching a new word, children did not learn as well as those who experienced an uninterrupted teaching episode. Mobile devices seemingly have the ability to alter the interactions between caregivers and children—and negatively affect child outcomes.

Research has repeatedly demonstrated the importance of face-to-face social interactions for both children and adults. Yet, sometimes technology gets in the way of these critical interactions. As addressed above, it appears that contingent interactions are most important for the youngest of children, so it follows that technoference may be the most detrimental for them as well. The effectiveness of technology for children's learning and development depends on the content, context, and characteristics of the interactions fostered, as well as the information delivered.

THE NEW FRONTIER

The emergence of virtual reality (VR) and augmented reality (AR) in recent years signals that the way we think about children and screens may be shifting from a focus on apps and videos to immersion in virtual worlds and a blending of the real and the virtual into a new image of reality. VR refers to an immersive experience where the user sees images and hears sounds that create a new world, usually via headsets, like Facebook's Oculus Rift. AR refers to the experience of having virtual images or sounds projected onto the real world, usually via smartphones; examples include Pokémon GO and Snapchat's Lens feature. Although children's use of these technologies is still low compared with other forms of media, by 2017 more than 1 in 10 children younger than 8 years had VR headsets at home (Rideout 2017), suggesting potential for growth in the coming years.

AR technologies appear to be ahead of VR in the marketplace in terms of attracting children's attention. Pokémon GO debuted in July 2016 and was wildly popular with children and adults alike, topping 15 million downloads within a week (Molina 2016). In the game, users track hidden Pokémon characters on a map and see them through the video camera using AR overlaid onto the real-world environment. Some early research suggested that the app could increase physical activity for users by encouraging outdoor experiences (Althoff et al. 2016, LeBlanc & Chaput 2017). The game also seemed to encourage co-use, and many parents reported that it provided opportunities for family bonding (Sobel et al. 2017). However, other experts warned about potential risks, like injury due to distracted walking and trespassing to chase Pokémon

onto private property (Serino et al. 2016), highlighting new challenges that accompany novel technologies.

Toy companies are also tapping into the new excitement around AR. For example, Shifu Orboot is a physical globe that when viewed through a tablet camera shows 3D objects and characters, like elephants in Africa and the Eiffel Tower in Paris, allowing children to engage with activities and educational information related to different locations. LEGO's Hidden Side allows children to build physical scenes with LEGO sets and then use an app to go hunting for ghosts. AR books are also available in which aiming a tablet at the illustrations reveals additional 3D features, and early research has identified several distinct ways that parents and children interact with these experiences (Cheng & Tsai 2014, 2016).

Given the novelty of both AR and VR, little research investigating its effects is available. However, some early data suggest that they can be powerful experiences for children. For example, Sharar et al. (2007) found that when using VR as a distraction tool during painful medical treatments, children reported higher levels of "presence" and "realness" of the VR experience compared with adults. This type of effect has led some to argue that children may be more easily influenced by VR than adults, potentially in both positive and negative ways (Bailey & Bailenson 2017). For example, one study found that children who see *Sesame Street*'s Grover in VR are more compliant with his instructions and give him more stickers afterward compared with children who saw the same content on a television screen (Bailey et al. 2019). However, children in VR performed worse on a measure of inhibitory control, perhaps because the environment seemed so real that it was harder for them to inhibit prepotent responses. Indeed, research suggests that VR may alter children's inhibitory control, social responses, and sharing behaviors in comparison to television viewing (Bailey et al. 2019).

The educational potential of VR and AR has been much discussed, and 62% of parents believe that VR can be educational (Aubrey et al. 2018). For example, VR might provide children who cannot travel with immersive experiences to supplement their educational curriculum in ways that video and books cannot. Although some evidence shows that children can learn from VR experiences (Ketelhut et al. 2007), other studies show no differences between VR and more traditional learning experiences (Moreno & Mayer 2004). Some researchers argue that VR creators need to balance maximizing the affordances of the technology with not distracting children from the content with the novel sensory experience (Bailenson 2018). More research is needed, but clearly both the potential and the interest are there.

FUTURE DIRECTIONS

In this review, we have examined the content and the contexts in which digital media are used to understand the effects that screen time has on children's learning and development. There are clear advantages and drawbacks to the technological advances of the last 15-plus years. In particular, the introduction of the smartphone and tablet gave children even more sources of screen time—in addition to television and computers—and have radically shifted the landscape of childhood. Both children's overall screen time and time spent on mobile devices are increasing rapidly (Rideout 2017), and this screen time has the potential to have real impacts on children, families, and society as a whole.

We also note that frequent developments in the type of devices available, as well as children's access to technology and changes in norms of technology use, result in a rapidly changing and sometimes contradictory literature. Research has demonstrated both positive and negative effects of screen time on children' development (e.g., Przybylski 2019, Stiglic & Viner 2019). Too much time with screens might relate in some cases to poorer developmental outcomes, but in our current

moment, children without access to screens also suffer negative outcomes due to an inability to engage in remote learning during the COVID-19 pandemic. Additionally, hot spots can be both effective for learning (e.g., Smeets & Bus 2014) and distracting (e.g., Parish-Morris et al. 2013).

