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The role of sleep in the relation between young children's mobile media use and effortful control

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We explored the relations among young children's mobile media use, sleep, and a form of self-regulation, temperamental effortful control (EC), among a national sample of 402 mothers who completed an online survey. We found that the relation between mobile media use and EC was moderated by children's sleep time. Tablet use was negatively related to EC only among children who slept less at night (40% of our sample). However, hand-held game player use was positively related to EC among children who slept longer at night (60% of our sample). In addition, sleep quality was a mediator in the relation between evening tablet use and EC. Evening use related to later bedtimes, more bedtime resistance, and worse sleep duration, and these indicators of poor sleep quality, in turn, predicted weaker EC.

Statement of contribution

What is already known on this subject?

- Young children are spending increasing amounts of time with mobile media, such as tablets and hand-held game players.
- Media exposure is related to children's self-regulation.
- Media exposure is related to children's sleep quality.

What does this study adds?

- Number of sleep hours moderates the relation between mobile media use and EC among young children.
- Tablet time is negatively related to EC among young children who get fewer sleep hours.
- Hand-held game playing is positively related to EC among young children who get greater sleep hours.
- Sleep quality mediates the relation between evening tablet time and EC among young children.

Children are spending an increasing amount of time with mobile media, such as tablet computers and hand-held video game players (Common Sense Media, 2013; Cristia & Seidl, 2015; Kabali *et al.*, 2015). Many parents and educators are hopeful that these interactive forms of technology will benefit children (Christakis, 2014), although concern remains that the time devoted to these devices may displace opportunities for other forms of learning (Radesky, Schumacher, & Zuckerman, 2015).

Thus far, scholars have not explored whether mobile device use is related to young children's effortful control (EC), a temperament-based type of self-regulation that is linked

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with a wide range of developmental outcomes. The current study explored the relation between the use of two forms of mobile media (tablets and hand-held games) and EC among 3- to 5-year-olds. In addition, we aimed to identify individual differences in the relation between mobile media use and EC. Building on the findings from our prior work (Nathanson & Beyens, 2016), which uncovered a negative association between 3- to 5-year-olds' tablet use and their sleep quality, we examined the role of sleep as a mediator and moderator of the relation between device use and EC.

Tablets, hand-held game players, and effortful control

Temperamental EC is a form of self-regulation that refers to a child's proclivity for inhibiting impulses, planning, and regulating attention (Eisenberg *et al.*, 2004). Children with strong EC enact goals to drive behaviours rather than rely on pre-potent reactions to stimuli. As a result, EC is viewed as a measure of voluntary, rather than reactive, control (Spinrad *et al.*, 2007). Moreover, children with strong EC can focus and sustain attention and, when necessary, easily shift their attention from one task to another. Consequently, measures of EC typically involve assessments of both inhibitory and attentional control (Eisenberg *et al.*, 2009). EC is similar to executive function (EF), another dimension of self-regulation (Zhou, Chen, & Main, 2012). Whereas EC is considered a type of temperament, EF has been studied as a form of neuropsychological functioning that is linked with working memory in addition to inhibitory control, attentional focusing, and attentional flexibility (Blair & Razza, 2007; Miyake *et al.*, 2000; Pennington & Ozonoff, 1996). Children with better self-regulation skills, whether in the form of EC or EF, have a higher likelihood of engaging in desirable everyday behaviours, such as following directions and turn-taking (Rhoades, Greenberg, & Domitrovich, 2009), and they enjoy greater success in both academic and social contexts (Kopp, 1982).

Although the development of self-regulation is linked with growth in the brain's pre-frontal cortex, the course of its evolution can be shaped by environmental features (Bernier, Carlson, Deschênes, & Matte-Gagné, 2012; Li-Grining, 2007; Zelazo & Carlson, 2012). Relatively few studies have explored whether children's media exposure is related to their self-regulation. This is surprising since (1) children are regularly exposed to media throughout their development; and (2) self-regulation is intimately connected to the kinds of social, academic, and behavioural outcomes that are often the focus of scholarship on media effects among children.

Some work has explored these associations among infants. For example, Radesky, Silverstein, Zuckerman, and Christakis (2014) examined the links between media exposure and infant self-regulation (e.g., self-soothing behaviours, mood regulation) and found that infants with greater self-regulation difficulties watched more television over 1 year later. This finding supports Thompson, Adair, and Bentley's (2013) finding that mothers are more likely to provide media to fussy or challenging infants.

Some research with older children has explored the links between television exposure and types of EC, such as task persistence, impulse control, and attention problems. Christakis (2009) explained that early exposure to fast-paced television may deprive children from experiences in which focused attention and deep processing are required and can train developing brains to expect the pace of real life to mimic the pace of television content. However, this work has produced mixed findings, from positive to negative to null associations between child television viewing and these EC-related outcomes (Anderson, Levin, & Lorch, 1977; Friedrich & Stein, 1973; Friedrich-Cofer, Huston-Stein, Kipnis, Susman, & Clewett, 1979; Zimmerman & Christakis, 2007).

Other research has investigated television exposure as a correlate or predictor of EF. This work has shown that heavy television viewing is related to weaker EF among young children, although relations sometimes vary according to what children view (Barr, Lauricella, Zack, & Calvert, 2010; Lillard, Drell, Richey, Boguszewski, & Smith, 2015; Lillard & Peterson, 2011; Linebarger, Barr, Lapierre, & Piotrowski, 2011; Nathanson, Aladé, Sharp, Rasmussen, & Christy, 2014). In explaining the positive associations observed in their work, Lillard *et al.* (2015) proposed that young children become cognitively overwhelmed by fast-paced, fantasy television content – an argument that could also describe children's reactions to tablet and gaming content. Nathanson *et al.* (2014) suggested that television programmes operate like an attention-directing parent, preventing children from processing stimuli they find interesting and requiring them to continually shift their attention to keep up with the programme.

Tablets and EC

While some evidence has been accumulating concerning the association between television viewing and aspects of children's self-regulation, it remains unclear as to whether exposure to tablets is related to young children's self-regulation as well. This is an important gap in the literature, as tablet use is common among children (Common Sense Media, 2013; Cristia & Seidl, 2015; Kabali *et al.*, 2015). Since tablets can stream the same programmes that appear on television, we might expect that tablets and televisions will share similar relations with self-regulation.

However, tablets and televisions differ in important ways. First, tablets afford more interactivity compared to televisions (Christakis, 2014). Content shown on tablets can be easily paused, replayed, or otherwise tailored to suit the needs of the user, providing children with opportunities to exercise user control. In addition, children can interact with tablets, thereby engaging in planning and decision-making (Lee, 2015). When tablets respond to children's needs and adjust content accordingly, children may gain confidence in their ability to control their environment. In this way, tablets may allow children to practise self-regulation skills.

Second, tablets are portable and may be used for short periods in a variety of settings. Parents may supply tablets to young children in situations that would otherwise challenge children's patience (e.g., at a restaurant; Bentley, Turner, & Jago, 2016; Radesky *et al.*, 2015). Children who use tablets in these settings may miss out on common opportunities to exercise their attentional focusing skills (Radesky *et al.*, 2015). In addition, tablets may provide additional stimulation in already high-stimulation environments, possibly overwhelming children's cognitive resources. Finally, because of their portability, tablets may be used, put away, and offered again, providing children with a series of short play periods that are initiated and terminated by the parents. Under these circumstances, tablet exposure may reflect an entertainment experience that is parent-controlled and which deprives children of opportunities for thoughtful engagement with media content.

For these reasons, we cannot assume that the relation between tablet exposure and child outcomes will mimic that between television and child outcomes. Moreover, rationales can be built to predict both positive and negative associations with exposure. We investigated two competing hypotheses in order to understand the relation between tablet use and EC: either that tablet use will be related to weaker EC among 3- to 5-year-olds (H1a); or that tablet use will be related to stronger EC among 3- to 5-year-olds (H1b).

Hand-held game players and EC

Video gaming, in general, has been studied for decades, but little work has considered its association with self-regulation among young children. Although the concept of self-regulation is present in this literature, it is typically conceptualized differently. For example, poor self-regulation is often discussed as a marker of gaming addiction among adolescents and adults (LaRose, Lin, & Eastin, 2003).

