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CHAPTER 4

Plugging Into Word Learning: The Role of Electronic Toys and Digital Media in Language Development

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In the late 1980s and early 1990s, the most technologically advanced toys might be a *Lite Brite* (a light box with colored pegs used to make an illuminated picture) and a 10-button play-a-sound storybook with a panel on the side. When you touched the pictures, various sound effects played. Favorite television shows had to be watched on a big (and we mean big) box in the living room at whatever time they were being aired. Today's reality offers a stark contrast. In 2016, children can play with a *Lite Brite* app on the iPad and read e-books with built-in games, interactive animations, and 3D visuals. Children now watch their favorite shows whenever they want to on DVRs and You-Tube and take these experiences to the car, to the restaurant, to the park, and even to the bathroom on mobile devices. The world of children's toys and media, along with the digital world more broadly, is changing at a rapid clip.

Although children's experiences in this media-saturated world may influence their development across a variety of domains (Wartella et al., 2016), in this chapter we focus on the role of electronic toys and digital media on language development. We outline six principles of language development derived from the Science of Learning (Harris, Golinkoff, & Hirsh-Pasek, 2011) and examine how these principles, in combination with recent research, can shed light on language learning in the age of interactive toys and media. These principles correspond to the section headings below.

CHILDREN LEARN WORDS FOR THINGS AND EVENTS THAT INTEREST THEM

Those of you who are parents will not be surprised by the idea that children learn words for things they are interested in as it is likely that your child's first words were about some of their favorite things, including yourself. Some of the most common early words for children in the US are "Daddy" and "Mommy," and "Hi" and "Bye," reflecting infants' early social interest in their parents and their comings and goings (Tardif et al., 2008). "Kitty," "dog," and "duck" are not far behind. Children learn these words early because they are focused on these topics and motivated to express these ideas.

In our new digital era, children's apparent interest in digital media may be good news, given its potential for supporting language learning. On average, children under the age of 8 spend almost 2 h a day using screen media and between 2011 and 2013, the average amount of time that children spent using mobile devices tripled (Common Sense Media, 2013). More recent data from an urban, low-income community show that these children have almost universal exposure to mobile devices (Kabali et al., 2015). Strikingly, these parents reported that over 90% of children under the age of 1 had already begun to use mobile devices daily and by the age of 4, 75% of children owned their own device (Kabali et al., 2015). Apps and mobile media may be especially appealing to children, perhaps because of their accessibility: most parents at least occasionally allow their child to use their smart mobile device and children often get passed their parents' or other family members' devices to use during travel or while waiting (Chiong & Shuler, 2010). Furthermore, most parents say that they have to make their child stop playing with the iPhone by taking it away rather than children getting bored or choosing another activity (Chiong & Shuler, 2010). The complete integration of mobile devices into our daily lives and those of our children can make it difficult to keep in mind that the use of mobile devices is a relatively new phenomenon—the first iPhone was introduced in 2007. Even the American Academy of Pediatrics may be struggling to keep up with this dizzying pace of change: In the fall of 2015, an announcement from the group signaled that their current media guideline discouraging any screen time for children under the age of 2 would soon be amended, because as they write, "our policies must evolve or become obsolete" (Brown, Shifrin, & Hill, 2015) and in the fall of 2016, the group released a new report that discourages screen time for children under 18 months, rather than age 2, and excludes video chat from this recommendation (AAP Council on Communications and Media, 2016).

The changing landscape of childhood extends beyond the screen and also includes electronic toys. Today's toys are not limited to the plastic cooking sets, cars, blocks, and games of our youth. Instead, they range from a Barbie with artificial intelligence that learns about your child's life and responds contingently to your child, to drones that your child can fly and use to watch video footage of your neighborhood, to electronic building block sets, to robot monkeys that follow children with their eyes, do tricks, and communicate; indeed, we appear to be in the midst of a digital revolution of toys (Hassinger-Das, Zosh, Hirsh-Pasek, & Golinkoff, 2017). While specific information is not available about electronic toys and media versus more traditional toys, related data suggest that electronic toys are quickly coming to dominate the marketplace. By way of example, among the top 20 best-selling items of 2015 in the "Kids' toys and gifts" category on Target's website, 14 were digital (Target.com, Retrieved February 16, 2016). These include a unicorn stuffed animal that "responds to voice and touch with more than 100 sound and motion combinations," an electronic pretend guitar targeted to children as young as 2, and a UNICEF Kid Power Band which is a kid-friendly version of the *FitBit* motion-tracker.

