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Beyens, I.; Nathanson, A.I.

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Electronic Media Use and Sleep Among Preschoolers: Evidence for Time-Shifted and Less Consolidated Sleep

Ine Beyens[a] and Amy I. Nathanson[b]

[a]Amsterdam School of Communication Research, University of Amsterdam; [b]School of Communication, Ohio State University

ABSTRACT

This study examined the association between electronic media use and sleep among preschoolers, using a national sample of 402 mothers of 3- to 5-year-olds. Participants completed an online survey assessing preschoolers' electronic media use, bedtime and wake time, sleep time, napping behaviors, and sleep consolidation. Results showed that heavier television use and tablet use, both overall and in the evening, were associated with later bedtimes and later wake times, but not with fewer hours of sleep, providing evidence for a time-shifting process. In addition, heavier daily television use and evening smartphone use were associated with increased daytime napping. Moreover, heavier daily television use, daily and evening smartphone use, and evening tablet use were associated with poorer sleep consolidation, suggesting less mature sleep patterns. These findings indicate that media effects on the timing of sleep and the proportion of sleep that occurs at night are important to consider when assessing the health risks of electronic media on children.

Sleep is essential to children's development. Children who achieve adequate sleep experience important cognitive, social, and health-related benefits (Carno, Hoffman, Carcillo, & Sanders, 2003; Davis, Parker, & Montgomery, 2004). In contrast, sleep-deprived children experience several problems, including weaker cognitive and academic performance (Astill, Van der Heijden, Van IJzendoorn, & Van Someren, 2012), social problems and aggression (Simola, Liukkonen, Pitkäranta, Pirinen, & Aronen, 2014), and being overweight (Snell, Adam, & Duncan, 2007).

A major factor that may affect children's sleep is their electronic media use. In fact, research has been accumulating evidence that electronic media disturb children's sleep (Cain & Gradisar, 2010; Carter, Rees, Hale, Bhattacharjee, & Paradkar, 2016; Hale & Guan, 2015). Previous studies have reported an association between electronic media use and poor sleep quality among both school-aged children and adolescents (Arora, Broglia, Thomas, & Taheri, 2014; Garmy, Nyberg, & Jakobsson, 2012). In addition, a recent meta-analysis of the relationship between mobile media use and sleep among school-aged children and adolescents found that the use of mobile media devices at bedtime is associated with inadequate sleep (Carter et al., 2016).

Given the widespread access to and use of electronic media among children (Kabali et al., 2015), scholars have underscored the importance of examining whether and how electronic media affect children's sleep (Carter et al., 2016; Hale & Guan, 2015). Yet, studies investigating the relationship between electronic media use and sleep mostly relied on samples of school-aged children, adolescents, and adults (e.g., Arora et al., 2014; Exelmans & Van den Bulck, 2016; Nuutinen et al., 2014; Van den Bulck, 2004). Although indications exist that electronic media use may be associated with sleep early in life (Garmy et al., 2012; Marinelli et al., 2014), research has paid far less attention to the relationship between electronic media use and sleep among preschoolers. In particular, much remains unknown as to whether preschoolers' electronic media use affects their bedtimes and wake times, sleep time, napping, and sleep consolidation.

Electronic media use and associations with bedtime, wake time, and nighttime sleep

Theoretically, several hypotheses have been put forward as to why electronic media use may be problematic for children's sleep. One prevailing explanation focusses on the effect of media on the brain's melatonin secretion. In particular, the *blue light hypothesis* states that the short-wavelength enriched light emitted by electronic media suppresses the production of melatonin in the brain (Salti et al., 2006; Wood, Rea, Plitnick, & Figueiro, 2013), which deregulates the child's circadian rhythms (Chang, Aeschbach, Duffy, & Czeisler, 2015). Subsequently, the suppression of melatonin secretion likely results in later bedtimes (Chang et al., 2015).