Relatedly, recommendations about children's technology use are about best practices, and in reality, it is not feasible for all families and educators to follow them all the time. Rather, we advocate being aware of ideal conditions for media use, striving for a balanced media diet, and having realistic expectations about what different forms of media can do for children. When researchers, journalists, and others write about screen time, we often view it as an amorphous term without considerations based on type, age, content, or context. Guernsey & Levine (2016) argue that decisions about children's technology use cannot be made without these considerations. More research is needed to determine what works for whom and when. These recommendations, and the field in general, are constantly evolving, and the goal should be to ensure that children have the best chance for high-quality interactions with technology.

After taking into account all of the nuances of the current field, the question that remains for us is: How do we build screen time that uses the pillars of learning and enhances rather than disrupts learning and engagement? Children learn best from digital media when activities are grounded in the Science of Learning and infused with active, engaged, meaningful, and socially interactive opportunities. Hirsh-Pasek et al. (2015b) have argued for using the four pillars presented in this review to evaluate apps to determine their educational value. Callaghan & Reich (2018) surveyed the Android and iOS app markets using a framework influenced by Hirsh-Pasek et al. (2015b) and found that few apps are in line with these ideas. In a recent article that further explores the application of the four pillars to the current app market, Meyer et al. (2020) analyzed some of the most common apps among preschoolers. They developed a scoring system based on the four pillars and found that scores were generally low across all four pillars, with free apps performing significantly worse than paid apps due to distracting advertisements and hot spots. This new assessment system offers the opportunity to better align apps with the Science of Learning and shows how far the field needs to go to meet the minimum requirements of the four pillars.

Even with efforts to synchronize technological developments with developmental science, a great deal of tension still exists between digital media content creators and developmental scientists (Dore et al. 2018b). Often, research studies are out of date before the findings are published, while much digital content that does not align with the latest scientific evidence is rushed to market. It would be powerful if we could bring these two arenas into alignment.

One example of such a collaboration is a vocabulary learning app for preschoolers designed by SmartyPal, an educational app developer, with the help of Dore et al. (2019b). The creators applied the four pillars in developing the app. The game featured a gender-neutral duck as the protagonist alongside a second-person narration of the tasks in the game (e.g., "You are going on a space adventure!") to encourage children's minds-on engagement (Dore et al. 2019b). To keep children engaged during the primary task, the game purposefully did not include pop-ups or hot spots that were not related to the vocabulary learning. Vocabulary words were presented within the narrative of the game—a space mission to rescue aliens—to make the words meaningful. For example, a character with a broken leg is described as experiencing "misfortune." To address the social interaction pillar, the game provided children with immediate, contingent feedback about their answers to questions, much in the way that a live partner would. In both laboratory and classroom settings, children demonstrated successful vocabulary learning from using the app. By addressing all four pillars, the researchers and developers created a promising new app for fostering vocabulary knowledge.

In addition to calling for these types of industry–research collaborations, this review makes evident that as we move into the next wave of the digital revolution, we need to be very clear on

how important social learning and interaction are for young children. We need to harness the power of digital possibilities to prompt social interaction rather than to thwart it.

CONCLUSION

The great natural experiment taking place during the COVID-19 pandemic has demonstrated that extreme isolation is very difficult for children and adults alike. It exposed how important it is for children to interact with peers and adults, and also showed us the need for digital media to find ways to create socially engaging materials that can invite people in instead of shutting them out. Often, social aspects of digital media close out adult involvement rather than supporting it—as shown in the case of electronic toys and caregiver–child language (Zosh et al. 2015). Logistic difficulties with using video chat software for shared book reading or game play also pose an issue that we must overcome. With regard to the issue of social interaction, we thus issue a challenge to the digital media industry to focus more on evidence-based content development and the prioritization of opportunities for social engagement.

Perhaps the biggest takeaway from the current status of the literature on children and screens is that the content, context, and characteristics of the material and the interactions supported through digital media have a large impact on children's outcomes. By creating shows, apps, and games that integrate active, engaged, meaningful, and socially interactive elements, content creators, caregivers, educators, and researchers can set children up for success in today's digital world. Digital media are neither inherently positive nor negative; it is all about how they are designed and used.

DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

ACKNOWLEDGMENTS

The writing of this review was supported by Institute of Education Sciences grants (R324A160241 and R305A15043) to R.M.G. and K.H.-P.

LITERATURE CITED

AAP (Am. Acad. Pediatr.), Counc. Commun. Media. 2016. Media use in school-aged children and adolescents. *Pediatrics* 138(5):e20162592

Abramovich G. 2018. Study finds consumers are embracing voice services. Here's how. *CMO by Adobe*, Sept. 5. **https://cmo.adobe.com/articles/2018/9/adobe-2018-consumer-voice-survey.html#gs.6cjfyo**

Aladé F, Lauricella AR, Beaudoin-Ryan L, Wartella E. 2016. Measuring with Murray: touchscreen technology and preschoolers' STEM learning. *Comput. Hum. Behav.* 62:433–41

Althoff T, White RW, Horvitz E. 2016. Influence of Pokémon GO on physical activity: study and implications. *J. Med. Internet Res.* 18(12):e315

