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Growing Up in the Digital Age: Early Learning and Family Media Ecology

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Abstract
Media is so pervasive that it should no longer be considered a nuisance variable that could affect development; rather, it should be seen as a fundamental part of the context in which development occurs. Despite the rapid growth in access to digital media, there is a scarcity of research examining changes in the family media ecology and the subsequent effects of early media exposure on sociocognitive development. Early research was erroneously focused on the absolute amount of exposure by the child. Current research now considers the entire household, including both intentional exposure to child-directed content and unintended exposure to background media sources. Such research demonstrates that young children can and do learn from well-designed media, particularly when they engage with other people during digital play.

Keywords
early childhood, joint media engagement, learning, media, technoference, transfer deficit

Parents, educators, and policymakers often have polarized responses regarding the adoption of digital devices by young children, either acting with extreme concern or overly optimistic enthusiasm (Lauricella, Blackwell, & Wartella, 2017). Media evokes such polarized responses because it is challenging for caregivers to navigate a rapidly changing digital world. In this review, I begin with an overview of the digital landscape, adopting an ecological perspective that includes media use by children, media use by parents, and joint media engagement between parents and children. This overview is followed by a discussion of current directions needed to address critical questions surrounding the consequences of growing up in the digital age.

What Is the Digital Landscape Like for Very Young Children?

Digital-media availability has surged over the past decade, fueled in part by the introduction of the iPhone in 2007 and the iPad in 2010. It pervades daily activities—from driving in the car to eating a meal with family at a restaurant (McDaniel & Radesky, 2017). Most early screen time (72%) is spent viewing televised content but is no longer limited to the family television set. Rather, televised media is viewed on multiple mobile devices and via multiple forms of content delivery (e.g., streaming video, cable, YouTube). For young children, media usage is governed by parental decisions. The American Academy of Pediatrics recommends that parents limit exposure to most types of screen time before 18 months of age (Reid Chassiakos, Radesky, Christakis, Moreno, & Cross, 2016). Parents seldom heed these recommendations and introduce infants to the digital world (Barr & Linebarger, 2017). In the United States, for example, infants under 2 years of age are exposed to approximately 1 hr of media per day, 2- to 4-year-olds are exposed to approximately 2 hr per day, and almost half (46%) of all children less than 2 years old have used a mobile device (Rideout, 2017). These estimates are based on parental reports of intentional direct exposure to media and do not include incidental background media exposure.

More recently, researchers have considered the family media ecology, focusing on how media is used by all members of the household and whether these media patterns promote or interfere with early learning (Barr

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& Linebarger, 2017). The term *technoference* describes instances in which technology interrupts interpersonal interactions and may disrupt a young child's ability to regulate his or her attention or emotions (McDaniel & Radesky, 2017). The most extensive research on technoference has measured the effects of background television, defined as television that is not intended for children that is on in the background while young children are engaged in other activities. In the United States, the average daily background television exposure for toddlers is 5.5 hr (Lapierre, Piotrowski, & Linebarger, 2012). Furthermore, 42% of parents in the United States report that the television is on "always" or "most of the time" in their home, whether anyone is watching or not (Rideout, 2017).

Infants and toddlers typically attend to the television only 5% of the time, probably because the content is mostly incomprehensible (Schmidt, Pempek, Kirkorian, Lund, & Anderson, 2008). But young children frequently orient to the screen for short periods, prompted by television sound effects, and then quickly look away. Parents may believe that because their infants are not "watching" background television, their infants are not being affected by it. However, background television decreases the duration, quality, and complexity of play (Schmidt et al., 2008). It also decreases parent–child interaction quality; parents are slower to respond to bids for attention and respond in a more passive manner (Kirkorian, Pempek, Murphy, Schmidt, & Anderson, 2009). Exposure to background television is associated with a negative effect on children's language development, cognitive development, and executive functioning skills (Barr, Lauricella, Zack, & Calvert, 2010; Linebarger, Barr, Lapierre, & Piotrowski, 2014; Wright et al., 2001; Zimmerman & Christakis, 2007).

Parental cell-phone usage can also be problematic; when checking cell phones, parents' faces typically have no expression, which may be perceived by young children as a "still face," to which children respond aversively (Adamson & Frick, 2003). This behavior appears to interrupt children's learning. Reed, Hirsh-Pasek, and Golinkoff (2017) asked mothers to teach their 2-year-olds two novel words. Mothers received a call that interrupted them while teaching one of the words but not the other. Children were significantly more likely to learn the uninterrupted word than the interrupted word. The result remained despite the child hearing the novel word the same number of times in both conditions.