The delay in children's bedtime may ultimately result in two distinctly different processes: a sleep displacement process or sleep time shifting process. In terms of the displacement process, the *media-induced sleep displacement hypothesis* proposes that children's media time displaces time that may otherwise be devoted to sleep (Cain & Gradisar, 2010). When electronic media use results in a sleep displacement process, this is reflected by later bedtimes but not later wake

CONTACT Ine Beyens i.beyens@uva.nl Amsterdam School of Communication Research, University of Amsterdam, 1001 NG Amsterdam, The Netherlands.

times, as well as fewer hours of sleep. Indeed, prior work among schoolchildren and adolescents found that time spent with electronic media, including watching television, using a computer, and playing games, displaces time spent sleeping, as evidenced by later bedtimes and fewer hours of sleep (Arora et al., 2014; Nuutinen, Ray, & Roos, 2013; Nuutinen et al., 2014; Van den Bulck, 2004).

However, an alternative process may occur, in which delayed bedtimes are compensated by later wake times. In such case, children's media use likely creates a time-shifting process (Custers & Van den Bulck, 2012; Exelmans & Van den Bulck, 2016; Van den Bulck, 1999). According to the *media-induced sleep time shifting hypothesis*, children's time spent with media shifts the time they spend sleeping (Custers & Van den Bulck, 2012; Van den Bulck, 1999). That is, the use of electronic media results in both later bedtimes and later wake times, but does not lead to fewer hours of sleep. Evidence for a process of time shifting was found in adult samples. In particular, research showed that watching television and using the internet prior to sleep (Custers & Van den Bulck, 2012) and using media, including television, videogames, and the internet, as a sleep aid (Exelmans & Van den Bulck, 2016) were associated with later bedtimes as well as later wake times, but not with fewer hours of sleep. As such, adults seem to compensate the later bedtimes induced by their media use by later wake times.

Together, from a developmental perspective, it appears that electronic media use differently affects the timing of sleep across different developmental phases. While electronic media use results in a time displacement process in childhood and adolescence (Arora et al., 2014; Nuutinen et al., 2013, 2014; Van den Bulck, 2004), it results in a time-shifting process in adulthood (Custers & Van den Bulck, 2012; Exelmans & Van den Bulck, 2016). One explanation for this discrepancy could be that school-aged children and adolescents are more strongly tied to a strict time schedule, that is largely influenced by school schedules, compared with adults (Exelmans & Van den Bulck, 2016). What is not yet clear, however, is which process occurs earlier in childhood, in the preschool years.

So far, the evidence suggests that electronic media use among preschoolers may create a time-shifting process. In fact, our prior work on the relationship between preschoolers' media use and their sleep quality provides some indications for a time-shifting process (Nathanson & Beyens, 2018). In particular, the coincidence of different media-induced sleep disturbances that were found in our prior work could reflect a process of time shifting rather than time displacement. More specifically, some items of the sleep disturbances scales suggested a delay in bedtime (e.g., "struggles at bedtime") and a delay in rise time (e.g., "hard time getting out of bed"). If this is the case, then children's media use shifts rather than displaces their sleep time.

Because our prior work investigated sleep quality and not actual bedtime, rise time, or actual sleep time, we did not determine whether preschoolers' media use was associated with a process of time shifting rather than time displacement. Therefore, the current study aimed to investigate this question. Based on the assumptions of the *media-induced sleep time shifting hypothesis* and building on the findings of our prior work, we propose the following hypothesis:

H1: Preschoolers' electronic media use is associated with both later bedtimes and wake times, but not with shorter sleep time.

Electronic media use and associations with napping and sleep consolidation

Prior research on media and sleep has focused on sleep indicators like sleep quality and total sleep time (Carter et al., 2016). However, in terms of children's development, two other, related aspects of sleep are emerging as important predictors of healthy outcomes: napping and nighttime sleep consolidation. During the preschool-age period, children's napping behaviors begin to extinguish (Iglowstein, Jenni, Molinari, & Largo, 2003). As a result, healthy sleep development is marked by a transition toward less daytime napping and a greater proportion of total sleep time occurring overnight, or more "consolidated" sleep (Bernier, Beauchamp, Bouvette-Turcot, Carlson, & Carrier, 2013). Sleep consolidation begins to develop rapidly in the first few months of life, as infants experience longer episodes of uninterrupted, or less fragmented, nighttime sleep, with most infants "sleeping through the night" by about 5 months of age (Henderson, France, Owens, & Blampied, 2010). As children mature, sleep patterns continue to re-organize and to move toward greater consolidation, with children taking fewer daytime naps and accruing the majority of their total sleep hours overnight. Bernier et al. (2013) assert that the proportion of total sleep time gained during the night is an especially meaningful measure of the maturity of the organization of sleep-wake cycles in children.