Given children's apparent interest in electronic toys and digital media, the language-learning principle that children learn words related to things that interest them suggests that digital devices could potentially be valuable sources of language learning—but they can only do so if they can use the other five principles, discussed next, to capitalize on this potential.

CHILDREN LEARN THE WORDS THAT THEY HEAR MOST

The second principle reflects the basic idea that children have to hear language to learn language. Although this may seem obvious, it has important implications. For example, children who hear more language should, in turn, learn more language. Indeed, research has shown that children's language skills at age 3 are strongly related to the amount that their parents talked to them in the previous 2 years (Hart & Risley, 1995). Even more important than the *quantity* of language is the *quality* of the language that young children hear: a recent study found that although the number of words children heard predicted language skills a year later, even more predictive was how much parents interacted with children by engaging in rituals (such as book reading), having fluid back and forth conversations, and adding gestures or words to enrich those conversations (Hirsh-Pasek, Adamson, et al., 2015). These findings show that to learn language, children must hear

many words but also have high-quality interactions with adults who scaffold their developing language skills.

These effects are also apparent in more specific domains. Children who hear more spatial language from their parents later do better on tests of spatial cognition (Pruden, Levine, & Huttenlocher, 2011). Similarly, the more parents talk to their toddlers about number, the better children understand the meaning of number words—especially numbers above three—in preschool (Levine, Ratliff, Huttenlocher, & Cannon, 2012). Given the focus on the STEM field (Science, Technology, Engineering, and Math) in the education system and broader economy, it is increasingly important to consider how children's early experiences can impact their future success in these areas (Office of the Press Secretary, 2010).

Recent research has expanded on these ideas by assessing the effect of digital toys and screen media on the quantity and quality of language interactions between children and their parents. For example, in a recent study our lab group gave young children and their parents either a traditional shape sorter toy or an electronic shape sorter toy to play with and video recorded their interactions. The results showed that although parents said approximately the same number of words to their children regardless of which toy they were playing with, parents who were playing with the traditional toy used more varied language, and said more spatial words, compared to parents who were playing with the electronic toy (Zosh et al., 2015). When parents were playing with the electronic toy, they talked more about the non–shape-related functions of the toy, like telling children to push a particular button and less about spatial concepts when compared to parent-child dyads playing with the traditional toy. These findings suggest that traditional toys may promote more high-quality language, as well as more on-topic talk from parents compared to electronic toys. Given what we know about the link between these kinds of language quality indicators, including the importance of high-quality spatial language specifically, it seems that replacing traditional toys with their electronic counterparts may come at a cost to children's developing language skills by degrading the quality of parent-child interactions.

But this issue is not restricted to spatial toys and spatial language. Studies have found similar effects with other types of toys like books and animal figures, showing that mothers are less responsive and teach less when using electronic versions of these toys with their infants than when using traditional versions (Wooldridge & Shapka, 2012) and that parents focus less on relevant content and engage in fewer back-and-forth conversational turns with children when using electronic as compared to traditional toys (Sosa, 2015).

Furthermore, playing with toys is not the only victim of the electronic era. Traditional books are now in competition with digital e-books, which have expanded over the years from electronic console books like the child-friendly *LeapFrog* to apps that present storybooks on smartphones or tablets. As these technologies have emerged, research has followed to examine how parent-child interaction might be affected by reading an e-book as compared to a traditional book. For example, one study in our lab had preschoolers and their parents read either a traditional book or an e-book together. Compared to parents reading traditional books, parents reading e-books talked less about the story and used fewer distancing prompts relating the content of the book to aspects of children's lives outside the book (Parish-Morris, Mahajan, Hirsh-Pasek, Golinkoff, & Collins, 2013). All children learned superficial information from both e-books and traditional books, and 4- and 5-year-olds also answered more difficult questions from both types of books. But 3-year-olds who were read the e-book did worse than those who were read the traditional book on the more difficult tasks assessing their under-standing of the deeper story structure and details, suggesting that the youngest children may need the type of parental support that is related to traditional book reading. Other research continues to find differences in how parents and children interact around traditional books and e-books, although some studies find similar levels of comprehension between the two types of media (Lauricella, Barr, & Calvert, 2014) and others suggest that e-books can have positive effects, such as more child-initiated discourse and greater responsive-ness to maternal talk (Korat & Or, 2010). Clearly, more research is needed in this area to determine what features of e-books might best promote positive parent-child interaction and children's learning.