Other work has explored the effects of video games on the cognitive performance of adults and children (Barlett, Vowels, Shanteau, Crow, & Miller, 2009; Boot, Kramer, Simons, Fabiani, & Gratton, 2008). The results of this work have been mixed, since video game use is associated with both worse academic performance and advanced cognitive skills among older children and adults, including aspects of EF (Bavelier *et al.*, 2011; Kuhn, Gleich, Lorenz, Lindenberger, & Gallinat, 2014). Sometimes video games are used to improve users' attentional focusing and cognitive flexibility. For example, computer games have been used as interventions to improve eight- to 12-year-old children's EF (Dovis, Van der Oord, Wiers, & Prins, 2015). These positive outcomes may be observed because game players must develop goals, exercise working memory, engage in impulse control, and use perspective-taking. In addition, when games are played as teams with partners, users gain experience with collaboration and turn-taking (Ulicsak & Cranmer, 2010).

Video game research has largely focused on stationary systems (e.g., Barlett *et al.*, 2009; Boot *et al.*, 2008; Dovis *et al.*, 2015), but hand-held games are worth studying as well. Hand-held games are a distinct and popular type of media device in which players use a small console that contains both the controls and the screen displaying game content. These devices are self-contained in that they do not connect to a larger screen (e.g., a television), thereby permitting users to play the games in any location (e.g., Nintendo DS, Sony PlayStation Portable). The experience of playing a hand-held game is distinct from playing on a stationary system, especially among young children. For example, hand-held device use may be more sporadic, with parents providing children with devices within short windows of time and then withdrawing them just as often. Using hand-held devices in this manner may undermine any benefits that game playing delivers.

As with tablets, the relation between hand-held game players and young children's EC has not been investigated thus far. We advanced competing hypotheses to explore the relation between hand-held game player use and EC: either that hand-held game player use will be related to weaker EC among 3- to 5-year-olds (H2a); or that hand-held game player use will be related to stronger EC among 3- to 5-year-olds (H2b).

Sleep as a mediator of the mobile electronic device-effortful control relation

We also examined sleep as a possible mediator of the relation between mobile device use and EC. It is well documented that using screen media before bedtime is associated with poorer sleep outcomes among children and adolescents, such as staying up too late and experiencing daytime fatigue (Cain & Gradisar, 2010; Garrison, Liekweg, & Christakis, 2011; Hale & Guan, 2015). Research on adolescents also indicates that using mobile electronic devices at bedtime is related to more impaired sleep (Kubiszewski, Fontaine, Rusch, & Hazouard, 2014) and might be a more potent source of disruption compared with television (Bartel, Gradisar, & Williamson, 2015), although the results may depend on how children engage with media (Cain & Gradisar, 2010).

Although lack of sleep is not related to overall intelligence, sleep deprivation is associated with greater attention problems among children (Paavonen, Porka-Heiskanen,

& Lahikainen, 2009) and weaker cognitive performance and EF among five- to 12-year-old children (Astill, Van der Heijden, Van Ijzendoorn, & Someren, 2012). If mobile device use is related to poorer sleep quality, then these devices may be indirectly related to EC via sleep. There is precedent for examining this relation in other work, as Nathanson and Fries (2014) tested a similar type of model in their study of 3- to 5-year-olds and television. Nathanson and Fries (2014) found that 3- to 5-year-olds' television exposure was related to fewer sleep hours which, in turn, predicted weaker theory of mind. The authors did not find a similar indirect relation when they examined EF as an outcome; however, they only examined children's total sleep time (nighttime plus nap time). The current study also examined indirect associations, utilizing a greater variety of sleep measures and focusing on young children's EC instead.

We explored whether tablet use is indirectly related to young children's EC via indicators of sleep quality that are typically associated with children's media use and self-regulation, including their bedtimes, bedtime resistance, hours of sleep, and daytime sleepiness. In our prior paper, we found that evening tablet use was uniquely related to sleep variables, compared with other media forms (Nathanson & Beyens, 2016). As a result, we explored whether 3- to 5-year-old children's EC was ultimately implicated in the negative relation between tablet use and sleep quality. We predicted that evening tablet use would be indirectly related to 3- to 5-year-olds' EC via sleep quality. More specifically, we expected that evening tablet use would be related to worse sleep quality and that poor sleep quality, in turn, would be related to weaker EC (H3). Because we did not previously find any relations between hand-held game player use and sleep (Holmes, Kim-Spoon, & Deater-Deckard, 2016), we did not advance any predictions about the indirect association between game use and EC via sleep.

Sleep as a moderator of the mobile electronic device-effortful control relation

In addition, sleep may moderate the relation between young children's mobile device use and EC. Prior work has found that the amount of sleep infants and young children accrue shapes how they respond to environmental influences (Berger, Miller, Seifer, Cares, & LeBourgeois, 2012; Bernier, Bélanger, Tarabulsy, Simard, & Carrier, 2014). During sleep, memories are consolidated, unnecessary synaptic connections established during the daytime are pruned, and the neural networks supporting sustained attention are maintained, contributing to better cognitive function (Astill *et al.*, 2012). As Bernier *et al.* (2014) explained, children who lack adequate sleep may be less able to profit from productive environments and will thereby experience less positive outcomes compared to children with better sleep experiences. For example, Bernier *et al.* (2014) found that mothers' sensitive parenting was predictive of better EF only among infants who experienced more sleep at night.

In the same way, mobile media devices may be used and experienced differently by children who get less sleep. Perhaps these children are less able to use strategies to engage with these devices and instead become relatively passive receivers rather than active users. Similarly, sleep-deprived children may be more vulnerable to any negative aspects associated with using these devices. For example, tablets and game players may weaken sleep-deprived children's already diminished attentional capacities by providing highly stimulating content that becomes distracting rather than providing opportunities for thoughtful engagement.

Alternatively, parents may provide certain types of media to children with specific sleep profiles and temperament. Parents may find that well-rested children with easier temperaments are most satisfied by game players (which require more sustained attention) and that sleepy children with weaker self-regulation are entertained by tablets. Although we could not investigate the causal relations among mobile media use, sleep, and EC, we nevertheless expected to find that sleep would moderate the relation between mobile media use and EC among young children. More specifically, we predicted that the number of hours slept at night would moderate the relation between 3- to 5-year-olds' EC and their tablet use (H4); and between their EC and hand-held game player use (H5).

Method

Participants and procedures

Survey data from a national sample of 402 mothers of 3-, 4-, and 5-year-old children (*M* = 4.0, *SD* = 0.80; 52% male) in the United States were collected for this study. Respondents were recruited through a national panel company and were required to meet several eligibility criteria, which included being the mother of a 3- to 5-year-old child who was not born prematurely, weighed at least 5 pounds at birth, who had not been diagnosed with a serious congenital anomaly or significant birth defect, and who did not experience any major trauma during delivery. Ethical approval for conducting this empirical work was provided by the author's institution.

Participants completed a 20-min online survey. On average, the participating mothers were 34.5 years old (*SD* = 8.7). Most mothers reported their ethnicity as Caucasian (80%), followed by African American (7%), Hispanic (6%), Asian or Pacific Islander (4%), multiracial (2%), and Native American (0.5%). Most mothers were married or cohabitating (80%) and 43% worked outside of the home. On average, participants had received some college education (*M* = 3.50, *SD* = 1.28, where response options ranged from *less than high school* [coded as 1] to *graduate degree* [coded as 6]). Average annual household income ranged between $25,000 and $49,999 (*M* = 4.26, *SD* = 1.39, where response options ranged from '*less than $10,000'* [coded as 1] to '*$25,000 and $49,000*' [coded as 4] to '*$200,000 or more'* [coded as 8]). On average, children attended a childcare provider 2 days per week (*M* = 2.59, *SD* = 2.22).