Presently, it is not clear whether or not napping past the age of two is ultimately beneficial or harmful to children's development (Thorpe et al., 2015; Wiggs, 2015). However, research has shown that daytime napping reduces total nighttime sleep (thereby causing a re-distribution of sleep; Staton, Smith, Pattinson, & Thorpe, 2015; Thorpe et al., 2015); and fewer nighttime sleep hours is related to increased cognitive and health risks among children (Hiscock, Scalzo, Canterford, & Wake, 2011; Lam, Mahone, Mason, & Scharf, 2011). Moreover, other work has shown that more mature sleep patterns (as manifested in greater sleep consolidation) are predictive of better child outcomes (Dionne et al., 2011). In fact, Bernier et al. (2013) found that the ratio of nighttime sleep to total sleep time was uniquely related to cognitive performance three years later, compared with total sleep time.

Although napping patterns evolve with age, suggesting a biological explanation for their extinction, other factors also influence napping, such as daycare attendance and parental attitudes (Jones & Ball, 2013; Wiggs, 2015). In this way, napping behaviors may reflect schedules and preferences of adults rather than children. Electronic media use could also coincide with napping behavior, although the direction of this

association is uncertain. In general, we should expect that media use will be related to less sleep, but napping behavior may operate differently. If electronic media use attenuates children's nighttime sleep, children may feel fatigued during the day and more likely to nap. Likewise, children who nap more because of media-induced nighttime sleep deprivation will exhibit less sleep consolidation.

Although other work has examined the association between media use and sleep, we are not aware of any media research that includes measures of napping and sleep consolidation. Given the importance of these sleep variables to children's development, we propose the following research questions:

RQ1: Is preschoolers' electronic media use related to their napping behavior?

RQ2: Is preschoolers' electronic media use related to their sleep consolidation?

Method

Participants and procedures

Data were collected from a national sample of 402 mothers of children aged 3 to 5 years in the United States who were recruited through a national panel company. To be eligible to participate in the study, participants had to be the mother of a 3-, 4-, or 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. Eligible mothers who matched the selection criteria completed an online survey that took 20 minutes to complete. The study received ethical approval from the author's institution.

On average, participants were 34.5 years old (SD = 8.7) and their children were 4 years old (SD = .80). Most participants were married or co-habitating (80%) and most of them self-identified as Caucasian (80%), 7% as African American, 6% as Hispanic, 4% as Asian or Pacific Islander, 2% as multi-racial, and 0.5% as Native American.

Measures

Children's electronic media use

Participants reported how many hours their child watches television, uses a tablet, a smartphone, a video iPod, a hand-held game player, and a laptop computer during the morning (i.e., "from the time the child awakens until lunch time"), afternoon (i.e., "between lunch and dinner time"), and evening (i.e., "between dinner and bedtime") on a typical weekday and on a typical weekend day. For each medium, participants indicated their response on a scale that provided 12 30-minute increments of time, such as "not at all," "1.5 hours," "3 hours," "more than 5 hours". For each medium, we calculated a total exposure time score by converting the responses into minutes (e.g., "not at all" was converted into "0," "1.5 hours" was converted into "90") and summing across the responses from each daypart, in minutes, for weekdays and weekends. For each medium, we then multiplied the sum for the weekday use by 5 and the sum for the weekend use by 2, summed these two products and divided them by 7 to produce average daily use, in minutes. Children's average evening media use was derived from participants' reports of their child's weekday and weekend evening exposure. All average daily use variables and average evening use variables were converted from minutes into hours to be included in the analyses.

Children's sleep behavior

Children's *bedtime* and *wake time* were measured by asking participants to report the time that their child goes to bed in the evening and the time their child awakens in the morning. Children's *nighttime sleep* was calculated by subtracting bedtime scores from wake-time scores. Children's *napping behavior* was measured by asking parents whether their child takes naps during the day and, when parents reported napping, how many naps their child takes each day as well as how long their child sleeps when he/she takes a nap. We then computed *naptime sleep* by multiplying the number of naps by the length of the naps, in minutes. Children's *total sleep time* was calculated by summing nighttime sleep duration (in minutes) and naptime sleep duration. Finally, children's *sleep consolidation* was calculated by dividing children's nighttime sleep duration by total sleep time, with higher scores indicating more consolidated sleep. The nighttime sleep to total sleep ratio as an indicator of sleep consolidation has been used successfully in prior studies (Bernier et al., 2013).

