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Mobile Media and Young Children's Cognitive Skills: A Review

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What this review adds: Emerging scholarship suggests young children can learn from mobile devices, but use is also associated with poorer language and self-regulation skills. As these abilities foreshadow important outcomes, additional rigorous and innovative research is needed. Implications for practice are discussed.

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Abstract

Though the use of mobile devices (e.g., tablets, smartphones) by young children is pervasive and increasing, research relating children's use of mobile devices to their development is only beginning to emerge. Learning, language development, and self-regulation skills among children aged zero to five are of particular interest to pediatric clinicians, researchers, parents, and policymakers, as these skills foreshadow important outcomes across the lifespan. Experimental research reviewed herein suggests that the interactivity allowed by mobile devices has benefits over passive viewing (for example, of television) for young children's learning and self-regulation, but studies of naturalistic use suggest increased use of mobile devices is associated with poorer language and self-regulation. Pediatric clinicians can be important sources of support for families endeavoring to navigate their children's use of mobile devices by providing advice and resources, such as communicating reasonable time limits and sharing sources of developmentally appropriate content. Future research should implement innovative, rigorous research designs and methods to clarify mechanisms underlying potential negative effects of naturalistic use of mobile devices by young children and investigate how content and context of young children's mobile-device use may influence relations between such use and children's skills.

Introduction

The use of mobile touchscreen media devices (e.g., smartphones, tablets; hereafter *mobile devices*) by young children in the U.S. is prevalent¹ and increasing.² As research takes time to catch up to practice, literature is just emerging to address questions regarding young children's use of these devices. Of particular interest to clinicians, researchers, parents, and policymakers are inquiries into relations between young children's use of mobile devices and their cognitive development. Substantial research indicates that television exposure can influence child development including growth of cognitive skills.³ While moderate amounts of high-quality television content have been shown to benefit toddlers and preschool-aged children's learning³ and socioemotional skills,⁴ developmentally inappropriate content and heightened exposure may harm self-regulation, language capabilities, and general cognitive abilities.⁵⁻⁷ Whether the use of mobile devices will replicate or diverge from television's relations to cognitive development in early childhood remains unclear.

This article reviews empirical investigations into relations between mobile-device use and cognitive skills of children aged five and under. Much of the research in this area focuses on young children's learning and transfer from mobile devices, or relations between the use of such devices and young children's language or self-regulation skills; as such, this review is configured into these three major categories. As learning from screen-media devices (which include mobile devices, but also television and computers) is supported by interactivity,⁸ mobile devices may offer enhanced opportunities for learning compared to television. Considering their importance as predictors of consequential outcomes across childhood, adolescence, and adulthood, young children's language⁹ and self-regulation¹⁰ are of considerable concern to stakeholders. To keep this review concise and practical, we have not included the scant literature focusing on other

topics such as fine motor skills.¹¹ We conclude by addressing implications for practice as well as directions for future research.

Learning and Transfer

One of the most apparent differences between mobile devices and television is the former's capacity for true interactivity. It is well documented that young children exhibit a *video transfer deficit* – the inability to apply what they observe on a screen¹² – and prior work with screen-mediated social interactions has indicated the primacy of contingency, or true interactivity, for toddlers' learning.⁸ Thus, young children's ability to learn from mobile devices is of significant interest to researchers concerned with the transfer deficit. Though still an emerging field, this topic has received the most attention of the three covered here; those interested in a more thorough exploration of learning and transfer from mobile devices can refer to recent reviews.^{13,14} Here, we briefly integrate studies of young children's transfer between two- and three-dimensional displays (i.e., material presented on a screen and live) into our larger discussion of cognitive skills and mobile-device use.

To determine whether young children can learn from interactions with mobile devices, it can be useful to differentiate between examinations of *near* and *far transfer*, or children's ability to apply their learning to similar versus dissimilar situations. In a series of near-transfer studies, preschool-aged children's latency and steps to completion of the *Tower of Hanoi*, a three-dimensional mathematical puzzle, improved after practice on an application-based facsimile.^{15,16} The contingency of responses allowed by mobile devices also seems to scaffold near transfer for toddlers. In another project, two- to three-year-old children interacted or passively watched as an on-screen cartoon character hid behind one of four objects displayed on the screen, and were subsequently asked to find a sticker matching the character hiding behind a picture of the same

object on a felt board.¹⁷ The youngest children in the sample performed best in the specific-contingency condition, in which children had to touch the on-screen character before it hid, as opposed to the general-contingency condition, where they touched anywhere on the screen to induce the character to hide, or the no-contingency, passive-viewing condition.