Technoference may also occur when parents use mobile devices to distract or calm their young children, and parents are more likely to use this strategy when their children have more difficult temperaments (Radesky, Peacock-Chambers, Zuckerman, & Silverstein, 2016). Radesky and colleagues caution that it is not possible to know whether parents with more difficult children used mobile devices more for calming, whether parents who felt more overwhelmed used mobile devices, or whether mobile devices were likely to result in more socioemotional difficulties. The latter explanation is the least likely, given that earlier socioemotional difficulties predict later television viewing habits and not vice versa. The authors argued that frequent use of mobile devices for self-regulation may result in the development of fewer other regulatory strategies by parents and children. Overall, parents are likely to be unaware of the impact of technoference on their children's play, learning, and emotion regulation.

In contrast, exposure to educational television programming is associated with better cognitive outcomes, particularly for families with low resources (Barr et al., 2010; Linebarger et al., 2014; Wright et al., 2001). In such families, educational media (e.g., television, apps, e-books) may provide cognitive stimulation to children, and these media may not have the same impact in families with higher resources (Linebarger et al., 2014). In sum, it is critical not only to examine the quantity of media consumed but also to consider the content and context of early-childhood media exposure (Barr & Linebarger, 2017).

Learning From Media

Infants and toddlers do learn from television and tablets (Barr, 2013). Infants as young as 6 months can imitate simple actions they see on television up to 24 hr later (Barr, Muentener, & Garcia, 2007), and by 18 months, toddlers can remember brief sequences they saw on television for 2 weeks. By 2 years old, they can remember these sequences for 1 month (Brito, Barr, McIntyre, & Simcock, 2012). There is, however, a *transfer deficit* in learning from television and tablets. It is easier for young children to learn from real-life interactions with people and objects compared with information delivered via a screen. The transfer deficit can result in a 50% decrement in learning (Barr, 2013).

This reduced learning is evident in many domains, including imitation, language learning, and object-retrieval tasks (Barr, 2013). For example, 1-year-olds imitate significantly less following a televised demonstration than after a live demonstration of the same actions (Barr & Hayne, 1999). Similarly, when 2-year-olds are told via a prerecorded video where to find an attractive toy hidden in the room, they are typically unable to locate the toy, even though children are perfectly capable of doing so when given the same information in person (Troseth, Saylor, & Archer, 2006). Children under the age of 3 years are also capable of learning from interactive touch-screen tablets, but they still experience a transfer deficit (Moser et al., 2015; Zack, Barr, Gerhardstein, Dickerson, & Meltzoff, 2009). The extent of the deficit depends on task complexity, memory load, and the number of repetitions of content (Barr, 2013). There are a number of potential explanations for the transfer deficit, including immature memory flexibility in young children (i.e., the inability to retrieve information after a change in cues; Barr, 2013), poor symbolic understanding of the connection between 2-D and 3-D sources (Troseth, 2010), and a lack of social contingency in 2-D sources (Troseth et al., 2006).

Ameliorating the Transfer Deficit

Media are tools that require children to learn new affordances that often do not equally apply in the 3-D world. Therefore, young children require scaffolded experiences to learn new affordances and to transfer media content to the real world.

Tablet interactivity

Tablets provide a new affordance, allowing children to easily interact directly with the device. The addition of an interactive component largely enhances transfer of learning, likely because of the addition of retrieval cues (Kirkorian, 2018). For example, in one study, 2-year-olds who engaged with interactive videos on touch-screen tablets demonstrated increased word learning compared with toddlers who viewed noninteractive videos on tablets (Kirkorian, Choi, & Pempek, 2016). But the effectiveness of the interactivity depended on the child's age: At 2 years of age, children benefited most when they were directed by the app to interact with specific information on the screen, whereas 2.5-year-olds did better when they could choose for themselves where to interact on the screen. Daily experiences also contribute to learning from media. Kirkorian and Choi (2017) reported that the more time toddlers had spent the previous day engaged in interactive media activities, the more they learned from both interactive tablets and videos.

Video chat

Research shows that the transfer deficit can be ameliorated by using socially contingent video calls instead of prerecorded video for imitation tasks (Myers, LeWitt, Gallo, & Maselli, 2017), object-search tasks (Troseth et al., 2006), and language-learning tasks (Roseberry, Hirsh-Pasek, & Golinkoff, 2014). For example, 2-year-olds learned new verbs via video-chat interactions as well as they did in traditional face-to-face interactions (Roseberry et al., 2014). This may be because social contingency focuses attention, is socially rewarding, and facilitates symbolic understanding. Video chat may also present some new cognitive challenges for young children: There may be audio or video delays, there is no physical contact with the social partner, and eye contact is often misaligned because of the location of the web cameras (McClure & Barr, 2017).

Joint media engagement

Learning from television (Strouse & Troseth, 2014), tablets (Zack & Barr, 2016), and video chat (Myers, Crawford, Murphy, Aka-Ezoua, & Felix, 2018) can be maximized via joint media engagement, which occurs when people interact around media together to scaffold learning. In one study, toddlers learned a word from a video only when a parent provided tailored verbal scaffolding to the child (Strouse & Troseth, 2014). High-quality parent joint media engagement also increased 15-month-olds' transfer of learning from the touch screen to an object in the physical world (Zack & Barr, 2016). Myers and colleagues (2018) reported that when the caregiver in the room was responsive, 2-year-olds remained engaged longer (e.g., looked, vocalized, and imitated more) and learned more during a video-chat interaction than when the caregiver was unresponsive. Effective strategies for joint media engagement, such as verbal descriptions of key features, structuring of the task, and encouragement, are the same ones that parents typically use when reading picture books to their young children (Fidler, Zack, & Barr, 2010; McClure & Barr, 2017).