Anderson DR, Bryant J, Wilder A, Santomero A, Williams M, Crawley AM. 2000. Researching Blue's Clues: viewing behavior and impact. *Media Psychol.* 2(2):179–94

Anderson DR, Pempek TA. 2005. Television and very young children. *Am. Behav. Sci.* 48(5):505–22

Aubrey JS, Robb MB, Bailey J, Bailenson J. 2018. *Virtual Reality 101: What You Need to Know About Kids and VR*. San Francisco: Common Sense

Ausubel DP. 1968. *The Psychology of Meaningful Learning: An Introduction to School Learning*. London: Grune & Stratton

Bailenson J. 2018. *Experience on Demand: What Virtual Reality Is, How It Works, and What It Can Do*. New York: Norton

Bailey JO, Bailenson JN. 2017. Immersive virtual reality and the developing child. In *Cognitive Development in Digital Contexts*, ed. F Blumberg, P Brooks, pp. 181–200. San Diego, CA: Academic

Bailey JO, Bailenson JN, Obradović J, Aguiar NR. 2019. Virtual reality's effect on children's inhibitory control, social compliance, and sharing. *J. Appl. Dev. Psychol.* 64:101052

Barr R. 2010. Transfer of learning between 2D and 3D sources during infancy: informing theory and practice. *Dev. Rev.* 30(2):128–54

Barr R, Danziger C, Hilliard ME, Andolina C, Ruskis J. 2010. Amount, content and context of infant media exposure: a parental questionnaire and diary analysis. *Int. J. Early Years Educ.* 18(2):107–22

Barr R, Zack E, Garcia A, Muentener P. 2008. Infants' attention and responsiveness to television increases with prior exposure and parental interaction. *Infancy* 13(1):30–56

Berkowitz T, Schaeffer MW, Maloney EA, Peterson L, Gregor C, et al. 2015. Math at home adds up to achievement in school. *Science* 350(6257):196–98

Bleakley A, Jordan AB, Hennessy M. 2013. The relationship between parents' and children's television viewing. *Pediatrics* 132(2):e364–71

Bransford JD, Brown AL, Cocking RR, eds. 1999. *How People Learn: Brain, Mind, Experience, and School*. Washington, DC: Natl. Acad. Press

Brown PC, Roediger HL III, McDaniel MA. 2014. *Make It Stick*. Boston: Harvard Univ. Press

Bus AG, Neuman SB, Roskos K. 2020. Screens, apps, and digital books for young children: the promise of multimedia. *AERA Open* 6(1). **https://doi.org/10.1177%2F2332858420901494**

Bus AG, Sarı B, Takacs ZK. 2019. The promise of multimedia enhancement in children's digital storybooks. In *Reading in the Digital Age: Young Children's Experiences with E-Books*, ed. J Kim, B Hassinger-Das, pp. 45–57. Cham, Switz.: Springer

Bus AG, Takacs ZK, Kegel CAT. 2015. Affordances and limitations of electronic storybooks for young children's emergent literacy. *Dev. Rev.* 35:79–97

Callaghan MN, Reich SM. 2018. Are educational preschool apps designed to teach? An analysis of the app market. *Learn. Media Technol.* 43(3):280–93

Calvert SL. 2017. Parasocial relationships with media characters: imaginary companions for young children's social and cognitive development. In *Cognitive Development in Digital Contexts*, ed. F Blumberg, P Brooks, pp. 93–117. San Diego, CA: Academic

Calvert SL, Putnam MM, Aguiar NR, Ryan RM, Wright CA, et al. 2019. Young children's mathematical learning from intelligent characters. *Child Dev*. In press. **https://doi.org/10.1111/cdev.13341**

Calvert SL, Strong B, Gallagher L. 2005. Control as an engagement feature for young children's attention to and learning of computer content. *Am. Behav. Sci.* 48(5):578–89

Calvert SL, Strong BL, Jacobs EL, Conger EE. 2007. Interaction and participation for young Hispanic and Caucasian girls' and boys' learning of media content. *Media Psychol*. 9(2):431–45

Carrier M, Pashler H. 1992. The influence of retrieval on retention. *Mem. Cogn.* 20:633–42

Cartmill EA, Armstrong BF, Gleitman LR, Goldin-Meadow S, Medina TN, Trueswell JC. 2013. Quality of early parent input predicts child vocabulary 3 years later. *PNAS* 110(28):11278–83

Cheng K-H, Tsai C-C. 2014. Children and parents' reading of an augmented reality picture book: analyses of behavioral patterns and cognitive attainment. *Comput. Educ.* 72:302–12

Cheng K-H, Tsai C-C. 2016. The interaction of child–parent shared reading with an augmented reality (AR) picture book and parents' conceptions of AR learning. *Br. J. Educ. Technol.* 47(1):203–22

Chi MT. 2009. Three types of conceptual change: belief revision, mental model transformation, and categorical shift. In *International Handbook of Research on Conceptual Change*, ed. S Vosniadou, pp. 89–110. London: Routledge