The scaffolding effect of interactivity appears to fade quickly with child age. Children at the mean age for the sample in the preceding example¹⁷ performed similarly across conditions, while the oldest children actually performed *worst* in the specific-contingency condition. It also seems that the age window at which children benefit from this specific interactivity may be brief. While interactivity supported the success of two-year-olds in the preceding example, toddlers of 15–16 months had difficulty learning that pressing a button on a physical toy or on its image presented on a mobile device both made a congruent noise (i.e., pushing a button on a toy cow or its image on a mobile device both made a mooing sound), but improved with help from a supportive parent.¹⁸

Among older preschool-aged children, it appears that difficult tasks, including those requiring far transfer, are better learned through less cognitively taxing activities such as passive viewing of material on a mobile device. Older preschool-aged children who watched, rather than played, a game application designed to teach children about organism growth and life cycles performed better when asked to arrange other animal toys by life stage.¹⁹ Similarly, preschool-aged children who watched yoked, or previously recorded, gameplay of an educational application designed to teach measurement skills were better able to measure an item with different units than those who had played.²⁰ Even so, a recent systematic review concluded that the bulk of the current scholarship supports young children's ability to learn from interaction with mobile devices, especially in relation to early literacy and numeracy skills.¹⁴

Language

Measured at school entry, language skills are one of the strongest predictors of later academic success.⁹ Research suggests that among the youngest children, greater television exposure is related to poorer language development,²¹ though this assertion is not without controversy.²² Emerging research regarding the use of mobile devices by young children has so far identified two seemingly contrasting findings. First, like findings related to learning and transfer, contingency can provide the support needed for younger children to learn words from mobile devices.^{23,24} Second, like findings from studies of television, young children's greater overall use of mobile devices may be related to poorer language outcomes including potential delays.²⁵

Though findings echo the studies of learning and transfer reviewed above, less work to date has focused on young children's word learning from mobile devices. One experiment showed that for the youngest two-year-olds, specific contingency supported word learning in a near-transfer test, in this case a simple recognition test for a novel object and label.²⁴ Other scholars replicated this finding, and further noted that while two-year-olds fail far transfer, unable to apply a novel label for a novel object learned via a 2D screen-mediated presentation to a real-world 3D presentation, children improve with age such that four-year-olds succeed at far transfer tasks.²⁴

These findings are encouraging for those interested in using mobile devices for vocabulary intervention. Indeed, in one study of four-year-olds from low-socioeconomic backgrounds, children who played an interactive word-learning application on a mobile device in their preschool classroom gained receptive and expressive understanding of target words.²⁶ Investigations into the effectiveness of word-learning applications for children prior to entry into

formal schooling are limited, but promising. In one study,²⁷ two-year-olds learned more vocabulary words from a mobile application than from physical flash cards; the difference was even greater when a parent joined the application-centered learning sessions.

Emerging studies of naturalistic use of mobile devices, at least by infants and toddlers, are less clear. One study of naturalistic use by U.S. 6- to 24-month-olds indicated that higher average daily mobile-device use was related to an increased risk of meeting criteria for an expressive language delay, and this association was strengthened by adjusting for parents' use of mobile devices and children's exposure to television.²⁵ A study in the U.K., however, failed to replicate this result, though the researchers did find improved fine motor skills among toddlers who used mobile devices more frequently.¹¹ Relations between naturalistic use of mobile devices and language skills among preschool-aged children are yet to be studied.

Self-regulation

When measured in early childhood, self-regulation, the ability to plan, monitor, and control one's behavior, emotions, and cognition particularly in response to environmental cues,²⁸ foreshadows later competencies including social functioning, academic success, health, income, criminality,¹⁰ and even parenting of the next generation.²⁹ Self-regulatory capacity has been linked to young children's television exposure;³⁰ with some notable exceptions,³¹ research suggests that excessive viewing and/or viewing low-quality content is related to poorer self-regulation.⁷ Recent interest in relations between young children's mobile-device use and their self-regulation has resulted in cross-sectional,^{32,33} longitudinal,³⁴ and experimental studies.^{35,36} Similar to the language-related research reviewed above, experimental work suggests mobile devices' interactivity may be beneficial to self-regulation, preventing immediate cognitive-

fatigue effects of viewing certain types of content. Studies examining naturalistic use, however, again suggest a more complicated picture.

Two recent experimental studies have compared the effect of passive viewing and interactivity on self-regulation skills assessed just after exposure.^{35,36} One series of experiments compared preschool-aged children's pre- and post-exposure scores on a computerized measure of inhibitory control,³⁶ one facet of self-regulation responsible for the suppression of attentional or behavioral impulses. Children either interacted with or viewed yoked video of a game application on a tablet; inhibition scores decreased from pre- to post-exposure in the viewing-only group but not in the interaction group. The research team also assessed cortical activation using functional near-infrared spectroscopy (fNIRS; a minimally invasive neuroimaging technique) with a smaller group of slightly older children. The researchers concluded that the poorer post-exposure self-regulation scores were a result of atypically high activity in the dorsolateral prefrontal cortex – an area of the brain recruited during self-regulation tasks – during passive viewing, suggesting a fatigue effect. A more recent experiment similarly reported that playing an educational application resulted in significantly higher self-regulation scores immediately after exposure than watching a cartoon for two- and three-year-olds.³⁵