Measures

Children's mobile device use

Participants reported how many hours their child uses a *tablet* on a typical weekday and on a typical weekend day during the morning ('from the time the child awakens until lunch time'), the afternoon ('between lunch and dinner time'), and the evening ('between dinner and bedtime'), for a total of six questions. Participants were provided with a list of 12 30-min increments of time to respond to the questions (e.g., 'not at all', '1.5 hr'). Responses were translated into minutes and total exposure time scores for weekdays and weekends were created by summing across the responses from each daypart. We multiplied the sum for the weekday use by 5 and the sum for the weekend use by 2. These two products were summed and divided by 7 to produce average daily tablet use. Children's *hand-held game player use* was measured and calculated in the same way that tablet use was measured, producing an estimate of average daily hand-held game player use. Children's average *evening tablet use* was calculated by (1) multiplying weekday evening use, in minutes, by 5; (2) multiplying weekend evening use, in minutes, by 2; and (3) summing the resulting products together and dividing by 7. Children's *evening* *hand-held game player use* was calculated in the same way that evening tablet use was calculated. All mobile device use scores were converted into average use in hours to be included in the analyses.

Children's sleep behaviours

We assessed children's sleep quantity and quality. Sleep quantity assessments were based on participant reports of the time that their child *goes to bed* in the evening and awakens in the morning. We calculated *total sleep time*, in hours, by subtracting bedtime scores from wake-time scores. Since parents are typically keenly aware of their children's schedules, parent estimates of bedtime and wake time are regarded as accurate and useful (Sadeh, 1996). In fact, parent reports of bedtime and wake time are used in conjunction with highly regarded actigraphy (activity-based monitoring) assessments in which sleep behaviours are derived from data provided by wristbands worn by the child overnight (Markovich, Gendron, & Corkum, 2015). Dimensions of sleep quality were assessed with the Children's Sleep Habits Questionnaire (CSHQ; Owens, Spirito, & McGuinn, 2000). The CSHQ is widely used in both academic and clinical research to assess children's sleep quality (Markovich *et al.*, 2015). Although its utility in diagnosing disordered sleep among children has been challenged (Markovich *et al.*, 2015), other work has demonstrated that the measure has good reliability and validity in distinguishing children without sleep disorders and those seeking help for possible sleep disorders (Owens *et al.*, 2000) and that CSHQ scores are correlated with actigraphy assessments (Veatch *et al.*, 2015). We employed three subscales of the CSHQ that Owens *et al.* (2000) found to have particularly strong internal inconsistency compared to the other subscales: *bedtime resistance* (six items; e.g., 'my child struggles at bedtime'), *sleep duration* (three items; e.g., 'my child sleeps too little'), and *daytime sleepiness* (eight items; e.g., 'my child takes a long time to be alert'). Sleep behaviours were rated on a 3-point scale including 1 ('*rarely [0 to 1 time per week]*'), 2 ('*sometimes [2 to 4 times per week]*'), and 3 ('*usually [5 to 7 times per week]*'). Responses were summed to create scales for bedtime resistance, $\alpha = .78$, sleep duration, $\alpha = .74$, and daytime sleepiness, $\alpha = .68$, with higher scores indicating parent perceptions of greater sleep difficulty.

Children's EC

Questions from the short form of the Early Childhood Behavior Questionnaire (ECB; Putnam, Gartstein, & Rothbart, 2006) were used to assess temperamental EC. The ECB is designed to measure aspects of temperament, including EC. Like Eisenberg *et al.* (2009), we measured attentional focusing (nine items, e.g., 'when picking up toys or other jobs, my 3–5-year-old child usually keeps at the task until it's done'), attentional shifting (five items, e.g., 'my 3–5-year-old child can easily shift from one activity to another'), and inhibitory control (13 items, e.g., 'my 3–5-year-old child is usually able to resist temptation when told s/he is not supposed to do something') to assess EC. On a scale from 1 (extremely untrue of my child) to 7 (extremely true of my child), participants rated how often they had observed their child engaged in the target behaviour within the past 6 months. Responses were averaged to create scales of attentional focusing, attentional shifting, and inhibitory control, with some questions requiring reverse coding. Following Cipriano and Stifter's (2010) procedures, we created a composite EC score by weighting each scale according to its total number of items and then summing the three products together. Composite scores are recommended and commonly used (Allan & Lonigan, 2011; Belfort *et al.*, 2016; Sulik, Blair, Mills-Koonce, & Greenberg, 2015; Tandon, Thompson, Moran, & Lengua, 2015), as they increase scale reliability, reduce random error, and provide parsimony (Holmes *et al.*, 2016; Rushton, Brainerd, & Pressley, 1983). Higher scores indicated stronger EC, $\alpha = .83$.

Covariates

We controlled for the child's age, the child's sex (1 = boy, 2 = girl), the mother's employment status (1 = employed, 2 = not employed), the number of days the child attends childcare, the mother's education, and the household income. In addition, we controlled for children's overall television viewing and evening television viewing so that we could assess the unique contributions of tablets and hand-held game players to EF. Parents reported their children's television viewing in the same way that tablet use and hand-held game player use were reported. Television viewing scores were converted into hours to be included in the analyses.

Analyses

To explore the hypothesized relations between EC and tablets (H1) and hand-held game players (H2), we conducted a multiple regression analysis. The first model included the covariates. The second model contained the media variables. An alpha level of .05 was used for this statistical test.

To examine the role of sleep as a mediator (H3) and moderator (H4, H5) of the relation between mobile device use and EC, we used PROCESS, a computational tool for SPSS (Hayes, 2013). The PROCESS SPSS macro uses linear regression analysis to test mediated and moderated relationships and uses bootstrap samples to generate estimates of mediation. To examine the mediated relationships, we conducted five different analyses, one for each sleep variable (bedtime, total sleep time, bedtime resistance, sleep duration, daytime sleepiness), using 5,000 bootstrap samples to generate bias-corrected bootstrap confidence intervals. All of the mediation analyses identified evening tablet use as the independent variable, the sleep variable as the mediator variable, and EC as the dependent variable, and included the covariates.

To examine the moderated relationships, we conducted two different analyses, one for tablet use and one for hand-held game player use. All of the moderation analyses included the interaction term between either tablet use or hand-held game player use and sleep hours, identified EC as the dependent variable, and included the covariates. The interactions were probed using the Johnson-Neyman technique (Bauer & Curran, 2005; Hayes, 2013) to determine at which levels of sleep time the relations between EC and tablet use and hand-held game playing were statistically significant. We used 95% confidence intervals to investigate the mediated and moderated relationships. Estimates are significant at the .05 level when the 95% confidence interval (CI) did not contain 0.

Results

Descriptive statistics

On average, children spent approximately 1 hr and 24 min a day using a tablet computer ($M = 84.15$ min, $SD = 126.69$; Median = 36.43 min, IQR = 120.00), with almost 25 min in the evening ($M = 23.46$ min, $SD = 39.78$; Median = 0.00 min, IQR = 30.00). Half of the children used a tablet for <36.43 min a day, one in four used a tablet between 36.43 min and 2 hr a day, and another quarter used a tablet for more than 2 hr a day. In addition, on average, children spent approximately half an hour using a hand-held game player a day (M = 35.34 min, SD = 83.61; Median = 0.00 min, IQR = 30.00), with almost 10 min in the evening (M = 8.88 min, SD = 23.43; Median = 0.00 min, IQR = 0.00). Almost three in four children never used a game player, and one in three children used a game player for more than 30 min a day. Moreover, on average, children watched television for approximately 3 hr and 48 min a day (M = 228.15 min, SD = 158.42; Median = 192.86 min, IQR = 171.43), with approximately 1 hr and 15 min in the evening (M = 76.77 min, SD = 63.15; Median = 60.00 min, IQR = 81.43). One in four children watched <2 hr of television a day, another quarter watched between 2 and 3 hr, and half of the children watched more than 3 hr a day.

