

# Digital Screen Media and Cognitive Development

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abstract

In this article, we examine the impact of digital screen devices, including television, on cognitive development. Although we know that young infants and toddlers are using touch screen devices, we know little about their comprehension of the content that they encounter on them. In contrast, research suggests that children begin to comprehend child-directed television starting at ~2 years of age. The cognitive impact of these media depends on the age of the child, the kind of programming (educational programming versus programming produced for adults), the social context of viewing, as well the particular kind of interactive media (eg, computer games). For children <2 years old, television viewing has mostly negative associations, especially for language and executive function. For preschool-aged children, television viewing has been found to have both positive and negative outcomes, and a large body of research suggests that educational television has a positive impact on cognitive development. Beyond the preschool years, children mostly consume entertainment programming, and cognitive outcomes are not well explored in research. The use of computer games as well as educational computer programs can lead to gains in academically relevant content and other cognitive skills. This article concludes by identifying topics and goals for future research and provides recommendations based on current research-based knowledge.

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Ever since mass media have been directed at children, there have been discussions about their impact on cognitive development, both negative and positive. These discussions have had a broad similarity across many media platforms, including novels, comic books, radio, movies, television, and interactive digital devices such as computers, electronic games, and touch screen devices (eg, iPhones and iPads). On the negative side, at least since the advent of the dime novel, there have been claims that mass media for children foster a laxness of thought, reduce cognitive competencies, and compete with more developmentally productive activities. On the positive side, all of these media have been claimed to be enriching, allowing children to vicariously experience and witness places and events far beyond their normal experiences. Media have repeatedly been claimed to be important sources of children's informal education beyond school. Such claims include the potential of electronic games and other interactive technologies (eg, educational apps for tablets and smartphones) to support learning in formal educational contexts.<sup>1</sup>

Here, we focus on what is known about the developmental impact of digital screen devices, including television, on cognitive development. Because television has been available for a much longer time than digital screen devices, much more is known about its cognitive impact. The experience of watching television, moreover, is broadly similar across presentation platforms (eg, traditional television sets, computers, and mobile devices). As long as a device remains switched on, audiovisual content unfolds in time regardless of whether the viewer is attentive or even present. Television content can generally be characterized as narrative, expository, or hortatory (as in commercials), and it typically

consists of edited audiovisual montage (ie, emerges over time over successions of shots that frequently require inferential cognition to comprehend in sequence).

Interactive digital media, on the other hand, generally require some kind of behavioral actions from users, and thus the sequential flow of content is influenced by user behavior. Depending on the hardware and/or device, formal features (such as screen icons), and user interface, a wide range of user behaviors may influence the flow of content, ranging from the computer mouse to touch screen, to user movement through space, to voice input. Moreover, the range of content available to children on digital, interactive devices is much larger than that on television. Increasingly, television or televisionlike video content is viewed through streaming services on interactive devices. The rapid, secular change in interactive digital screen technology combined with the much broader range of content makes generalizations from research on interactive devices much more problematic than generalizations based on research concerning television (whether it be broadcast, streamed, or on DVD). At this point in history, working conclusions based on television research should be considered more reliable than those based on research of interactive digital media.

## CURRENT STATE

### Development of Screen Media Use and Comprehension

Although on average children begin attending to the television screen at ~6 months of age,<sup>2</sup> sustained attention increases until ~5 years of age, reflecting increasing ability to comprehend a wide array of content types.<sup>3</sup> Substantial comprehension of child-directed television does not appear until ~2 years of age. For as yet unknown reasons, children

in this early period learn less from video than from equivalent real-life presentations,<sup>4</sup> but this video deficit can be ameliorated by repetition, experience with closed-circuit video, and making the video experience appear to be a real social interaction.<sup>5</sup>

During the preschool and elementary school years, television is the dominant screen medium and is used approximately twice as much as interactive screen media.<sup>2</sup> Anecdotally, and by parental report, infants and toddlers use interactive touch screen media.<sup>2</sup> However, there have been no direct observational studies on the developmental time course of interactive media use or comprehension during early childhood.

### Impact of Screen Media on Cognitive Development During Infancy

The cognitive impact of television use on infants and toddlers (<~2.5 years old) is related to the amount of exposure, the program content, and the social context of viewing. For children <2 years of age, associations with aspects of cognitive development are negative, especially for language and executive function<sup>6,7</sup> largely because of exposure to programming produced for adults. Because children of this age pay little overt attention to such programs and likely have little comprehension of them, adult programming can be considered background television from the perspective of the child. Background television has been shown to disrupt 12- and 24-month-old children's sustained toy play and reduce the quality and quantity of parent-child interactions compared with when the television is not on.<sup>8,9</sup> In particular, background television reduces the quantity and quality of parental language addressed to their 12- and 24-month-old children.<sup>10,11</sup>

The evidence is mixed about the impact of child-directed television content on infants and toddlers, with some studies finding no relationship

to cognitive development, and others finding a negative impact, depending on child age and whether the programming is intended to be educational.<sup>7</sup> Whereas parents speak less to their infants during coviewing of infant-directed television programs (compared with no television), they tend to use richer vocabularies both during and immediately after viewing.<sup>12</sup> Although there have been no comparable studies on the impact of interactive screen media during infancy, there is some evidence that toddlers (24 to 36 month olds) can more readily learn from touch screen devices than they can from television.<sup>13</sup> Parental use of mobile devices, however, has been shown to considerably reduce parental interactions with young children.<sup>14</sup> Thus, it appears that parental engagement with both television and interactive media, such as smartphones, may reduce the quantity and quality of parent-child interactions, which are crucial for the development of cognitive skills, especially language and executive function.