Chiong C, Ree J, Takeuchi L, Erickson I. 2012. Print books vs. e-books: comparing parent-child co-reading on print, basic and enhanced e-book platforms. *Joan Ganz Cooney Cent*. Spring:1–5. **http://www.joanganzcooneycenter.org/wp-content/uploads/2012/07/jgcc_ebooks_quickreport.pdf**

Christakis DA, Zimmerman FJ, DiGiuseppe DL, McCarty CA. 2004. Early television exposure and subsequent attentional problems in children. *Pediatrics* 113(4):708–13

Clements DH. 1999. "Concrete" manipulatives, concrete ideas. *Contemp. Issues Early Child.* 1:45–60

Connell SL, Lauricella AR, Wartella E. 2015. Parental co-use of media technology with their young children in the USA. *J. Child. Media* 9(1):5–21

Courage ML. 2019. From print to digital: The medium is only part of the message. In *Reading in the Digital Age: Young Children's Experiences with E-Books*, ed. JE Kim, B Hassinger-Das, pp. 23–43. Cham, Switz.: Springer

Craik FI, Tulving E. 1975. Depth of processing and the retention of words in episodic memory. *J. Exp. Psychol. Gen.* 104(3):268–94

Crawley AM, Anderson DR, Santomero A, Wilder A, Williams M, et al. 2002. Do children learn how to watch television? The impact of extensive experience with Blue's Clues on preschool children's television viewing behavior. *J. Commun.* 52(2):264–80

Csibra G, Gergely G. 2009. Natural pedagogy. *Trends Cogn. Sci.* 13(4):148–53

de Jong MT, Bus AG. 2003. How well suited are electronic books to supporting literacy? *J. Early Child. Lit.* 3(2):147–64

DeLoache JS, Chiong C, Sherman K, Islam N, Vanderborght M, et al. 2010. Do babies learn from baby media? *Psychol. Sci.* 21(11):1570–74

Dickinson DK, McCabe A, Essex MJ. 2006. A window of opportunity we must open to all: the case for preschool with high-quality support for language and literacy. In *Handbook of Early Literacy Research*, Vol. 2, ed. DK Dickinson, SB Neuman, pp. 11–28. New York: Guilford

Dore RA, Avelar DA, Schwichtenberg AJ, Puttre H, Foster L, et al. 2019a. *Emotional experiences during parent-child e-book reading: physiological arousal and facial affect*. Paper presented at Technology in Tandem: Characteristics and Effects of Joint Media Engagement in the Digital Age. Symposium Conducted at the American Psychological Association's Conference on Technology, Mind & Society, Washington, DC

Dore RA, Hassinger-Das B, Brezack N, Valladares TL, Paller A, et al. 2018a. The parent advantage in fostering children's e-book comprehension. *Early Child. Res. Q.* 44:24–33

Dore RA, Shirilla M, Hopkins E, Collins M, Scott M, et al. 2019b. Education in the app store: using a mobile game to support US preschoolers' vocabulary learning. *J. Child. Media* 13(4):452–71

Dore RA, Shirilla M, Verdine BN, Zimmermann L, Golinkoff RM, Hirsh-Pasek K. 2018b. Developer meets developmentalist: improving industry–research partnerships in children's educational technology. *J. Child. Media* 12(2):227–35

Dowdall N, Melendez-Torres GJ, Murray L, Gardner F, Hartford L, Cooper PJ. 2020. Shared picture book reading interventions for child language development: a systematic review and meta-analysis. *Child Dev.* 91(2):e383–99

Eisen S, Lillard AS. 2020. Learning from apps and objects: the human touch. *Mind Brain Educ.* 14(1):16–23

Etta RA, Kirkorian HL. 2019. Children's learning from interactive ebooks: Simple irrelevant features are not necessarily worse than relevant ones. *Front. Psychol.* 9:2733

Fisch SM. 2004. What's so "new" about "new media?" Comparing effective features of children's educational software, television, and magazines. In *Proceedings of the 2004 Conference on Interaction Design and Children* (*IDC '04*), pp. 105–11. New York: ACM

Fisch SM, Akerman A, Morgenlander M, McCann Brown SK, Fisch SR, et al. 2008. Coviewing preschool television in the US: eliciting parent–child interaction via onscreen prompts. *J. Child. Media* 2(2):163–73

Fisch SM, Truglio RT, eds. 2001. *G Is for Growing: Thirty Years of Research on Children and Sesame Street*. London: Routledge

Foster EM, Watkins S. 2010. The value of reanalysis: TV viewing and attention problems. *Child Dev.* 81(1):368–75

Funke C. 2004. *The Princess Knight*. New York: Scholastic

Gola AAH, Richards MN, Lauricella AR, Calvert SL. 2013. Building meaningful parasocial relationships between toddlers and media characters to teach early mathematical skills. *Media Psychol.* 16(4):390–411

Goldin-Meadow S. 2015. From action to abstraction: gesture as a mechanism of change. *Dev. Rev.* 38:167–84

Grabinger RS, Dunlap JC. 1995. Rich environments for active learning: a definition. *ALT-J* 3(2):5–34

Guernsey L, Levine MH. 2016. Nurturing young readers: how digital media can promote literacy instead of undermining it. *Am. Educ.* 40(3):23–28

