



Relationship of TV watching, computer use, and reading to children's neurocognitive functions



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ABSTRACT

We studied the relationship between time spent watching TV, using the computer, or reading and performance on neurocognitive tasks of attention/executive functions, language, memory/learning, social perception, and visuospatial processing in 5–12-year-old children ($N = 381$). The results showed significant positive (for computer use and reading) and negative (for TV watching) relations between media use and neurocognitive functions as assessed with the NEPSY-II. When media and background variables (age, sex, and maternal education) were taken into account, computer use was positively related to language, memory/learning, and social perception. Reading was positively related to attention/executive functions and visuospatial processing in the younger age groups. There were also significant positive relations between reading and memory/learning when maternal education was lower than average. In contrast, TV watching was negatively related to all assessed neurocognitive domains and, in all, maternal education, not the media variables, was the strongest predictor of all neurocognitive variables.

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During the past decades, research has been conducted evaluating the relationship between media use, including watching TV, using the computer, and playing video games, or more traditional activities, such as reading, and children's development and well-being in general (e.g., Schmidt & Vandewater, 2008). However, the relationship between media use and more specific areas of neurocognitive functions, such as, attention/executive functions, language, memory/learning, social perception, and visuospatial processing, is relatively unexplored.

Cognitive functions develop not only with the maturing brain, but also in close relationship with the environment (e.g., McLoyd, 1998). Electronic media use plays an important role in the lives and the environment of children of all ages, even in infancy (e.g. Chonchaiya & Pruksananonda, 2008; Linebarger & Walker, 2005). Naturally, this media use increases with age. Also, there is some evidence of children's media environment relating to, for instance, their academic achievement (Borzekowski & Robinson, 2005). The school years are a time of intensive development and change, not only with respect to the increasing use of media during this time, but also with regard to neurocognitive performance. In general, the development of neurocognitive capacities has been shown to differ somewhat between functions, but generally to be rapid between ages 5 to 9, the rate of development decelerating

after that (Korkman, Lahti-Nuutila, Laasonen, Kemp, & Holdnack, 2013). Naturally, children use media in different ways depending on their age. Therefore, studies with comprehensively assessed cognitive functions, a broad age span, as well as several media variables are needed in order to elucidate the relationship between neurocognition and media use. This could lead to information of both clinical and research-related importance, and may also provide important information for families considering rules for media use in the home. We focused on pre-adolescent school-aged children, in order to investigate the relationship between media use and neurocognition during this period of vigorous change in development.

1. TV watching

The effects of TV watching on children's achievement and development have been the focus of research for several decades. The association between TV watching and educational achievement or TV watching and school performance has been inconsistent in children and adolescents. Some studies have found negative relations, mostly in adolescents or adults, between time spent watching TV and academic achievement (e.g. Razel, 2001; Sharif, Wills, & Sargent, 2010). Others have reported some positive relations (Borzekowski & Robinson, 2005), and some (mainly conducted with infants or a narrow age span of older children) no relations (e.g. Schmidt, Rich, Rifas-Shiman, Oken, & Taveras, 2009; Shashi Kumar et al., 2013) of TV watching to cognition or academic

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performance. Most previous studies have assessed television viewing through parent questionnaires or interviews, whereas the positive relations were found using a classroom survey with 3rd graders (Borzekowski & Robinson, 2005). Thus, these different results may at least to some extent depend on methodological differences and different age groups studied, but these dissimilarities do not explain all observed differences in the previous findings, and, therefore, more research is still needed.

In addition, the research evaluating the relationship between TV watching and more specific neurocognitive functions is scarce. Regarding attention and executive functions, TV watching has been shown to have negative relations with visual attention, attention span, and executive functioning, and to induce ADHD-type behavior, both in cross-sectional (Levine & Waite, 2000, Lillard & Peterson, 2011) and longitudinal (e.g., Acevedo-Polakovich, Lorch, Milich, & Ashby, 2006) studies. However, this view has been challenged as significant effects of TV viewing on attention have been attributed to confounding factors or methodological differences (Ferguson, 2011; Foster & Watkins, 2010). With respect to linguistic abilities, the research is equivocal. Both negative (Chonchaiya & Pruksananonda, 2008) and some positive relations (e.g., Linebarger & Walker, 2005) between TV viewing and language skills in young children have been reported. TV watching, when studied experimentally, did not have any significant effects on visuospatial or verbal memory performance in young adolescents (Dworak, Schierl, Bruns, & Struder, 2007). Concerning social functions, a recent study reported that exposure to background television at home had a negative association with preschool-aged children's performance on theory-of-mind tasks, even if the actual time spent viewing television was only marginally related to this performance (Nathanson, Sharp, Aladé, Rasmussen, & Christy, 2013). However, there is also evidence that parent's recognition of children's movie titles, but not television programs, positively predicts development of theory of mind (Mar, Tackett, & Moore, 2010). Even if TV is a visual medium, we have found no studies conducted past the 1980s on its relations to visuospatial functions. In fact, TV watching has been referred to as a non-spatial activity (Cherney & Voyer, 2010).