Another line of research shows that children do not have to be actively engaging with electronic or screen media for it to affect the potential for their language learning; even having a television on in the background while parents play with their children can affect the type of language input children receive. Researchers compared parent-child interaction while an adult-directed television program was on in the background to parent-child inter-action without background television. The results showed that parents were less verbally interactive with their children and less responsive to their children's bids for attention when the television was on in the background (Kirkorian, Pempek, Murphy, Schmidt, & Anderson, 2009). Furthermore, when parents did interact with children in the presence of background television, those interactions were more likely to be passive rather than active. That is, they were more likely to, for example, take a toy offered

by the child without speaking and less likely to have reciprocal exchanges, e.g., engaging in a conversation.

Overall, the research in this area suggests that electronic toys, e-books, and even background television and mobile device use can lead to lower quality parent–child interactions, which may have negative effects on children's later language development. However, electronic books, toys, and media are not necessarily always worse than their traditional counterparts. Furthermore, caregivers are not always present and available for high-quality interactions, and in those cases, the digital technology offers information not available from adult playmates. Thus, it is important for research to determine which features of digital technology may promote learning and which may detract from learning.

INTERACTIVE AND RESPONSIVE RATHER THAN PASSIVE CONTEXTS FAVOR VOCABULARY LEARNING

Studies from the Science of Learning suggest that children learn best in contexts that are active, not passive (Chi, 2009; Hirsh-Pasek, Zosh, et al., 2015). One key to promoting active learning is through joint attention, turn-taking, and contingent responses to children's communicative bids. Even very young children are sensitive to the back–and–forth nature of social interactions that promote active engagement. One study found that when parents were instructed to listen while their infant vocalized and then immediately vocalize in return, their infants produced more syllabic, or speech-like, vocalizations than those whose parents were instructed to vocalize at random times (Bloom, Russell, & Wassenberg, 1987; Goldstein, King, & West, 2003; Goldstein & Schwade, 2008). Given this early sensitivity, it is unsurprising that when adults take turns in interactions and share periods of joint attention with their children, they provide the scaffolding needed to help promote children's language learning (Bradley et al., 1989; Clarke-Stewart, 1973; Tomasello & Farrar, 1986).

The implications of this principle for children's language learning from digital media are profound: If children learn words better from interactions involving turn-taking and joint attention, traditional screen media does not seem like an optimal learning environment. Indeed, a large body of research has provided evidence for a "video deficit effect" in which children under 2.5 or 3 years of age cannot learn from a video as well as they learn from a live person (Anderson & Pempek, 2005). Similarly, research has tested infants' and toddlers' learning from commercially produced educational videos

and found that they are ineffective in teaching new vocabulary (DeLoache et al., 2010; Richert, Robb, Fender, & Wartella, 2010).

Traditionally, the video technology available to young children often contained language samples that were not contingent. The "speaker" would follow a script and could not respond meaningfully or temporally to the language used by the child. At best, a "gap" might be inserted so that children could respond to a scripted question, as in *Blues Clues*. However, modern technology has progressed such that video chat software like Skype now allows live social interactions to take place through a screen. And indeed, when contingency is added back to video, it appears that this video deficit is eliminated. A study in our lab group presented toddlers with new words in one of three conditions: live interaction, socially contingent video over Skype, or non-contingent video over Skype (i.e., observed another child's Skype interaction with the trainer). Results indicated that children learned the words just as well from the contingent Skype chat as they did from the live interaction, whereas they did worse after seeing a non-contingent video (Roseberry, Hirsh-Pasek, & Golinkoff, 2014). These findings suggest that although traditional screen media is not as facilitative of language learning as interacting live, the problem is not the screen, but rather the lack of social interaction.