In summary, because media content is a symbolic representation of information existing in the real world, children need guidance to learn the relation between images and real objects. Children rapidly master these skills under responsive and supportive conditions, and such mastery may be important for school readiness and academic achievement.

Current Directions

Media now comprise a significant part of daily experiences for young children. There are significant gaps in the literature, including lack of research on neural mechanisms underlying learning from media, poor assessment of family media ecology, and lack of longitudinal research on the effects of media exposure across diverse populations.

Little is known about how the brain processes different forms of media during early childhood. A comprehensive series of studies examining the development of attention to media using heart rate measurement during early childhood illustrates the utility of adding biological measures (Richards, 2010). This elegant series of studies showed how attention, indexed via heart rate deceleration patterns, changed as a function of age and stimulus complexity of the media. Richards concluded that the comprehension of content involved active processing rather than a passive process. Basic audiovisual-processing mechanisms have been examined using functional near-infrared spectroscopy (fNIRS), a noninvasive neuroimaging technique that measures cortical hemodynamic activity via changes in infrared light absorption that index changes in blood oxygenation (Aslin, 2012). Early confirmatory studies documented cortical responding to audio, visual, and audiovisual stimuli in the predicted regions of temporal, occipital, and temporal-occipital activity, respectively (e.g., Hespos, Ferry, Cannistraci, Gore, & Park, 2009). The advantages of fNIRS for conducting studies of learning from media in young children include tolerance of head motion, no noise, and no physical constraints. Currently, there are very few theories of developmental cognitive neuroscience that consider media. Well-designed cognitive neuroscientific experiments will be important for theory building because they will be able to evaluate how the brain processes different media content and to determine the neural resources needed to transfer learning.

More precise measurement of the family ecology of early media exposure is needed in order to predict the long-term effects of media exposure on child outcomes. Currently, there is no standardized, systematic, scalable, and cost-effective tool that comprehensively and accurately captures child and household media exposure as well as the social context surrounding that exposure. Taking a synergistic approach, a group of researchers is developing a more comprehensive assessment of family media exposure (Barr et al., 2018) that will include parental reports of household patterns accompanied by detailed online time-use diaries and data collected via passive sensing applications. Time-use diaries are more accurate than surveys for measuring blocks of time to estimate television viewing, video-game play, and other activities. They can account for displacement and reduce social desirability because all activities have to be included, and detailed content and context information is collected (Vandewater & Lee, 2009). Parent reports might be less reliable for mobile-device use, which tends to occur in shorter and more frequent bursts (Goedhart, Kromhout, Wiart, & Vermeulen, 2015). Passive sensing applications detect media usage on mobile devices, eliminating parents' recall bias and establishing more accurate usage estimates. Finally, there are a number of wearable devices that could be added to track physiological responses, such as heart rate variability and locomotion. New assessments also need to capture emerging technologies such as video chat, virtual reality, and intelligent agents.

Limited longitudinal assessment of the long-term outcomes associated with media exposure exists (for an exception, see Wright et al., 2001). Unfortunately, ongoing, large-scale longitudinal studies have not routinely included media assessment, despite the fact that media are embedded in children's daily lives. Furthermore, there is a lack of multination reports on media usage; reports almost exclusively originate from within the United States. Over the past decade, mobile technology has been rapidly adopted across the globe. Although very limited in number, studies suggest that quantity of media exposure is similar cross-culturally, particularly exposure via mobile devices (e.g., in Singapore, Goh et al., 2016).

In sum, new studies of any domain of development need to consider the family media environment. These studies should include comprehensive assessment of family media ecology and well-designed experiments that include neural imaging and physiological responses along with robust behavioral measures of learning. Data collection from multiple countries is needed to document both commonalities and cultural differences in the content and context of early media usage across the globe. In addition, inclusion of participants across the socioeconomic spectrum is necessary to build a complete picture of the effects of media on child outcomes. Within this framework, designs that focus closely on fundamental developmental and learning principles will allow us to address the consequences of growing up in the digital age, despite an ever-evolving digital landscape.

Conclusion

The content and context of early media exposure are likely to shape developmental trajectories (Barr & Linebarger, 2017). Research demonstrates positive associations between joint media engagement of age-appropriate, well-designed media content and child outcomes and negative associations between technoference and child outcomes. In this time of unprecedented technological expansion, researchers need better tools to track family media ecology and child responses and to use longitudinal approaches to examine how developmental trajectories of media exposure affect child outcomes.

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