### **Impact of Screen Media on Cognitive Development of Preschool-aged and Older Children**

By ~2.5 years of age, children are able to comprehend and learn from age-appropriate, child-directed television programs, although comprehension of more complex television programming continues to increase at least up to ~12 years of age.<sup>15</sup> Once comprehension is established, television begins to influence child knowledge and, therefore, cognitive development more generally. This influence can be both positive and negative. On the positive side, numerous evaluations of preschool educational television programs such as “Sesame Street” have found a positive impact on vocabulary, literacy, social behavior, and academic knowledge.<sup>16</sup> Educational television viewing

is associated with greater school readiness and increased academic performance that is traceable through high school.<sup>17,18</sup> There is little question from a large amount of research that educational television has a positive impact on cognitive development.

Beyond the preschool years, however, most television watched by children is entertainment programming. Beginning at ~6 years old, children watch increasing amounts of entertainment programming directed at adult audiences. There is little research on whether watching adult entertainment programming has an overall positive or negative cognitive effect, but there is fairly clear evidence that violent content can influence antisocial and aggressive behavior.<sup>19</sup> This, in turn, may account for negative associations of viewing violent content with school achievement.<sup>18</sup>

One theory concerning potential negative effects of television is that time spent viewing may displace valuable cognitive activities, such as book reading. There is some evidence for this insofar as television viewing during the years when children are learning to read is associated with lesser reading achievement.<sup>20</sup> There has been considerable concern that television may negatively influence young children’s executive function, especially the ability to focus and sustain attention in task situations. Research on this issue has produced mixed findings of either no impact or a negative impact. At this time, the issue is unresolved, with effects likely depending on age of a child, the type of programming watched, and other contextual factors.<sup>21</sup>

With respect to interactive digital media, extant research has examined effects of content and skills on learning.<sup>1</sup> Parallel to findings for television, there is also evidence that violent computer games can influence antisocial and aggressive

behavior.<sup>22</sup> However, Subrahmanyam and Renukarya<sup>1</sup> concluded in a recent review that research “on game content has yielded disappointing results with regard to learning and educational outcomes.” In contrast, experimental training studies have found short-term increases in cognitive skills from playing games that use those skills. Benefits have been reported for attentional<sup>23</sup> and visual processing skills,<sup>24</sup> iconic<sup>25</sup> and spatial<sup>26</sup> representational skills, as well as executive function skills<sup>27</sup> and visual spatial working memory.<sup>28</sup> The effects on particular cognitive skills are specific to the games played, and there is no evidence that they would accrue from playing any electronic game that did not require practice of the skills.<sup>1</sup>

Cognitive gains have been found in experimental studies of game playing when skills were assessed immediately after the completion of training as well as when they were assessed after a lapse of time.<sup>29</sup> Although based on correlational data, the superior attentional, processing, and representational skills of video-game players<sup>29</sup> indicate that there may be longer-lasting cognitive implications from playing interactive games. A drawback is that some of the research has been done with older children and young adults. It is largely unknown if these cognitive effects can be extended to children and, if so, whether age may moderate the effects.

### **FUTURE RESEARCH**

When children become capable of comprehending the media they experience, it is likely that the greatest impact on cognitive development is via content. Although some television studies have demonstrated the value of a television diet that is rich in educational content, there has been a lack of research on the differential effects of content with regards to

interactive digital media. As a simple example of the type of research that is needed, a recent small-scale experiment provided 1 group of 18 4-year-old children from low-income families with a touch screen mobile device (an iPod Touch) loaded with age-appropriate educational game software that focused on math and literacy skills. A comparison group of 11 children received the devices with age-appropriate entertainment software. Cognitive assessments after 3 months revealed a literacy skill gain of 11 standard score points on the Test of Emergent Preschool Literacy for the educational software group and of only 4 points for the entertainment software group. For math skills, the respective gains were 8 vs 1 on the Test of Early Math Ability.<sup>30</sup> If this study can be replicated at a much larger scale, the results point to the potential of a media touch screen diet that is rich in educational software as a relatively inexpensive mode of early intervention for school readiness.

Television use during the years in which children are learning to read has a negative impact on reading achievement, likely because of the displacement of reading for pleasure by entertainment television viewing. It is not known whether this finding extends to educational television use or whether it extends to the use of interactive media, educational or otherwise. This may partly depend on how much a child is engaged in reading while using interactive software. Television rarely requires young viewers to read; software programs sometimes do.

Research must also investigate the psychological and neural mechanisms that underlie learning and other effects of media. For instance, video-game play may produce processing changes because of physiologic arousal, changes in task difficulty and input variability, the activation of brain regions that are sensitive to

reward and reinforcement, and the shaping of neural networks.<sup>29</sup>

## RECOMMENDATIONS

### Clinicians and Providers

- Clinicians and providers should talk to parents about limiting television exposure (especially background television) before the age of 2 years;
- Clinicians and providers should counsel parents about the impact of their own media use, including smartphones and tablets, on their interactions with their infants and toddlers; and
- Clinicians and providers should talk to parents about providing their children with media diets that are rich in educational content while discouraging heavy screen media use, especially when children are beginning to learn to read. In this regard, parents should read to their children and encourage reading by their children.

### Policy Makers

- Policy makers should encourage and support research on developing content for new digital media.

### Educators

- Early childhood educators should be encouraged to interact with toddlers and touch screen devices (including e-books) in much the same way they are encouraged to use and interact with children while reading traditional books.

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