Only a few parents reported that their child went to bed before 18:00 (0.5%) or between 18:00 and 19:00 (0.7%) in the evening. One in seven parents reported that their child went to bed between 19:00 and 20:00 (14.9%), 36.1% between 20:00 and 21:00, 29.4% between 21:00 and 22:00, 12.9% between 22:00 and 23:00, and 6% after 23:00. One percentage of parents reported that their child woke up between 04:00 and 05:00 in the morning, and 3% between 05:00 and 06:00. Almost one in four parents reported that their child woke up between 06:00 and 07:00 in the morning (24.4%), 36.6% between 07:00 and 08:00, 21.1% between 08:00 and 09:00, 9.2% between 09:00 and 10:00, 2.7% between 10:00 and 11:00, and 2% after 11:00. These bedtimes and wake times are similar to those reported in prior research (Yuwen *et al.*, 2016). On average, children slept for approximately 10 hr and 40 min each night (M = 10.66 hr, SD = 1.02; Median = 11.00 hr, IQR = 1.00). With respect to children's sleep quality, parents indicated that, on average, children rarely experienced bedtime resistance (M = 9.21, SD = 3.02; Median = 8.00, IQR = 4.00), compromised sleep duration (M = 4.15, SD = 1.45; Median = 4.00, IQR = 2.00), or daytime sleepiness (M = 11.33, SD = 2.58; Median = 11.00, IQR = 4.00). Almost one in four parents indicated that their child at least sometimes (2–4 times per week) experienced bedtime resistance (22.9%), approximately two in 10 parents indicated that their child at least sometimes experienced compromised sleep duration (18.4%), and 7.2% of parents indicated that their child at least sometimes experienced daytime sleepiness.

Finally, on average, parents indicated that children's EC was at about the mid-point of the scales, suggesting neutral to slight agreement with the items (attentional focusing, M = 4.53, SD = 0.94; Median = 4.56, IQR = 1.22; attentional shifting, M = 4.25, SD = 0.99; Median = 4.20, IQR = 1.20; inhibitory control, M = 4.62, SD = 0.93; Median = 4.62, IQR = 1.15; and composite EC, M = 4.52, SD = 0.83; Median = 4.52, IQR = 1.07). More than one in three parents rated their child's attentional focusing behaviours (34.9%) and attentional shifting behaviours (37.9%) to be slightly to extremely true, and six in 10 parents rated their child's inhibitory control to be slightly to extremely true (60.1%).

Hypothesis testing

The correlations among all key variables are included in Table 1.

H1 and H2 focused on the association between EC and tablets and hand-held game players, respectively. In the first model of the regression analysis, the child's age (β = .18, p < .001) and income level (β = .16, p = .003) were significantly related to EC. Older children and children in households with higher income had relatively stronger EC. The

Table 1. Zero-order correlations among all measures

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
1. Child's age	—	.03	.22***	.00	.05	−.03	−.08	.04	.06	−.03	.01	.05	.03	−.14**	−.05	$.09^{+}$	.18***
2. Child's sex		—	−.01	$-.09^{+}$	.05	−.04	.02	−.05	−.01	.04	$-.09^{+}$	−.04	.05	.04	−.01	.01	.09
3. Childcare attendance			—	−.34***	.11*	.12*	−.07	.08	.02	−.01	$.10^{+}$	.08	−.18***	−.01	.02	.28***	.03
4. Maternal employment				—	−.26***	−.28***	.01	−.10*	$-.09^{+}$	−.04	−.10*	−.08	$.09^{+}$	−.01	−.02	−.23***	−.10*
5. Household income					—	.44***	−.14**	.03	.09	−.11*	.05	.13*	−.04	−.07	−.02	.01	.23***
6. Maternal education						—	−.15**	−.01	$.08^{+}$	−.14**	−.01	$.09^{+}$	−.03	−.06	.00	−.01	.17**
7. Television viewing							—	.23***	.15**	.86***	.23***	.12*	.02	.20***	.19***	.21***	−.13**
8. Game player use								—	.11*	.22***	.82***	.06	.00	$.08^{+}$	.05	.17**	.11*
9. Tablet use									—	.11*	$.10^{+}$	.83***	−.06	.17***	.16**	.16**	−.07
10. Evening television viewing										—	.25***	.14**	−.07	.21***	.19***	.24***	$-.10^{+}$
11. Evening game player use											—	.08	−.03	.05	.11*	.17**	.07
12. Evening tablet use												—	−.11*	.18***	.15**	.16**	−.05
13. Sleep time													—	−.17**	−.23***	−.15**	$.09^{+}$
14. Bedtime resistance														—	.41***	.23***	−.19***
15. Sleep duration															—	.28***	−.27***
16. Daytime sleepiness																—	−.18***
17. Effortful control																	—

Notes. $^{+}p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

first step of the regression equation explained 8% of variance in EC. In the second model, all of the media variables contributed an additional 4% of variance, with television viewing holding a negative association ($\beta = -.10$, $p = .045$). Tablet use was negatively related to EC ($\beta = -.11$, $p = .029$), but hand-held game player use was positively related to EC ($\beta = .14$, $p = .004$). Consequently, overall tablet use was related to relatively worse EC and hand-held game player use was related to relatively better EC.

H3 predicted that evening tablet use would be related to more sleep disturbances which, in turn, would predict relatively weaker EC. We found that evening tablet use was significantly associated with children's EC via (1) their bedtimes (point estimate = −.0008; bias-corrected bootstrap 95% CI = −.0015 to −.0002); (2) bedtime resistance (point estimate = −.0005; bias-corrected bootstrap 95% CI = −.0011 to −.0001); and (3) sleep duration (point estimate = −.0007; bias-corrected bootstrap 95% CI = −.0014 to −.0002) (see Table 2). Evening tablet use was related to later bedtimes, more bedtime resistance, and worse sleep duration. Each sleep variable was, in turn, related to weaker EC. Children's total sleep time and daytime sleepiness were not significant mediators.

H4 and H5 predicted that the relations between tablet use (H4) and hand-held game player use (H5) and EC would be moderated by children's total sleep time. We found

Table 2. Mediation of the relation between evening tablet use and children's temperamental effortful control via sleep disturbances

			95% CI	
	Point estimate	*SE*	Lower	Upper
Bedtime				
Direct effects	−.0009	0.0011	−0.0030	0.0012
Indirect effects	−.0008	0.0003	−0.0015	−0.0002
Total effects	−.0017	0.0010	−0.0037	0.0003
Bedtime resistance				
Direct effects	−.0012	0.0010	−0.0032	0.0008
Indirect effects	−.0005	0.0002	−0.0011	−0.0001
Total effects	−.0017	0.0010	−0.0037	0.0003
Sleep duration				
Direct effects	−.0010	0.0010	−0.0030	0.0009
Indirect effects	−.0007	0.0003	−0.0014	−0.0002
Total effects	−.0017	0.0010	−0.0037	0.0003
Total sleep time				
Direct effects	−.0016	0.0010	−0.0036	0.0004
Indirect effects	−.0001	0.0001	−0.0005	0.0000
Total effects	−.0017	0.0010	−0.0037	0.0003
Daytime sleepiness				
Direct effects	−.0013	0.0010	−0.0033	0.0007
Indirect effects	−.0004	0.0003	−0.0011	0.0000
Total effects	−.0017	0.0010	−0.0037	0.0003

Note. Analyses are based on 5,000 bootstrap samples and control for the child's age, the child's sex, the child's typical evening television viewing time, childcare attendance, maternal education, maternal employment, and household income. CI = confidence interval; an estimate is significant at the .05 level if the 95% CI does not contain 0.

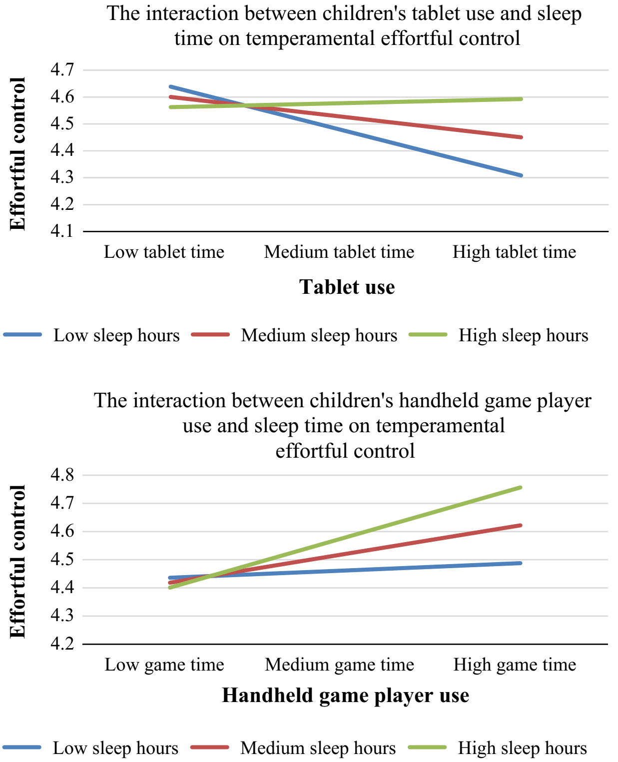

Figure 1. The interactions between children's mobile electronic device use (tablet use, hand-held game player use) and sleep time on temperamental effortful control. *Note.* All analyses were performed via PROCESS (Hayes, 2013). Both interactions were significant (for tablet use, coeff = .0007, 95% CI = 0.0001–0.0013; for game player use, coeff = .0009, 95% CI = 0.0001–0.0017). Analyses control for the child's age, the child's sex, the child's typical television viewing time, childcare attendance, maternal education, maternal employment, and household income. [Colour figure can be viewed at wileyonlinelibrary.com]