Hadley EB, Dickinson DK, Hirsh-Pasek K, Golinkoff RM, Nesbitt KT. 2016. Examining the acquisition of vocabulary knowledge depth among preschool students. *Read. Res. Q.* 51:181–98

Hassinger-Das B, Ridge K, Parker A, Golinkoff RM, Hirsh-Pasek K, Dickinson DK. 2016. Building vocabulary knowledge in preschoolers through shared book reading and gameplay. *Mind Brain Educ.* 10(2):71–80

Hiniker A, Radesky JS, Livingstone S, Blum-Ross A. 2019. Moving beyond "The Great Screen Time Debate" in the design of technology for children. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*, pp. 1–6. New York: ACM

Hirsh-Pasek K, Adamson LB, Bakeman R, Owen MT, Golinkoff RM, et al. 2015a. The contribution of early communication quality to low-income children's language success. *Psychol. Sci.* 26(7):1071–83

Hirsh-Pasek K, Zosh JM, Golinkoff RM, Gray JH, Robb MB, Kaufman J. 2015b. Putting education in "educational" apps: lessons from the science of learning. *Psychol. Sci. Public Interest* 16(1):3–34

Hudson J, Nelson K. 1983. Effects of script structure on children's story recall. *Dev. Psychol.* 19(4):625–35

Huston AC. 1992. *Big World, Small Screen: The Role of Television in American Society*. Omaha: Univ. Nebr. Press

Kearney MS, Levine PB. 2019. Early childhood education by television: lessons from Sesame Street. *Am. Econ. J. Appl. Econ.* 11(1):318–50

Ketelhut DJ, Dede C, Clarke J, Nelson B, Bowman C. 2007. Studying situated learning in a multi-user virtual environment. In *Assessment of Problem Solving Using Simulations*, ed. E Baker, J Dickieson, W Wulfeck, H O'Neil, pp. 37–58. Mahwah, NJ: Erlbaum

Kirkorian HL, Choi K. 2017. Associations between toddlers' naturalistic media experience and observed learning from screens. *Infancy* 22(2):271–77

Kirkorian HL, Choi K, Pempek TA. 2016. Toddlers' word learning from contingent and noncontingent video on touch screens. *Child Dev.* 87(2):405–13

Kirkorian HL, Pempek TA, Murphy LA, Schmidt ME, Anderson DR. 2009. The impact of background television on parent–child interaction. *Child Dev.* 80(5):1350–59

Kirschner PA, Sweller J, Clark RE. 2006. Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educ. Psychol.* 41(2):75–86

Krcmar M. 2010. Can social meaningfulness and repeat exposure help infants and toddlers overcome the video deficit? *Media Psychol.* 13(1):31–53

Krcmar M, Cingel DP. 2014. Parent–child joint reading in traditional and electronic formats. *Media Psychol.* 17(3):262–81

Kucirkova N, Messer D, Sheehy K. 2014. Reading personalized books with preschool children enhances their word acquisition. *First Lang.* 34(3):227–43

Kuhl PK. 2007. Is speech learning 'gated' by the social brain? *Dev. Sci.* 10(1):110–20

Kuhl PK, Tsao FM, Liu HM. 2003. Foreign-language experience in infancy: effects of short-term exposure and social interaction on phonetic learning. *PNAS* 100(15):9096–101

Ladd GW, Dinella LM. 2009. Continuity and change in early school engagement: predictive of children's achievement trajectories from first to eighth grade? *J. Educ. Psychol.* 101(1):190–206

Lauricella AR, Barr R, Calvert SL. 2014. Parent–child interactions during traditional and computer storybook reading for children's comprehension: implications for electronic storybook design. *Int. J. Child Comput. Interact.* 2(1):17–25

Lauricella AR, Gola AAH, Calvert SL. 2011. Toddlers' learning from socially meaningful video characters. *Media Psychol.* 14(2):216–32

Lauricella AR, Pempek TA, Barr R, Calvert SL. 2010. Contingent computer interactions for young children's object retrieval success. *J. Appl. Dev. Psychol.* 31(5):362–69

Lauricella AR, Wartella E, Rideout VJ. 2015. Young children's screen time: the complex role of parent and child factors. *J. Appl. Dev. Psychol.* 36:11–17

LeBlanc AG, Chaput JP. 2017. Pokémon GO: a game changer for the physical inactivity crisis? *Prev. Med.* 101:235–37

Lemish D, Rice ML. 1986. Television as a talking picture book: a prop for language acquisition. *J. Child Lang.* 13(2):251–74

Lorch EP, Anderson DR, Levin SR. 1979. The relationship of visual attention to children's comprehension of television. *Child Dev.* 50:722–27

Lovato SB, Piper AM, Wartella EA. 2019. Hey Google, do unicorns exist? Conversational agents as a path to answers to children's questions. In *Proceedings of the 2019 Conference on Interaction Design and Children* (*IDC '19*), pp. 301–13. New York: ACM

Lytle SR, Garcia-Sierra A, Kuhl PK. 2018. Two are better than one: Infant language learning from video improves in the presence of peers. *PNAS* 115(40):9859–66