Research on naturalistic use by young children, however, does not always support the benign influence of mobile-device use on self-regulation observed in experimental studies. A recent survey study linked preschool-aged children's poorer self-regulation to their greater use of tablets at a single time point, but only for children who, on average, slept less each night than the median hours for the sample.³² Additionally, use of mobile devices has been cross-sectionally connected to toddlers' emotion regulation, a subset of self-regulation skills that allow for monitoring and control of emotion expression; parents who reported that their toddlers had poor

socioemotional skills were significantly more likely to also report using mobile devices as a calming tool for their children.³⁷ In a longitudinal study, preschool-aged children who spent more than 30 minutes per day engaging with mobile applications scored lower on a computerized inhibitory control task a year later.³⁴ Our own research extended these findings by incorporating a multifaceted behavioral assessment of children's self-regulation;³³ greater current average weekly mobile-device use and younger age of first use of any screen-media device were associated with lower self-regulation scores in children aged 32 to 47 months. Even so, other research has found no relation between toddlers'²⁵ or preschool-aged children's³⁸ naturalistic mobile-device use and their self-regulation; given that contrasting results across studies could be due to differences in samples, media content consumed, methodologies, or a combination of factors, further research is needed.

Implications

Taken together, what do these findings mean for researchers, clinicians, and the families with whom they work? Regarding transfer, it seems young children can learn from interaction with mobile devices when certain criteria are met. For this to happen, applications need to provide just enough interactivity and contingency for the demands of the task and capabilities of the child; designing applications to operate in such a manner is not an easy endeavor and may not be of financial interest to content creators. It is also likely that applications that can be used as part of a dynamic interaction between an adult and child best support learning.^{27,39} In preschool settings, application-based mathematics⁴⁰ and literacy⁴¹ interventions have shown promise, but the longevity of treatment effects on learning is yet to be determined.

Regarding relations between young children's mobile-device use and self-regulation or language skills, what may underlie differential effects of experimental versus naturalistic use?

Since parents report that young children primarily use mobile devices to view television content instead of to use applications,⁴² naturalistic use of mobile devices may mimic television's effects. As with television,⁴³ use of mobile devices may also compete for time with more salutary activities that support the development of language and self-regulation, such as engaging in imaginative play⁴⁴ or interacting with caregivers.⁴⁵ Furthermore, mobile-device use may prevent children from practicing self-soothing³⁷ and other coping skills³² in challenging situations. Thus, clinicians may wish to inform families of applicable screen-time recommendations and discuss soothing and coping skills that do not involve technology. Finally, future research may reveal that the quality of the content children consume via mobile devices differentially influences their abilities in these and other domains, as is sometimes found with television.⁷ While easily accessible, high-quality television content such as *Sesame Street* is well established to benefit young children,⁴ caregivers seeking to introduce educational applications have to wade through thousands of offerings, many of which claim – without evidence – to provide educational benefits.⁴⁶ Clinicians can support caregivers by directing them to accessible resources and research-backed, developmentally appropriate content.

Future Directions

Research suggests widespread access to mobile devices presents an exciting educational opportunity, but one which should be tempered by reasonable caution. For example, it appears that mobile devices can provide an excellent vehicle to support young children's optimal development utilizing carefully created and thoughtfully selected content, and the wide availability of this vehicle allows broad access to such content. More research is necessary, however, to determine why naturalistic use of mobile devices by young children has been sometimes linked to suboptimal language and self-regulation outcomes. Future longitudinal

research implementing contemporary research designs, from passive-sensing technology to neuroimaging, will be necessary to interrogate contrasting findings.

More work is also needed to determine which children are most at risk of deleterious effects or most likely to obtain benefits. It has been noted that young children with poor self-regulation watch more television⁴⁷ and those with poor socioemotional skills are more likely to be provided with a mobile device to help calm them,³⁷ though no such relation between child self-regulatory skills and mobile-device use has been found to date.^{25,33} Consistent with the differential susceptibility to media effects model, which states that individuals may be more or less influenced by media depending on dispositional, developmental, and social factors,⁴⁸ research reviewed in this article has noted that findings differed by child age,^{15,17,23,35,39} gender,²¹ and factors related to biological processes such as sleep.³² Furthermore, future research must endeavor to recruit more generalizable samples, including children frequently overlooked in basic research.⁴⁹

Finally, the context of children's use of mobile devices deserves further exploration. In alignment with research on television,⁵⁰ studies reviewed in this article indicated the benefits of interacting with adults as part of the mobile-device experience.^{18,27} Adults can augment the learning opportunities created by educational content, and future studies should examine just how caregivers and teachers can best support young children's learning from mobile devices. Taken together, research following these suggestions could fuel the design of interventions; after rigorous evaluation, interventions delivered via mobile devices could ensure effective, efficient services are provided in the future to the young children who need them most.

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