Another way that digital media may affect language learning is by influencing parents' responsiveness during interactions with their children. Survey data show that 32% of parents report sometimes or often using mobile devices themselves while playing with their children (Common Sense Media, 2013). Radesky and colleagues (2014) completed a recent naturalistic observation study of 55 families in a fast-food restaurant, and found that 40 of them (72%) used mobile devices during the meal, ranging from the devices being on the table, to the parents being completely absorbed with the device. The authors also analyzed the interactions between parents and children and noted, "we did find it striking that during caregiver absorption with devices, some children appeared to accept the lack of engagement and entertained themselves, whereas others showed increasing bids for attention that were often answered with negative parent responses" (p. 6). It is clear that these devices are as intrusive, if not more intrusive than background television and have the potential to change the nature of crucial parent-child interaction in negative ways.

Given the extent to which mobile devices are integrated into parents' daily lives, it is important to examine how these devices may be affecting their interactions with children and children's language development specifically. In a recent study from our lab group to address these issues, parents of

2-year-olds were asked to teach their children two novel words with one of the two teaching periods interrupted by a brief cell phone call. Children learned the word when the teaching was not interrupted, but did not learn the word when the session was interrupted by the phone call (Reed, Hirsh-Pasek, & Golinkoff, 2015). These results suggest that the disruption of parents' contingent responsiveness led to children's difficulty in learning. If this study reflects what is occurring in children's everyday lives, it seems that parents' use of mobile devices may have important negative consequences for interactions with their children, and subsequently for children's language learning.

Overall, the research on contingency and responsiveness in language learning suggests that children learn language best from partners who are responsive to them, whether that is in a live interaction or mediated through a screen; they do not learn as well from less responsive adults, such as pre-recorded actors on video or adults who are distracted from interactions by mobile devices. It is important to note, however, that electronic media is quickly changing with apps and devices becoming increasingly responsive and contingent to children's taps, clicks, and vocalizations (even without a human on the other end). Given this rapidly changing profile of electronic devices and digital media, it will be crucial to investigate learning from more advanced digital media that harnesses the power of contingency in ways that more closely mimic human-to-human interaction.

CHILDREN LEARN WORDS BEST IN MEANINGFUL CONTEXTS

Adding meaning to facilitate memory is one of the oldest mnemonic tricks in the book. Think about how hard it is to remember a PIN number that the bank gives you compared to remembering the one you created. It is likely easier to remember the number you created because it had meaning for you (e.g., using your child's birthday, your anniversary, or your first address). Indeed, studies have shown that when adults are given a list of words to memorize in order, participants who are told to construct a story around the words remember the lists better later, presumably because the words acquire meaning (Bower & Clark, 1969). Language learning works in a similar way; children learn words better when they are put in a meaningful context, rather than being presented as random, disconnected facts to memorize.

Embedding new vocabulary in storybooks is effective in promoting word learning because a narrative can provide a meaningful context for new words. However, young children sometimes need additional support in translating the narrative's meaning to their real lives. Parents can support this kind of meaning-making by asking questions and providing the necessary scaffolding for children to understand a story and, in turn, learn new words. Research shows that having parents read with their children using these kinds of techniques, called dialogic reading, can help children learn the specific vocabulary words in a book and improve their performance on general measures of expressive language (Hargrave & Sénéchal, 2000; Whitehurst et al., 1988).

More recent research has shown that the same is true of children's learning from digital media. For example, when parents who watched a video with their child made connections between objects in the video and their real-life counterparts, children were more likely to demonstrate transfer of the new words from the video to reality (Strouse & Troseth, 2014). In another study, researchers trained parents to use dialogic questioning techniques during educational television viewing and found that children of these parents learned more vocabulary from a video than children whose parents did not receive the training (Strouse, O'Doherty, & Troseth, 2013). Another group of children saw a video that included an actress engaging in dialogic questioning; children also learned from this method but not as much as when their parent used the dialogic techniques.