Mares M-L, Pan Z. 2013. Effects of *Sesame Street*: a meta-analysis of children's learning in 15 countries. *J. Appl. Dev. Psychol.* 34(3):140–51

Mayer RE. 2004. Should there be a three-strikes rule against pure discovery learning? *Am. Psychol.* 59(1):14–19

McDaniel BT. 2019. Parent distraction with phones, reasons for use, and impacts on parenting and child outcomes: a review of the emerging research. *Hum. Behav. Emerg. Technol.* 1(2):72–80

McDaniel BT, Galovan AM, Cravens JD, Drouin M. 2018. "Technoference" and implications for mothers' and fathers' couple and coparenting relationship quality. *Comput. Hum. Behav.* 80:303–13

McDaniel BT, Radesky JS. 2018. Technoference: longitudinal associations between parent technology use, parenting stress, and child behavior problems. *Pediatr. Res.* 84(2):210–18

Meltzoff AN, Moore MK. 1983. Newborn infants imitate adult facial gestures. *Child Dev.* 53(3):702–9

Meyer M, Zosh JM, McLaren C, Robb M, Golinkoff RM, et al. 2020. *How educational are 'educational' apps for young children? App store content analysis using the Four Pillars of Learning framework*. Poster prepared for the 2020 Inaugural University of Michigan Research Symposium on Children and Adolescents, Ann Arbor, MI. **https://umich.app.box.com/s/mpow33zymf8gk6iz2ctg0fbkjqu29x5i**

Mistry KB, Minkovitz CS, Strobino DM, Borzekowski DL. 2007. Children's television exposure and behavioral and social outcomes at 5.5 years: Does timing of exposure matter? *Pediatrics* 120(4):762–69

Molina B. 2016. 'Pokémon GO' downloads top 15 million. *USA Today*, July 13. **http://www.usatoday.com/story/tech/gaming/2016/07/13/report-pokemon-go-downloads-top-15-million/87022202/**

Moody AK. 2010. Using electronic books in the classroom to enhance emergent literacy skills in young children. *J. Lit. Technol.* 11(4):22–52

Moreno R, Mayer RE. 2004. Personalized messages that promote science learning in virtual environments. *J. Educ. Psychol.* 96(1):165–73

Myers LJ, LeWitt RB, Gallo RE, Maselli NM. 2017. Baby FaceTime: Can toddlers learn from online video chat? *Dev. Sci.* 20(4). **https://doi.org/10.1111/desc.12430**

Myruski S, Gulyayeva O, Birk S, Pérez-Edgar K, Buss KA, Dennis-Tiwary TA. 2017. Digital disruption? Maternal mobile device use is related to infant social-emotional functioning. *Dev. Sci.* 21(4):e12610

Neuman SB, Dwyer J. 2011. Developing vocabulary and conceptual knowledge for low-income preschoolers: a design experiment. *J. Lit. Res.* 43(2):103–29

Neumann MM, Neumann DL. 2014. Touch screen tablets and emergent literacy. *Early Child. Educ. J.* 42(4):231–39

Novak JD. 2002. Meaningful learning: the essential factor for conceptual change in limited or inappropriate propositional hierarchies leading to empowerment of learners. *Sci. Educ.* 86(4):548–71

Nussenbaum K, Amso D. 2016. An attentional Goldilocks effect: An optimal amount of social interactivity promotes word learning from video. *J. Cogn. Dev.* 17(1):30–40

O'Doherty K, Troseth GL, Shimpi PM, Goldenberg E, Akhtar N, Saylor MM. 2011. Third-party social interaction and word learning from video. *Child Dev.* 82(3):902–15

Ofcom. 2020. *Children and parents: media use and attitudes report 2019*. Rep., Ofcom, London, UK. **https://www.ofcom.org.uk/research-and-data/media-literacy-research/childrens/children-and-parents-media-use-and-attitudes-report-2019**

Okumura Y, Kanakogi Y, Kanda T, Ishiguro H, Itakura S. 2013. Infants understand the referential nature of human gaze but not robot gaze. *J. Exp. Child Psychol.* 116(1):86–95

Parish-Morris MJ, Mahajan N, Hirsh-Pasek K, Golinkoff RM, Collins MF. 2013. Once upon a time: parent–child dialogue and storybook reading in the electronic era. *Mind Brain Educ.* 7(3):200–11

Piaget J. 1964. Cognitive development in children. *J. Res. Sci. Teach.* 2(2):176–86

Pila S, Aladé F, Sheehan KJ, Lauricella AR, Wartella EA. 2019. Learning to code via tablet applications: an evaluation of Daisy the Dinosaur and Kodable as learning tools for young children. *Comput. Educ.* 128:52–62

Przybylski AK. 2019. Digital screen time and pediatric sleep: evidence from a preregistered cohort study. *J. Pediatr.* 205:218–23.e1

Radesky JS, Kistin C, Eisenberg S, Gross J, Block G, et al. 2016. Parent perspectives on their mobile technology use: the excitement and exhaustion of parenting while connected. *J. Dev. Behav. Pediatr.* 37(9):694–701

Radesky JS, Kistin CJ, Zuckerman B, Nitzberg K, Gross J, et al. 2014. Patterns of mobile device use by caregivers and children during meals in fast food restaurants. *Pediatrics* 133(4):e843–49