significant interactions in both cases (Figure 1). The negative relation between tablet use and EC was only significant when children received less sleep (coeff = .0007, 95% CI = 0.0001–0.0013). Conversely, the positive association between hand-held game playing and EC was only significant when children slept for a greater number of hours (coeff = .0009, 95% CI = 0.0001–0.0017).

Johnson-Neyman significance regions showed that sleep time significantly moderated the relation between tablet use and EC at sleep time scores below 10.61 hr. When children slept < 10.61 hr, the relation between tablet use and EC was significantly negative. This was the case for 40.40% of the children in our sample. When children slept 10.61 hr or more, no significant relationship between tablet use and EC was observed. For hand-held game playing, Johnson-Neyman significance regions showed that sleep time significantly moderated the relation with EC at sleep time scores higher than 10.42. When children got more than 10.42 hr of sleep, the relation between hand-held game playing and EC was significantly positive (59.60% of the children in our sample). When children slept 10.42 hr or less, no significant relation between hand-held game playing and EC was observed.

Discussion

The purpose of our study was to understand whether young children's EC is related to time spent with tablets and hand-held game players. To date, relatively little work has considered the association between self-regulation and media use among children, despite the fact that self-regulation is intimately connected with many outcomes that media effects scholars investigate, including aggression (Utendale & Hastings, 2011), prosocial behaviour (Rhoades *et al.*, 2009), learning (Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009), and academic performance (McClelland *et al.*, 2014). Although some work has explored the relations between television exposure and EF (Lillard *et al.*, 2015) or infant self-regulation (Radesky, Kistin, *et al.*, 2014), there is a particular dearth in knowledge concerning media exposure's role in young children's temperamental EC. Our study's first contribution is to add to the small literature on media effects and self-regulation by documenting that time spent using tablets and hand-held game players is related to EC. However, the nature of these relations depended on children's sleep.

There was a significant and negative relation between young children's tablet time and their EC, but only among children who received <10.61 hr of sleep at night. In our study, this reflected about 40% of children. In addition, time with hand-held game players was positively related to EC only when children experienced more than 10.42 hr of nightly sleep (which applied to about 60% of our sample). According to the National Sleep Foundation (retrieved April 22, 2016), 3- to 5-year-olds require between 11 and 13 hr of nightly sleep. Our results suggest that sufficient sleep is an important variable in understanding the association between mobile media exposure and EC.

Because our study was cross-sectional, two explanations for this pattern of results are possible. First, it is possible that children who fall below their minimum threshold for sufficient sleep may be more vulnerable to the negative effects of tablet devices and those who approach or exceed the threshold can benefit from exposure to hand-held gaming devices. According to Bernier *et al.* (2014), children who receive adequate sleep can capitalize on the influence of positive parenting techniques. These children may be more cognitively adept and emotionally steady, thereby increasing their ability to absorb positive influences. Lack of sleep may reduce children's resilience to negative environmental influences. In addition, it may be that sleep-deprived children use tablets differently (perhaps in a more fragmented or passive manner) or respond distinctly to tablet features. Similarly, children may not experience benefits from playing with hand-held games unless they receive adequate sleep. The mental clarity that comes from meeting sleep needs may enable children to deeply engage with the games, develop goals, and practise skills that will benefit self-regulation.

The second plausible explanation for our results is that parents are more likely to supply sleep-deprived children who have weaker EC with tablet devices. Likewise, parents may be more inclined to provide 'easier' children (i.e., with higher EC) who also get adequate rest with hand-held gaming devices. It is not clear why parents would supply different forms of mobile devices to children with different characteristics. Perhaps tablets provide a greater variety of options, including both passive and active media consumption, that can better adapt to a challenging child's needs. In fact, there is evidence that parents do increase media exposure in response to challenging child behaviours (e.g., Radesky, Peacock-Chambers, Zuckerman, & Silverstein, 2016; Thompson *et al.*, 2013). In a qualitative study, Bentley *et al.* (2016) found that mothers used television programmes and mobile devices to soothe and calm children and to prevent unwanted behaviour. Since tablets, like television, can also show videos, perhaps they are perceived as conducive to soothing sleep-deprived children with weaker EC compared with other forms of media. Hand-held games, however, require sustained attention and alertness; as a result, parents may note that this entertainment form engages and pleases children who are well rested and who are already skilled at enacting goal-directed behaviour. This line of reasoning suggests that, through experience, parents learn that certain forms of media appropriately engage and satisfy children with distinct needs, leading parents to provide that form of media to their children.

We encourage future work to explore the inter-relations among young children's mobile media use, sleep, and indicators of self-regulation, like EC and EF. Longitudinal work would provide valuable information about the causal direction of these associations. In addition, observational work would greatly enhance our understanding of how mobile media are used by children. Perhaps young children, especially ones who are sleep-deprived, experience tablets in a manner that mimics their experiences with television. Children may not take advantage of the affordances inherent to the tablet platform (or may be unable to without parental assistance) and use tablets passively. Or, because tablet applications – even educational ones – may contain extraneous features, such as animation, graphics, and sound, that are not central to the application's focus, perhaps young children become distracted by these content-irrelevant features, thereby preventing them from meaningfully engaging with the material for an extended period. Finally, perhaps young children's tablet use consists primarily of short segments of time, experienced in settings that are counterproductive to learning. Some scholars note that repeated exposure to media content that is fast-paced and overstimulating is associated with attention problems (Christakis, Zimmerman, DiGiuseppe, & McCarty, 2004; Zimmerman & Christakis, 2007), which are closely related to EC.

Overall, although these findings provide evidence that 3- to 5-year-olds' EC is related to the amount of time they spend with particular types of mobile devices, they also reveal the importance of considering children's sleep as a moderator of these associations. Studies of media uses and effects among children rarely consider the potential role of children's sleep, despite its importance to child development. We encourage future work on children's media uses and effects to investigate the role that children's sleep plays.

Our study's second contribution involves identifying one evidence-based explanation for why tablet use is related to children's EC. Children with later bedtimes, heightened bedtime resistance, and problematic sleep duration had higher evening tablet use. Moreover, each of these indicators of disrupted sleep was related to weaker EC.

The sleep variables that mediated the tablet-EC relation in this study may reflect more disorganized, less consistent, or chaotic bedtime routines. In contrast, the total amount of sleep and whether the child experienced fatigue were not significant mediators. Perhaps it is the relative chaos that surrounds bedtime, in part prompted by or at least marked by higher tablet use, that contributes to weaker EC. Other research, in fact, has found that children who live amidst household chaos have lower self-regulation scores compared with other children (Vernon-Feagans, Willoughby, & Garrett-Peters, 2016). Alternatively, it could be that families with individuals with lower EC have more difficulty creating structure and routine, which manifests in more household chaos, including increased screen exposure among family members. Regardless of the direction of causality, future work might consider the possible connection between family routines, including rituals surrounding bedtime, and media use. These explanations are purely speculative and intended to guide continued work.

Limitations

There are several limitations of this study. First, this study was cross-sectional and therefore we cannot make any inferences about the causal relations between mobile device use and EC. This is a very significant point to consider since individual differences can cause distinct media exposure patterns (Valkenburg & Peter, 2013). As noted earlier, it is plausible that parents are more likely to (1) provide tablet devices to children with sleep issues and weaker EF; and (2) give hand-held game players to children with better EF who get adequate sleep. Consequently, we cannot claim that mobile device use caused child outcomes. Rather, we can only assert that they are related. Most likely, following recent media effects theories, the inter-relations are reciprocal (Slater, 2007; Valkenburg & Peter, 2013).