Statistical analyses

The relationships between children's electronic media use and sleep behavior were investigated using multiple regression analysis. Separate analyses were conducted for average daily media use and average evening media use. For each analysis, we entered the covariates into the first block of the equation. Child's age (1 = "3 years old," 2 = "4 years old," and 3 = "5 years old"), frequency of attending childcare (0 = "0 days per week" to 7 = "7days per week"), the mother's education level (1 = "less than high school" to 6 = "graduate degree"), the mother's employment status (1 = "yes" and 2 = "no"), and household income (1 = "less than $10,000" to 8 = "$200,000 or more") were included as covariates as these variables are typically related to children's electronic media use, sleep behavior, or both (Magee, Lee, & Vella, 2014; Marinelli et al., 2014). In the second block of each regression model, we entered television use either overall or in the evening and in the third block of each regression model we entered either overall or evening mobile device use for each mobile device separately. The electronic media use measures were included in the regression models as average use in hours.

To assess the assumption of no multicollinearity, we investigated collinearity statistics. These statistics indicated that for all our regression models the variance inflation factors (VIF) values were well below the critical value of 5.3 (Hair,

Anderson, Tatham, & Black, 1992) and the tolerance statistics were all well above 0.2 (Menard, 1995). In addition, the average VIF value for each regression model was close to 1. These statistics indicate that multicollinearity was not a problem for our models.

Results

Descriptive statistics

Children's average daily television viewing time was 3 h and 48 min (M = 228.15 min, SD = 158.42), with 1 h and 17 min in the evening (M = 76.77 min, SD = 63.15). Average daily mobile device use was more than three hours (M = 184.81 min, SD = 244.69), with almost an hour and a half spent using a tablet device (M = 84.15 min, SD = 126.69), more than half an hour using a handheld game player (M = 35.34, SD = 83.61), half an hour using a laptop computer (M = 30.31 minutes, SD = 79.70), approximately 25 min using a smartphone (M = 24.56 min, SD = 66.48), and 10 min using a video iPod (M = 10.45 min, SD = 47.02). Average evening mobile device use was approximately 50 minutes (M = 49.71 min, SD = 71.93), with 23.46 min spent using a tablet (SD = 39.78), and less than 10 min spent using a smartphone (M = 7.10 min, SD = 22.59), a handheld game player (M = 8.88 min, SD = 23.43), a laptop computer (M = 7.53 min, SD = 21.92), and a video iPod (M = 2.74 min, SD = 13.32).

A relatively small proportion of the participants indicated that their children's bedtime was before 18:00 (0.5%) or between 18:00 and 19:00 (0.7%) in the evening. One in seven parents indicated that their children's bedtime was 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 percent of the participants indicated that their children's wake time was between 04:00 and 05:00 in the morning, and 3% between 05:00 and 06:00. Approximately one in four parents indicated that their children's wake time was between 06:00 and 07:00 (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. Children's average daily total sleep time was almost 11 hours and a half (M = 681.79 min, SD = 73.39), and average daily nighttime sleep was almost 11 hours (M = 639.70 min, SD = 61.26). Children who took naps during the day (48.3%), had, on average, 1.07 daily naps (SD = .30), with average daily total naptime sleep being almost an hour and a half (M = 87.22 min, SD = 39.13). Children's average sleep consolidation score was 0.88 (SD = .05).

Electronic media use and associations with bedtime, wake time, and nighttime sleep

The results of the regression analyses for bedtime, wake time, and nighttime sleep are displayed in Table 1. H1 predicted that preschoolers' electronic media use would be associated with both later bedtimes and wake times, but not with shorter sleep time. The results indicated that heavier evening and daily television use were both associated with later bedtimes (β = .23, p < .001 for evening TV use, β = .18, p < .001 for daily TV use). In addition, heavier evening and daily television use were both associated with later wake times (β = .17, p < .01 for evening TV use, β = .18, p < .001 for daily TV use). The coincidence of later bedtimes and later wake times associated with television use provides evidence for a time shifting process, supporting H1.