Radesky JS, Schumacher J, Zuckerman B. 2015. Mobile and interactive media use by young children: the good, the bad, and the unknown. *Pediatrics* 135(1):1–3

Reed J, Hirsh-Pasek K, Golinkoff RM. 2017. Learning on hold: Cell phones sidetrack parent–child interactions. *Dev. Psychol.* 53(8):1428–36

Reich SM, Yau JC, Warschauer M. 2016. Tablet-based ebooks for young children: What does the research say? *J. Dev. Behav. Pediatr.* 37(7):585–91

Renninger KA, Bachrach JE. 2015. Studying triggers for interest and engagement using observational methods. *Educ. Psychol.* 50(1):58–69

Revelle GL, Strouse GA, Troseth GL, Rvachew S, Thompson Forrester D. 2019. Technology support for adults and children reading together: questions answered and questions raised. In *Reading in the Digital Age: Young Children's Experiences with E-Books*, Vol. 18, ed. JE Kim, B Hassinger-Das, pp. 103–32. Cham, Switz.: Springer

Rice ML, Huston AC, Truglio R, Wright JC. 1990. Words from "Sesame Street": learning vocabulary while viewing. *Dev. Psychol.* 26(3):421–28

Richards MN, Calvert SL. 2017. Media characters, parasocial relationships, and the social aspects of children's learning across media platforms. In *Media Exposure During Infancy and Early Childhood*, ed. R Barr, D Linebarger, pp. 141–63. Berlin: Springer

Richert RA, Robb MB, Fender JG, Wartella E. 2010. Word learning from baby videos. *Arch. Pediatr. Adolesc. Med.* 164(5):432–37

Richert RA, Robb MB, Smith EI. 2011. Media as social partners: the social nature of young children's learning from screen media. *Child Dev.* 82(1):82–95

Richter A, Courage ML. 2017. Comparing electronic and paper storybooks for preschoolers: attention, engagement, and recall. *J. Appl. Dev. Psychol.* 48:92–102

Rideout VJ. 2017. *The Common Sense Census: Media Use by Kids Age Zero to Eight*. San Francisco: Common Sense. **https://www.commonsensemedia.org/sites/default/files/uploads/research/csm_zerotoeight_fullreport_release_2.pdf**

Robb MB, Richert RA, Wartella EA. 2009. Just a talking book? Word learning from watching baby videos. *Br. J. Dev. Psychol.* 27(1):27–45

Roseberry S, Hirsh-Pasek K, Golinkoff RM. 2014. Skype me! Socially contingent interactions help toddlers learn language. *Child Dev.* 85(3):956–70

Roseberry S, Hirsh-Pasek K, Parish-Morris J, Golinkoff RM. 2009. Live action: Can young children learn verbs from video? *Child Dev.* 80(5):1360–75

Ross KM, Pye RE, Randell J. 2016. Reading touch screen storybooks with mothers negatively affects 7-year-old readers' comprehension but enriches emotional engagement. *Front. Psychol.* 7:1728

Salomon G. 1977. Effects of encouraging Israeli mothers to co-observe "Sesame Street" with their five-year-olds. *Child Dev.* 48(3):1146–51

Sawyer RK. 2006. Introduction: the new science of learning. In *The Cambridge Handbook of the Learning Sciences*, ed. RK Sawyer, pp. 1–16. Cambridge, UK: Cambridge Univ. Press

Schmidt ME, Pempek TA, Kirkorian HL, Lund AF, Anderson DR. 2008. The effects of background television on the toy play behavior of very young children. *Child Dev.* 79(4):1137–51

Schmidt ME, Rich M, Rifas-Shiman SL, Oken E, Taveras EM. 2009. Television viewing in infancy and child cognition at 3 years of age in a US cohort. *Pediatrics* 123(3):e370–75

Schramm WL, Lyle J, Parker EB. 1961. *Television in the Lives of Children*. Stanford, CA: Stanford Univ. Press

Serino M, Cordrey K, McLaughlin L, Milanaik RL. 2016. Pokémon GO and augmented virtual reality games: a cautionary commentary for parents and pediatricians. *Curr. Opin. Pediatr.* 28(5):673–77

Shapiro J. 2018. *The New Childhood: Raising Kids to Thrive in a Digitally Connected World*. London: Hachette

Sharar SR, Carrougher GJ, Nakamura D, Hoffman HG, Blough DK, Patterson DR. 2007. Factors influencing the efficacy of virtual reality distraction analgesia during postburn physical therapy: preliminary results from 3 ongoing studies. *Arch. Phys. Med. Rehabil.* 88(12):S43–49

Shernoff DJ, Kelly S, Tonks SM, Anderson B, Cavanagh RF, et al. 2016. Student engagement as a function of environmental complexity in high school classrooms. *Learn. Instrum.* 43:52–60

Shonkoff JP, Phillips DA, eds. 2000. *From Neurons to Neighborhoods: The Science of Early Childhood Development*. Washington, DC: Natl. Acad. Press

Smeets DJH, Bus AG. 2014. The interactive animated e-book as a word learning device for kindergartens. *Appl. Psycholinguist.* 36(4):899–920