These findings suggest that electronic media can use the principle of meaning-making to promote language learning. One way to do so is to provide meaningful information within the app itself. Imagine an app designed to teach shapes that present a traditional, equilateral, brightly colored shape on a colored background while children hear the word "triangle" and the image floats peacefully around the screen. Contrast that with another app that may begin by showing a child an image of an equilateral triangle, but then presents the child other examples of isosceles and obtuse triangles, with children asked to discover the "secret" of the triangle shape. Then, children are tasked with finding as many triangles of all shapes and sizes in real-world pictures of kitchens, playgrounds, and family rooms. In the former example, more basic, rote learning may occur but when we—either adults or a well-designed app—help them to find meaning as in the later example, deeper learning will likely occur. Indeed, in a completely non-electronic study of shape learning, our lab discovered that children learn best when adults scaffold children to discover new knowledge (as in the latter

case) rather than by explicitly telling them or not providing any guidance at all (Fisher, Hirsh-Pasek, Newcombe, & Golinkoff, 2013). Lessons learned in nontraditional formats can and should be applied to digital learning across domains.[1]

More recently, companies have begun to produce toys that blend on-screen and off-screen experiences that help children to draw connections between content on the screen or in an app and what it happening in the real world. In Alien Assignment, an app produced by Fred Rogers, children are given a mission to help a newly landed alien (on the screen) make sense of the real world around them (off the screen). Children go on missions to take pictures of items that match certain qualities (e.g., is a certain shape or has a certain function) and parents provide feedback and presumably discuss the answers with the child. The Words app, by *Osmo*, presents children with an on-screen challenge, such as spelling a word or finding a missing letter, but the app allows children to play with real-life manipulable letter tiles that the tablet can recognize. The app then provides a contingent response to the actual 3D tiles in front of the child. As technology becomes more advanced, it will be important that developers, educators, and researchers promote activities that use language in a meaningful context—whether those activities happen on the screen, off the screen, or in a hybrid on-and-off-the-screen format.

Overall, this principle suggests that digital media may be useful in language development to the extent that it can be made meaningful and connected to children's lives. Parents and teachers are the best source of these connections but there may also be ways that we can adapt media content and/or promote high-quality interactions to help children make meaning from these sources.

CHILDREN NEED CLEAR INFORMATION ABOUT WORD MEANING

The old adage that children are like sponges likely rings true if you have ever heard a child repeat a word that they have only heard once or twice. Indeed, this kind of "fast mapping" is an important feature of early word learning (Carey & Bartlett, 1978). However, the construction of a deeper

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[1] See Hirsh-Pasek, Zosh, et al. (2015) for an example of taking the lessons from the Science of Learning and applying them to the specific case of educational apps.

understanding of word meaning requires more explicit definitional informa-
tion (Hadley, Dickinson, Hirsh-Pasek, Golinkoff, & Nesbitt, 2016). For
example, one observational study found that although the proportion of
sophisticated words mothers used with their children predicted later language
outcomes, how often those words were embedded in helpful or instructive
interactions was also related to later vocabulary (Weizman & Snow, 2001).
This suggests that hearing more information about these sophisticated words
helped children construct a more complete understanding of word meanings.
Similarly, other research has found that including explanations of words in
book reading increases children's learning substantially, especially for chil-
dren with weaker language skills (Biemiller & Boothe, 2006; Penno, Wilkin-
son, & Moore, 2002).

In the domain of digital media, this principle relates to a series of findings
in children's vocabulary learning from e-books. As discussed above, research
is mixed as to the effectiveness of e-books overall in story comprehension
and vocabulary. However, the findings in this literature do suggest an
important dichotomy in the types of e-book features that are supportive
of and detrimental to language learning (Bus, Takacs, & Kegel, 2015;
Takacs, Swart, & Bus, 2015). Specifically, some multimedia features like ani-
mated pictures, music, and sound effects seem to be beneficial for word
learning, likely because these features can point to a word's meaning or sup-
port definitional information in the text. For example, an animation of
someone fanning a fire would likely lead to a more complete understanding
of the meaning of the word "fanning" than a still image would because the
back and forth motion would be visible in the animation, whereas motion is
more difficult to depict in a still image. On the other hand, not all features
that e-books afford are beneficial for word learning: interactive features like
games and hotspots that can be touched to activate a sound or animation
seem to disrupt word learning, likely because they are often not focused
on central aspects of the text and distract children from more relevant infor-
mation (Parish-Morris et al., 2013).