Similar results were found for tablet use. Heavier evening and daily tablet use were associated with later bedtimes (β = .30, p < .001 for evening tablet use, β = .28, p < .001 for daily tablet use) and later wake times (β = .20, p < .001 for evening tablet use, β = .21, p < .001 for daily tablet use). As with television use, these findings suggest a time shifting process, again supporting H1. In addition, heavier daily smartphone use was marginally significantly associated with later bedtimes (β = .09, p = .07), but not with later wake times (β = .02, p = .70). Unexpectedly, heavier evening iPod use was associated with earlier bedtimes (β = –.11, p < .05), but not with wake times (β = –.05, p = .31). In addition, daily iPod use was marginally significantly associated with earlier bedtimes (β = –.09, p = .09) and wake times (β = –.09, p = .08). Children's game player use and laptop use were not significantly associated with their bedtimes and wake times.

Finally, the results indicated that children's electronic media use was not associated with their nighttime sleep. Neither children's daily media use nor their evening media use was significantly associated with the time they slept at night, although heavier evening tablet use was marginally significantly associated with fewer hours of nighttime sleep (β = –.09, p = .09). These findings further support the media-induced sleep time shifting hypothesis (H1).

Electronic media use and associations with napping and sleep consolidation

The results of the regression analyses for napping, total sleep time, and sleep consolidation are displayed in Table 2. RQ1 asked whether electronic media use is related to preschoolers' napping behavior. The results indicated that heavier daily television use (β = .25, p < .01) and evening smartphone use (β = .17, p < .05) were associated with increased naptime sleep, and heavier evening television use (β = .14, p = .06) and daily smartphone use (β = .14, p = .07) were marginally significantly associated with increased naptime sleep. However, children's media use was unrelated to their total sleep time (nighttime sleep plus naptime sleep).

RQ2 asked whether electronic media use is related to preschoolers' sleep consolidation. The results indicated that heavier daily television use (β = –.23, p < .01), evening tablet use (β = –.16, p < .05), and both daily (β = –.17, p < .05) and evening smartphone use (β = –.20, p < .01) were associated with poorer sleep consolidation. Heavier evening television use (β = –.14, p = .06) and daily tablet use (β = –.14, p = .07) were marginally significantly associated with poorer sleep consolidation.

Discussion

The current study investigated the relation of preschoolers' electronic media use with their bedtimes and wake times, sleep time, napping behaviors, and nighttime sleep

Table 1. Regression analysis of the relation between children's overall electronic media use and evening electronic media use and bedtime, wake time, and nighttime sleep.

Overall Electronic Media Use	Bedtime			Wake Time			Nighttime Sleep		
	B	*SE*	β	*B*	*SE*	β	*B*	*SE*	β
Step 1									
Mother's education	−.13	.05	−.15**	−.12	.05	−.12*	.75	2.71	.02
Mother's employment	.20	.12	.09⁺	.24	.13	.10⁺	2.26	6.88	.02
Household income	.02	.04	.03	.01	.05	.01	−.87	2.48	−.02
Child's age	−.08	.07	−.06	.02	.08	.01	6.08	3.94	.08
Childcare attendance	−.02	.03	−.05	−.11	.03	−.20***	−5.13	1.51	−.19**
R^2	.03**			.08***			.03**		
Step 2									
TV viewing	.07	.02	.18***	.08	.02	.18***	.55	1.24	.02
Incr. R^2/R^2	.04***/.08***			.04***/.12***			.00/.03*		
Step 3									
Tablet use	.15	.03	.28***	.13	.03	.21***	−1.39	1.55	−.05
Smartphone use	.09	.05	.09⁺	.02	.05	.02	−4.02	2.83	−.07
Game player use	−.06	.04	−.08	−.04	.05	−.04	1.56	2.50	.04
Laptop use	.05	.05	.06	.03	.05	.03	−1.41	2.69	−.03
iPod use	−.12	.07	−.09⁺	−.14	.08	−.09⁺	−1.25	4.26	−.02
Incr. R^2/R^2	.09***/.15***			.04**/.15***			.01/.02*		
F	7.56***			7.50***			1.88*		