Second, we cannot ascertain whether certain types of content are better or worse for EC. There can be great variability in the type of content children encounter via mobile devices. Future work should explore how the relations between EC and mobile device use vary according to the content that is experienced. Similarly, it will be important for future work to assess not just tablet exposure (as we did), but also what children are doing with their tablets (e.g., game playing, watching videos). The variability in the nature of tablet activity might help explain the associations between exposure and outcomes.

Third, we did not have measures of other variables that might explain the relations among media exposure, sleep, and EC. These variables can include parent factors (e.g., parenting strategies, parental self-regulation), child factors (e.g., ADHD symptomology), and household factors (e.g., household chaos). Moreover, these other factors are indicative of other problems that can contribute to either higher media exposure, weaker EC, or both. For example, household chaos is related to lower socio-economic status, poorer housing conditions, reduced availability of educational resources (e.g., books), and reduced cognitive performance and conduct among children (Deater-Deckard *et al.*, 2009; Pike, Iervolino, Elay, Price, & Plomin, 2006). Future research should incorporate these other factors to determine the extent to which media use is uniquely related to sleep and EC, with these other factors controlled.

Fourth, our data are based on parent reports of children's behaviours, which are likely biased. For example, since tablets and hand-held game players can be used in a variety of settings and often for short periods of time, parents may struggle to accurately report their child's exposure time. Moreover, parents may be reluctant to report undesirable child behaviours (e.g., excessive media use, impulsivity) in an effort to provide socially desirable responses. Observational or time diary data may provide superior assessments of children's mobile media use and EC.

In addition, parent reports of children's sleep behaviours are suspected to overestimate sleep quantity and quality (Diaz *et al.*, 2016). Although parent reports of sleep behaviours are pervasive in the literature (and the CSHQ is particularly prevalent in both academic and clinical work, Markovich *et al.*, 2015), there is growing demand to utilize more objective forms of measurement, such as actigraphy, to capture children's sleep quality (Diaz *et al.*, 2016). Even so, actigraphy involves the subjective reports of a child's bedtime and wake time, which Sadeh (1996) found were accurate. The gold standard assessment of sleep behaviours comes from polysomnography (PSG; De Weerd, 2014; Sadeh, 2015), which is not usually feasible for most research because it involves the placement of electrodes on the child's body and observation in a laboratory overnight. Markovich *et al.* (2015) found that four subscales of the CSHQ (including the sleep duration scale used in our study and three other scales not used in our study) were predominantly not significantly related to PSG and actigraphy readings, with the CSHQ more likely to under-diagnose sleep problems in children. As a result, we encourage readers to interpret our results involving the sleep duration subscale of the CSHQ with particular caution. More generally, we remind readers that all of our sleep measures are based on parent reports and thus may better reflect parent perceptions of children's sleep problems rather than actual problems. From this perspective, our results reveal that parent perceptions of children's sleep play an important role in the association between mobile device use and EC. Because of the likelihood of biased parent reporting plaguing our measures, it is imperative that future research follow up on our work to verify these relations using objective measures.

Relatedly, we relied on a single informant to provide all of the information on children's behaviours, rather than gathering assessments from multiple informants (e.g., parents, children, teachers, researchers). The practice of using a single informant to provide all the data increases the likelihood of shared method variance, which (unlike the problem of biased estimates) would inflate the intervariable associations we observed. As a result, it is unclear whether our results reflect true associations among variables or whether they emerged because of shared method variance. We view our results as tentative and suggestive of relations among child mobile media use, sleep, and EC, but continued research is needed to verify whether these results would replicate with more objective measures and the use of multiple informants.

Conclusion

Our study discovered that sleep plays an important role in the association between young children's temperamental EC and their mobile media use. We recommend continued investigation of children's EC as an outcome (as well as a predictor) of children's media use. In addition, we encourage future work to consider the relevance of children's sleep when studying the effects of media on children – not only as an outcome of exposure, but also as a mediator and a moderator of other outcomes. Scholars should consider the factors which are known to play a substantive role in children's cognitive, social, and emotional development, such as sleep quantity and quality. Integrating the knowledge gleaned from child development experts into our study of media effects on children should yield a more complete understanding of how media are used, experienced, and responded to among this population.

References

Allan, N. P., & Lonigan, C. J. (2011). Examining the dimensionality of effortful control in preschool children and its relation to academic and socioemotional indicators. *Developmental Psychology*, *47*, 905–915. https://doi.org/10.1037/a0023748

Anderson, D. R., Levin, S. R., & Lorch, E. P. (1977). The effects of TV program packing on the behavior of preschool children. *AV Communication Review*, *25*, 159–166.

Astill, R. G., Van der Heijden, K. B., Van Ijzendoorn, M. H., & Someren, E. J. W. (2012). Sleep, cognition, and behavioral problems in school-age children: A century of research meta-analyzed. *Psychological Bulletin*, *138*, 1109–1138. https://doi.org/10.1037/a0028204

Barlett, C. P., Vowels, C. L., Shanteau, J., Crow, J., & Miller, T. (2009). The effect of violent and non-violent computer games on cognitive performance. *Computers in Human Behavior*, *25*, 96–102. https://doi.org/10.1016/j.chb.2008.07.008

Barr, R., Lauricella, A., Zack, E., & Calvert, S. L. (2010). Infant and early childhood exposure to adult-directed and child-directed television programming: Relations with cognitive skills at age four. *Merrill-Palmer Quarterly*, *56*, 21–48. https://doi.org/10.1353/mpq.0.0038

Bartel, K. A., Gradisar, M., & Williamson, P. (2015). Protective and risk factors for adolescent sleep: A meta-analytic review. *Sleep Medicine Reviews*, *21*, 72–85. https://doi.org/10.1016/j.smrv.2014.08.002

Bauer, D. J., & Curran, P. J. (2005). Probing interactions in fixed and multilevel regression: Inferential and graphical techniques. *Multivariate Behavioral Research*, *40*, 373–400. https://doi.org/10.1207/s15327906mbr4003_5

Bavelier, D., Green, C. S., Han, D. H., Renshaw, P. F., Merzenich, M. M., & Gentile, D. A. (2011). Brains on video games. *Nature Reviews Neuroscience*, *12*, 763–768. https://doi.org/10.1038/nrn3135

Belfort, M. B., Rifus-Shiman, S. L., Kleinman, K. P., Bellinger, D. C., Harris, M. H., Taveras, E. M., . . . Oken, E. (2016). Infant breastfeeding duration and mid-childhood executive function, behavior, and social-emotional development. *Journal of Developmental & Behavioral Pediatrics*, *37*, 43–52. https://doi.org/10.1097%2fdbp.0000000000000237

Bentley, G. F., Turner, K. M., & Jago, R. (2016). Mothers' views of their preschool child's screen-viewing behaviour: A qualitative study. *BMC Public Health*, *16*, 718. https://doi.org/10.1186/s12889-016-3440-z

Berger, R. H., Miller, A. L., Seifer, R., Cares, S. R., & LeBourgeois, M. K. (2012). Acute sleep restriction effects on emotion responses in 30- to 36-month-old children. *Journal of Sleep Research*, *21*, 235–246. https://doi.org/10.1111/j.1365-2869.2011.00962.x

Bernier, A., Bélanger, M.-È., Tarabulsy, G. M., Simard, V., & Carrier, J. (2014). My mother is sensitive, but I am too tired to know: Infant sleep as a moderator of prospective relations between maternal sensitivity and infant outcomes. *Infant Behavior and Development*, *37*, 682–694. https://doi.org/10.1016/j.infbeh.2014.08.011

Bernier, A., Carlson, S. M., Deschênes, M., & Matte-Gagné, C. (2012). Social factors in the development of early executive functioning: A closer look at caregiving environment. *Developmental Science*, *15*, 12–24. https://doi.org/10.1111/j.1467-7687.2011.01093.x

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, *78*, 647–663. https://doi.org/10.1111/j.1467-8624.2007.01019.x