2. Computer use

Many studies have focused on the increasing use of computers, with somewhat contradictory findings. There is some evidence of both computer use in general, or, more specifically, frequent use of the internet being positively related to cognitive and academic performance (e.g. Borzekowski & Robinson, 2005; Jackson et al., 2006; Subrahmanyam, Greenfield, Kraut, & Gross, 2001). Other studies have found negative (Sharif et al., 2010) or no significant (e.g. Skoric, Teo, & Neo, 2009) relations between time spent playing games and school achievement. Methodology differences may, thus, at least partly explain these differences in findings: It seems that a broader use of computers may be positively related to different aspects of academic performance (e.g. Borzekowski & Robinson, 2005; Jackson et al., 2006; Subrahmanyam et al., 2001), whereas the evidence concerning playing games is still equivocal.

Research on associations between time spent on computers and specific aspects of neurocognitive abilities is sparse, and the applicability and methodologies of at least different computer game playing studies have been discussed (Boot, Blakely, & Simons, 2011; van Ravenzwaaij, Boekel, Forstmann, Ratcliff, & Wagenmakers, 2014). Most previous studies have investigated computer game playing in relation to specific task performance by comparing specific or general cognitive abilities of frequent versus non-frequent computer game players, often adults (see overview by, for instance, Boot et al., 2011). Some of these studies suggest that attention and executive functions are related to computer game play: Processing speed in tasks of visual attention was faster in children who regularly played games compared to non-players (e.g., Dye, Green, & Bavelier, 2009) and playing

games has been associated with increased attentional skills in general (see reviews by, for instance, Green & Bavelier, 2012; Schmidt & Vandewater, 2008). However, some evidence also suggests playing games is associated with increased attention difficulties as assessed with behavior rating scales, which may possibly explain the contradiction compared to the other reported studies (e.g., Chan & Rabinowitz, 2006), even if no significant relations of computer game playing to behavioral attention skills also have been reported (Ferguson, 2011). Thus, it may be that the association between computer use and attention as a cognitive mechanism is positive, whereas the association between computer use and behavioral or ADHD-related aspects of attention is inconsistent. Still, knowledge of the relationship between more broadly assessed cognitive aspects of attentional functions and computer use in general is lacking.

Regarding the relationship between computer use and other neurocognitive capacities, computer game playing may negatively impact verbal-memory functioning (Dworak et al., 2007). On the contrary, playing different kinds of games has led to better visuo-spatial skills (for reviews, see, for instance, Schmidt & Vandewater, 2008; Spence & Feng, 2010), even if zero effects of playing violent videogames on visuospatial performance also have been reported (e.g. Ferguson, Garza, Jerabeck, Ramos, & Galindo, 2013). Computer use may have positive effects on social, interaction, and communication skills (for a review, see Subrahmanyam et al., 2001). However, to our knowledge, it still remains to be explored whether a relationship between time spent using the computer and neurocognitive performance exists.

3. Reading

In general, reading is considered to have a positive and enhancing effect on practically all kinds of development and academic work (e.g. Evans, Kelley, & Sikora, 2014; Mol & Bus, 2011; Rowe, 1991). In fact, to our knowledge, there are no negative effects of reading to be reported. Building upon this information, it still remains to be investigated which neurocognitive abilities can be enhanced by frequent reading, and to what extent.

The relationships between reading and attention as well as language have received some interest. Self-reported reading activity at home has been shown to be related to 5- to 14-year-old children's teacher-rated classroom attentiveness (Rowe, 1991). Also, frequent readers of different ages are more successful in different language skills (e.g., vocabulary, oral language, or comprehension) and emerging literacy tasks (e.g. Echols, West, Stanovich, & Zehr, 1996; Mol & Bus, 2011; Whitehurst & Lonigan, 1998). To our knowledge, no studies have investigated the relationship between time spent reading and memory, social perception, or visuospatial processing.

4. Summary and aims

During the past decades, a large amount of research has focused on the relationship between media use and the cognitive and social development of the child. However, previous studies have differed in methodology and in their results. Regarding TV watching, the results of the previous studies have been inconsistent, showing positive, negative, or no relations with academic performance or neurocognitive functions, possibly partly depending on the age groups studied. For computer use, previous studies are also somewhat inconsistent and most studies have been conducted with adults or adolescents, often assessing different aspects of computer/video game playing. Studies on more specific neurocognitive capacities in relation to time spent using the computer are still lacking. Findings on the relationship between reading and attention/executive functions or language, as well as academic achievement, are indicative of a positive relationship. Regarding memory, social perception, and visuospatial processing, the relationship to reading still remains to be investigated. In addition, previous studies have often included only one media variable (or even

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