This principle highlights both the promise and the danger of modern
technology in children's language learning. To the extent that creators
and users of digital media capitalize on technology's increasing abilities to
support children's learning by providing additional information about word
meaning, these sources may provide an overall advantage for language devel-
opment. As devices become more and more diagnostic and adaptive to each
individual child, the potential for them to meet children where they are
is unparalleled. Indeed, this approach is already beginning to revolutionize

the college classroom through modern technologies like adaptive learning software (Oremus, 2015). This technology uses students' responses and can pinpoint exactly what issues are well understood by the student and which are not—and the software will individually tailor what comes next based on an individual student's performance. However, it is crucial for app and toy developers to keep in mind that more does not always equal better. When technological features are included in children's media for their own sake and are tangentially related to the to-be-learned information, digital media may prove ineffective compared to more traditional sources of vocabulary information.

VOCABULARY LEARNING AND GRAMMATICAL DEVELOPMENT ARE RECIPROCAL PROCESSES

In thinking about language development, we often jump straight to vocabulary, but it is important to not leave grammar and syntax out of the equation. Research shows that vocabulary and grammar develop together across childhood (Bates & Goodman, 2001; Gillette, Gleitman, Gleitman, & Lederer, 1999). In other words, children need to know some vocabulary to learn grammar and can use cues from grammar and syntax to support word learning. For example, studies have shown that by paying attention to the linguistic context of a new word, children can better induce that word's part of speech (Imai et al., 2008).

However, despite the importance of grammar in language development generally, the existing evidence suggests that digital media may encourage a focus on vocabulary without much consideration of grammar. A recent analysis from the Joan Cooney Center culled a list of top educational apps for children and examined the most common language and literacy skills the apps claimed to target. Grammar was not even in the top eight most common skills targeted by these apps; specifically, it was represented in less than 7% of the apps identified (Vaala, Ly, & Levine, 2015).

This principle suggests that grammar's important supporting role in children's language development should not be lost in the age of digital and screen media. Vocabulary learning is certainly vital and may be easier than grammar to present in electronic and interactive formats, but words taught in isolation will likely not be learned as effectively as words presented in richer linguistic contexts. Apps and other media sources that reflect the importance of grammar will likely best support language development in general.

CONCLUSIONS

We are in the midst of a digital revolution. But it is crucial to remember that electronic toys and digital media are neither savior nor Satan for children's language development. Rather, today's technology has opened up a wide range of new features and possibilities for children's play and media, and each of these affordances must be considered in the context of what research shows us about how children learn language. Certainly, the existing research has shown some ways that these digital media can have negative effects on children's ability to learn, but if used in a thoughtful and responsible way, these sources may be able to be used to have a positive impact on language development. Indeed, given the availability of these devices in homes varying in SES, and the low cost of apps, harnessing the power of the digital revolution presents a potential intervention that could bring high-quality experiences to millions of families.

Digital media can take us to new horizons in learning more generally. For example, a digital diagram with moving parts can help us understand the cause and effect in science and the ability to zoom-in on Google Earth allows us to see what life looks like across the world. In these cases, the digital format offers real advantages over the static book or even the moving color of television. Our challenge now is to identify how we can use digital media in new and innovative ways to promote learning. In the early years of the digital revolution, creators of children's digital media and electronic toys have spent too much time transferring our traditional options into digital formats—creating apps from books and adding sound effects and flashing lights to shape sorters. In the second wave of the revolution, we need to instead focus on optimizing the affordances of these novel platforms so that we can fully realize their potential. It is important for future research to continue to study how language learning occurs within the context of today's increasingly digital and connected world. Although we can make educated guesses about the utility or danger of new innovations, researchers will need to investigate how children's interactions with toys and media might change as technology blurs the lines between live and mediated interactions and between real and digital objects. Only by studying the effects of the changing world can we hope to shed light on how to use the substantial resources at our fingertips to best promote healthy development in language and beyond.

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