Boot, W. R., Kramer, A. F., Simons, D. J., Fabiani, M., & Gratton, G. (2008). The effects of video game playing on attention, memory, and executive control. *Acta Psychologica*, *129*, 387–398. https://doi.org/10.1016/j.actpsy.2008.09.005

Brock, L. L., Rimm-Kaufman, S. E., Nathanson, L., & Grimm, K. J. (2009). The contributions of 'hot' and 'cool' executive function to children's academic achievement, learning-related behaviors, and engagement in kindergarten. *Early Childhood Research Quarterly*, *24*, 337–349. https://doi.org/10.1016/j.ecresq.2009.06.001

Cain, N., & Gradisar, M. (2010). Electronic media use and sleep in school-aged children and adolescents: A review. *Sleep Medicine*, *11*, 735–742. https://doi.org/10.1016/j.smrv.2014.07.007

Christakis, D. A. (2009). The effects of infant media usage: What do we know and what should we learn? *Acta Paediatrica*, *98*, 8–16. https://doi.org/10.1111/j.1651-2227.2008.01027.x

Christakis, D. A. (2014). Interactive media use at younger than the age of 2 years: Time to rethink the American Academy of Pediatrics Guideline? *JAMA Pediatrics*, *168*, 399–400. https://doi.org/10.1001/jamapediatrics.2013.5081

Christakis, D. A., Zimmerman, F. J., DiGiuseppe, D. L., & McCarty, C. A. (2004). Early television exposure and subsequent attention problems in children. *Pediatrics*, *113*, 708–713.

Cipriano, E. A., & Stifter, C. A. (2010). Predicting preschool effortful control from toddler temperament and parenting behavior. *Journal of Applied Developmental Psychology*, *31*, 221–230. https://doi.org/10.1016/j.appdev.2010.02.004

Common Sense Media (2013). *Zero to eight: Children's media use in America 2013*. New York, NY: Author.

Cristia, A., & Seidl, A. (2015). Parental reports on touch screen use in early Childhood. *PLoS One*, *10*, e0128338. https://doi.org/10.1371/journal.pone.0128338

De Weerd, A. W. (2014). Actigraphy, the alternative way? *Frontiers in Psychiatry*, *5*, 155. https://doi.org/10.3389/fpsyt.2014.00155

Deater-Deckard, K., Mullineaux, P. Y., Beekman, C., Petrill, S. A., Schatschneider, C., & Thompson, L. A. (2009). Conduct problems, IQ, and household chaos: A longitudinal multi-informant study. *Journal of Child Psychology and Psychiatry*, *50*, 1301–1308. https://doi.org/10.1111/j.1469-7610.2009.02108.x

Diaz, A., Berger, R., Valiente, C., Eisenberg, N., VanSchyndel, S. K., Tao, C., . . . Southworth, J. (2016). Children's sleep and academic achievement: The moderating role of effortful control. *International Journal of Behavioral Development*, *41*, 275–284. https://doi.org/10.1177/0165025416635284

Dovis, S., Van der Oord, S., Wiers, R. W., & Prins, P. J. M. (2015). Improving executive functioning in children with ADHD: Training multiple executive functions within the context of a computer game. A randomized double-blind placebo controlled trial. *PLoS One*, *10*, e0121651. https://doi.org/10.1371/journal.pone.0121651

Eisenberg, N., Spinrad, T. L., Fabes, R. A., Reiser, M., Cumbeland, A., Shepard, S., . . . Murphy, B. (2004). The relations of effortful control and impulsivity to children's resiliency and adjustment. *Child Development*, *75*, 25–46. https://doi.org/10.1111/j.1467-8624.2004.00652.x

Eisenberg, N., Valiente, C., Spinrad, T., Cumberland, A., Liew, J., Reiser, M., . . . Losoya, S. H. (2009). Longitudinal relations of children's effortful control, impulsivity, and negative emotionality to their externalizing, internalizing, and co-occurring behavior problems. *Developmental Psychology*, *45*, 988–1008. https://doi.org/10.1037/a0016213

Friedrich, L. K., & Stein, A. H. (1973). Aggressive and prosocial television programs and the natural behavior of preschool children. *Monographs of the Society for Research in Child Development*, *38*, 1–64.

Friedrich-Cofer, L. K., Huston-Stein, A., Kipnis, D. M., Susman, E. J., & Clewett, A. S. (1979). Environmental enhancement of prosocial television content: Effects on interpersonal behavior, imaginative play, and self-regulation in a natural setting. *Developmental Psychology*, *15*, 637–646.

Garrison, M. M., Liekweg, K., & Christakis, D. A. (2011). Media use and child sleep: The impact of content, timing, and environment. *Pediatrics*, *128*, 29–35. https://doi.org/10.1542/peds.2010-3304

Hale, L., & Guan, S. (2015). Screen time and sleep among school-aged children and adolescents: A systematic literature review. *Sleep Medicine Reviews*, *21*, 50–58. https://doi.org/10.1016/j.smrv.2014.07.007

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. New York, NY: The Guilford Press.

Holmes, C. J., Kim-Spoon, J., & Deater-Deckard, K. (2016). Linking executive function and peer problems from early childhood through middle adolescence. *Journal of Abnormal Child Psychology*, *44*, 31–42. https://doi.org/10.1007/s10802-015-0044-5

Kabali, H. K., Irigoyen, M. M., Nunez-Davis, R., Budacki, J. G., Mohanty, S. H., Leister, K. P., & Bonner, R. L. (2015). Exposure and use of mobile media devices by young children. *Pediatrics*, *136*, 1044–1050. https://doi.org/10.1542/peds.2015-2151

Kopp, C. B. (1982). Antecedents of self regulation: A developmental perspective. *Developmental Psychology*, *18*, 199–214.

Kubiszewski, V., Fontaine, R., Rusch, E., & Hazouard, E. (2014). Association between electronic media use and sleep habits: An eight-day follow-up study. *International Journal of Adolescence and Youth*, *19*, 395–407. https://doi.org/10.1080/02673843.2012.751039

Kuhn, S., Gleich, T., Lorenz, R. C., Lindenberger, U., & Gallinat, J. (2014). Playing Super Mario induces structural brain plasticity: Gray matter changes resulting from training with a commercial video game. *Molecular Psychiatry*, *19*, 265–271. https://doi.org/10.1038/mp.2013.120

LaRose, R., Lin, C. A., & Eastin, M. S. (2003). Unregulated internet usage: Addiction, habit, or deficit self-regulation? *Media Psychology*, *5*, 225–253. https://doi.org/10.1207/s1532785xmep0503_01

Lee, L. (2015). Digital media and young children's learning: A case study of using iPads in American preschools. *International Journal of Information and Education Technology*, *5*, 947–950. https://doi.org/10.7763/IJIET.2015.V5.643

Li-Grining, C. P. (2007). Effortful control among low-income preschoolers in three cities: Stability, change, and individual differences. *Developmental Psychology*, *43*, 208–221. https://doi.org/10.1037/0012-1649.43.1.208

Lillard, A. S., Drell, M. B., Richey, E. M., Boguszewski, K., & Smith, E. D. (2015). Further examination of the immediate impact of television on children's executive function. *Developmental Psychology*, *51*, 792–805. https://doi.org/10.1037/a0039097

Lillard, A. S., & Peterson, J. (2011). The immediate impact of different types of television on young children's executive function. *Pediatrics*, *128*, 644–649. https://doi.org/10.1542/peds.2010-1919

Linebarger, D. L., Barr, R., Lapierre, M. A., & Piotrowski, J. T. (2011, March). *Predicting executive function skills from background television exposure*. Poster presented at the biennial meeting of the Society for Research on Child Development, Montreal, QC.