Sobel K, Bhattacharya A, Hiniker A, Lee JH, Kientz JA, Yip JC. 2017. It wasn't really about the Pokémon: parents' perspectives on a location-based mobile game. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, pp. 1483–96. New York: ACM

Stevens T, Mulsow M. 2006. There is no meaningful relationship between television exposure and symptoms of attention-deficit/hyperactivity disorder. *Pediatrics* 117(3):665–72

Stiglic N, Viner RM. 2019. Effects of screentime on the health and well-being of children and adolescents: a systematic review of reviews. *BMJ Open* 9(1):e023191

Strouse GA, Flores I, Stuckelman Z, Russo Johnson C, Troseth G. 2017. *Built-in questions support parent–child talk during shared reading of an electronic text*. Poster presented at Biennial Meeting of the Cognitive Development Society, Portland, OR. **https://osf.io/mr5d9/**

Strouse GA, Ganea PA. 2017. Toddlers' word learning and transfer from electronic and print books. *J. Exp. Child Psychol.* 156:129–42

Strouse GA, O'Doherty K, Troseth GL. 2013. Effective coviewing: preschoolers' learning from video after a dialogic questioning intervention. *Dev. Psychol.* 49(12):2368–82

Takacs ZK, Swart EK, Bus AG. 2015. Benefits and pitfalls of multimedia and interactive features in technology-enhanced storybooks: a meta-analysis. *Rev. Educ. Res.* 85(4):698–739

Tamis-LeMonda CS, Kuchirko Y, Song L. 2014. Why is infant language learning facilitated by parental responsiveness? *Curr. Dir. Psychol. Sci.* 23(2):121–26

Troseth GL, Saylor MM, Archer AH. 2006. Young children's use of video as a source of socially relevant information. *Child Dev.* 77(3):786–99

Troseth GL, Strouse GA. 2017. Designing and using digital books for learning: the informative case of young children and video. *Int. J. Child Comput. Interact.* 12:3–7

Troseth GL, Strouse GA, Flores I, Stuckelman ZD, Russo Johnson C. 2020. An enhanced ebook facilitates parent–child talk during shared reading by families of low socioeconomic status. *Early Child. Res. Q.* 50:45–48

Tsuji S, Jincho N, Mazuka R, Cristia A. 2020. Communicative cues in the absence of a human interaction partner enhance 12-month-old infants' word learning. *J. Exp. Child Psychol.* 191:104740

Van Kleeck A. 2008. Providing preschool foundations for later reading comprehension: the importance of and ideas for targeting inferencing in storybook-sharing interventions. *Psychol. Sch.* 45(7):627–43

Vygotsky L. 1976. Play and its role in the mental development of the child. In *Play: Its Role in Development and Evolution*, ed. JS Bruner, A Jolly, K Sylva, pp. 537–54. Harmondsworth, UK: Penguin

Wang B, Taylor L, Sun Q. 2018. Families that play together stay together: investigating family bonding through video games. *New Media Soc.* 20(11):4074–94

Whitehurst GJ, Arnold DS, Epstein JN, Angell AL, Smith M, Fischel JE. 1994. A picture book reading intervention in day care and home for children from low-income families. *Dev. Psychol.* 30(5):679–89

Wright JC, Huston AC. 1983. A matter of form: potentials of television for young viewers. *Am. Psychol.* 38(7):835–43. **https://doi.org/10.1037/0003-066X.38.7.835**

Wright JC, Huston AC, Murphy KC St. Peters M, Pinon M, et al. 2001a. The relationships of early television viewing to school readiness and vocabulary of children from low-income families: the Early Window Project. *Child Dev.* 72(5):1347–66

Wright JC, Huston AC, Scantlin R, Kotler J. 2001b. The Early Window Project: Sesame Street prepares children for school. See Fisch & Truglio 2001, pp. 97–114

Xu Y, Warschauer M. 2020. What are you talking to? Understanding children's perceptions of conversational agents. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pp. 1–13. New York: ACM

Yuill N, Martin AF. 2016. Curling up with a good e-book: Mother–child shared story reading on screen or paper affects embodied interaction and warmth. *Front. Psychol.* 7:1951

Zack E, Barr R. 2016. The role of interactional quality in learning from touch screens during infancy: Context matters. *Front. Psychol.* 7:1264

Zimmerle JC. 2019. Limiting technoference: healthy screen time habits for new parents. *Int. J. Childbirth Educ.* 34(2):54–59

Zimmerman FJ, Christakis DA. 2005. Children's television viewing and cognitive outcomes: a longitudinal analysis of national data. *Arch. Pediatr. Adolesc. Med.* 159(7):619–25

Zimmerman FJ, Christakis DA, Meltzoff AN. 2007. Television and DVD/video viewing in children younger than 2 years. *Arch. Pediatr. Adolesc. Med.* 161(5):473–79

Zosh JM, Verdine BN, Filipowicz A, Golinkoff RM, Hirsh-Pasek K, Newcombe NS. 2015. Talking shape: parental language with electronic versus traditional shape sorters. *Mind Brain Educ.* 9(3):136–44