Markovich, A. N., Gendron, M. A., & Corkum, P. V. (2015). Validating the Children's Sleep Habit Questionnaire against polysomnography and actigraphy in school-aged children. *Frontiers in Psychiatry*, *5*, 188. https://doi.org/10.3389/fpsyt.2014.00188

McClelland, M. M., Cameron, C. E., Duncan, R., Bowles, R. P., Acock, A. C., Miao, A., & Pratt, M. E. (2014). Predictors of early growth in academic achievement: The head-toes-knees-shoulders task. *Frontiers in Psychology*, *5*, 599. https://doi.org/10.3389/fpsyg.2014.00599

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*, 49–100. https://doi.org/10.1006/cogp.1999.0734/

Nathanson, A. I., Aladé, F., Sharp, M. L., Rasmussen, E. E., & Christy, K. (2014). The relation between television exposure and executive function among preschoolers. *Developmental Psychology*, *50*, 1497–1506. https://doi.org/10.1037/a0035714

Nathanson, A. I., & Beyens, I. (2016). The relation between use of mobile electronic devices and bedtime resistance, sleep duration, and daytime sleepiness among preschoolers. *Behavioral Sleep Medicine*. https://doi.org/10.1080/15402002.2016.1188389

Nathanson, A. I., & Fries, P. T. (2014). Television exposure, sleep time, and neuropsychological function among preschoolers. *Media Psychology*, *17*, 237–261. https://doi.org/10.1080/15213269.2014.915197

National Sleep Foundation (2016). Retrieved from https://sleepfoundation.org/sleep-topics/children-and-sleep/page/0/2

Owens, J. A., Spirito, A., & McGuinn, M. (2000). The children's sleep habits questionnaire (CSHQ): Psychometric properties of a survey instrument for school-aged children. *Sleep*, *23*, 1043–1051.

Paavonen, E. J., Porka-Heiskanen, T., & Lahikainen, A. R. (2009). Sleep quality, duration and behavioral symptoms among 5-6-year-old children. *European Child and Adolescent Psychiatry*, *18*, 747–754. https://doi.org/10.1542/peds.2008-2164

Pennington, B. F., & Ozonoff, S. (1996). Executive functions and developmental psychopathology. *Journal of Child Psychology and Psychiatry*, *37*, 51–87. https://doi.org/10.1111/j.1469-7610.1996.tb01380.x

Pike, A., Iervolino, A. C., Elay, T. C., Price, T. S., & Plomin, R. (2006). Environmental risk and young children's cognitive and behavioral development. *International Journal of Behavioral Development*, *30*, 55–66. https://doi.org/10.1177/0165025406062124

Putnam, S. P., Gartstein, M. A., & Rothbart, M. K. (2006). Measurement of fine-grained aspects of toddler temperament: The Early Childhood Behavior Questionnaire. *Infant Behavior and Development*, *29*, 386–401. https://doi.org/10.1016/j.infbeh.2006.01.004

Radesky, J. S., Kistin, C. J., Zuckerman, B., Nitzberg, K., Gross, J., Kaplan-Sanoff, M., . . . Silverstein, M. (2014). Patterns of mobile device use by caregivers and children during meals in fast food restaurants. *Pediatrics*, *133*, e843–e849. https://doi.org/10.1542/peds.2013-3703

Radesky, J. S., Peacock-Chambers, E., Zuckerman, B., & Silverstein, M. (2016). Use of mobile technology to calm upset children: Association with social-emotional development. *JAMA Pediatrics*, *170*, 397–399. https://doi.org/10.1001/jamapediatrics.2015.4260

Radesky, J. S., Schumacher, J., & Zuckerman, B. (2015). Mobile and interactive media use by young children: The good, the bad, and the unknown. *Pediatrics*, *135*, 1–3. https://doi.org/10.1542/peds.2014-2251

Radesky, J. S., Silverstein, M., Zuckerman, B., & Christakis, D. A. (2014). Infant self-regulation and early childhood media exposure. *Pediatrics*, *133*, e1172–e1178. https://doi.org/10.1542/peds.2013-2367

Rhoades, B. L., Greenberg, M. T., & Domitrovich, C. E. (2009). The contribution of inhibitory control to preschoolers' social-emotional competence. *Journal of Applied Developmental Psychology*, *30*, 310–320. https://doi.org/10.1016/j.appdev.2008.12.012

Rushton, J. P., Brainerd, C. J., & Pressley, M. (1983). Behavioral development and construct validity: The principle of aggregation. *Psychological Bulletin*, *94*, 18–38. https://doi.org/10.1037/0033-2909.94.1.18

Sadeh, A. (1996). Evaluating night wakings in sleep-disturbed infants: A methodological study of parental reports and actigraphy. *Sleep*, *19*, 757–762. https://doi.org/10.1093/sleep/19.10.757

Sadeh, A. (2015). Sleep assessment methods. *Monographs of the Society for Research in Child Development*, *80*, 33–48. https://doi.org/10.1111/mono.12143

Slater, M. (2007). Reinforcing spirals: The mutual influence of media selectivity and media effects and their impact on individual behavior and social identity. *Communication Theory*, *17*, 281–303. https://doi.org/10.1111/j.1468-2885.2007.00296.x

Spinrad, T. L., Eisenberg, N., Gaertner, B., Popp, T., Smith, C. L., Kupfer, A., . . . Hofer, C. (2007). Relations of maternal socialization and toddlers' effortful control to children's adjustment and social competence. *Developmental Psychology*, *43*, 1170–1186. https://doi.org/10.1037/0012-1649.43.5.1170

Sulik, M., Blair, C., Mills-Koonce, R., Greenberg, M., & The Family Life Project Investigators (2015). Early parenting and the development of externalizing behavior problems: Longitudinal mediation through children's executive function. *Child Development*, *86*, 1588–1603. https://doi.org/10.1111/cdev.12386

Tandon, P., Thompson, S., Moran, L., & Lengua, L. (2015). Body mass index mediates the effects of low income on preschool children's executive control, with implications for behavior and academics. *Childhood Obesity*, *11*, 569–576.

Thompson, A. L., Adair, L. S., & Bentley, M. E. (2013). Maternal characteristics and perception of temperament associated with infant TV exposure. *Pediatrics*, *131*, e390–e397. https://doi.org/10.1542/peds.2012-1224

Ulicsak, M., & Cranmer, S. (2010). *Gaming in families: Final report*. Retrieved from https://www.nfer.ac.uk/publications/FUTL28/FUTL28.pdf

Utendale, W. T., & Hastings, P. D. (2011). Developmental changes in the relations between inhibitory control and externalizing problems during early childhood. *Infant and Child Development*, *20*, 181–193. https://doi.org/10.1002/icd.691

Valkenburg, P. M., & Peter, J. (2013). The differential susceptibility to media effects model. *Journal of Communication*, *63*, 221–243. https://doi.org/10.1111/jcom.12024

Veatch, O. J., Reynolds, A., Katz, T., Weiss, S. K., Loh, A., Wang, L., & Malow, B. A. (2015). Sleep in children with autism spectrum disorders: How are measures of parent report and actigraphy related and affected by sleep education? *Behavioral Sleep Medicine*, *14*, 665–676. https://doi.org/10.1080/15402002.2015.1065408

Vernon-Feagans, L., Willoughby, M., & Garrett-Peters, P. (2016). Predictors of behavioral regulation in kindergarten: Household chaos, parenting, and early executive functions. *Developmental Psychology*, *52*, 430–441. https://doi.org/10.1037/dev0000087

Yuwen, W., Chen, M. L., Cain, K. C., Ringold, S., Wallace, C. A., & Ward, T. M. (2016). Daily sleep patterns, sleep quality, and sleep hygiene among parent-child dyads of young children newly diagnosed with juvenile idiopathic arthritis and typically developing children. *Journal of Pediatric Psychology*, *41*, 651–660. https://doi.org/10.1093/jpepsy/jsw007

Zelazo, P. D., & Carlson, S. M. (2012). Hot and cool executive function in childhood and adolescence: Development and plasticity. *Child Development Perspectives*, *6*, 354–360. https://doi.org/10.1111/j.1750-8606.2012.00246.x

Zhou, Q., Chen, S. H., & Main, A. (2012). Commonalities and differences in the research on children's effortful control and executive function: A call for an integrated model of self-regulation. *Child Development Perspectives*, *6*, 112–121. https://doi.org/10.1111/j.1750-8606.2011.00176.x

Zimmerman, F. J., & Christakis, D. A. (2007). Associations between content types of early media exposure and subsequent attentional problems. *Pediatrics*, *120*, 986–992. https://doi.org/10.1542/peds.2006-3322

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