Evening Electronic Media Use	Bedtime			Wake Time			Nighttime Sleep		
	B	*SE*	β	*B*	*SE*	β	*B*	*SE*	β
Step 1									
Mother's education	−.12	.05	−.14**	−.12	.05	−.12*	.40	2.69	.01
Mother's employment	.19	.11	.09⁺	.23	.13	.09⁺	2.36	6.85	.02
Household income	.01	.04	.02	−.00	.05	−.00	−.91	2.47	−.02
Child's age	−.09	.07	−.06	.03	.08	.02	6.79	3.91	.09⁺
Childcare attendance	−.04	.03	−.08	−.13	.03	−.22***	−5.17	1.50	−.19*
R^2	.03**			.08***			.03**		
Step 2									
Evening TV viewing	.24	.05	.23***	.20	.06	.17**	−2.38	3.07	−.04
Incr. R^2/R^2	.07***/.11***			.04***/.12***			.00/.03**		
Step 3									
Evening tablet use	.51	.08	.30***	.37	.09	.20***	−8.30	4.87	−.09⁺
Evening smartphone use	.21	.14	.07	.05	.16	.02	−9.53	8.24	−.06
Evening game player use	−.12	.14	−.04	−.05	.17	−.02	4.14	8.60	.03
Evening laptop use	.21	.15	.07	−.03	.18	−.01	−14.37	9.23	−.09
Evening iPod use	−.55	.25	−.11*	−.30	.29	−.05	15.32	15.19	.06
Incr. R^2/R^2	.10***/.19***			.04**/.14***			.02/.04**		
F	9.67***			7.04***					

Note. $^{+}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.
Analyses control for mother's education, mother's employment, household income, child's age, and childcare attendance

consolidation. The findings showed that watching television and using a tablet, both overall and in the evening, are consistently associated with later bedtimes and later wake times, but not with fewer hours of sleep. In addition, heavier daily television use and evening smartphone use were associated with increased napping and heavier daily television use, evening tablet use, and both daily and evening smartphone use were associated with poorer sleep consolidation. Together, these findings indicate that the time preschoolers spend using electronic media shifts their sleep time and coincides with less mature sleep patterns.

Because it appears that preschoolers, like adults (Custers & Van den Bulck, 2012; Exelmans & Van den Bulck, 2016), compensate for later bedtimes with later rise times, it is tempting to conclude that electronic media exposure is not detrimental to sleep. However, even when the total amount of sleep is constant, the shift in sleep time presents worrisome implications for young children's development. Under normal circumstances, bedtimes and rise times are responsive, in part, to levels of melatonin released in the brain. The circadian system changes throughout development, which accounts for differences between young children and adolescents in their bedtimes and wake times (another shift occurs among older adults, whose circadian system begins to promote earlier bedtimes and wake times). "Circadian misalignment" occurs when bedtimes and wake times do not coincide with the patterns of melatonin release in the body (LeBourgeois et al., 2013), such as when children go to sleep several hours after the onset of melatonin release, and stay sleeping during the "biological" daytime. Circadian misalignment may be a risk factor for a variety of negative physical and cognitive outcomes among adults and adolescents (Tenkanen, Sjöblom, & Härmä, 1998; Wolfson & Carskadon, 1998). As a result, media effects on the timing of sleep—not just the total amount of sleep—are important to consider in weighing the health risks of electronic media exposure on children.

Watching television and using tablets, both overall and in the evening, were the most strongly associated with children's sleep behavior, with children's tablet use being the strongest predictor of children's bedtimes and wake times, above and beyond their television use. Since children's screen time is largely dominated by television viewing and the use of tablets (Kabali et al., 2015), these are important findings. The widespread use of both televisions and tablets and the increasing popularity of tablet devices and other mobile devices imply that children's sleep is very likely to be disrupted by media use.

Unexpectedly, heavier evening iPod use was associated with earlier bedtimes. Several explanations are possible for this finding. Since many parents indicate that they use mobile devices as a sleep aid for their children (Kabali et al., 2015), it could be that parents put children to bed earlier with an iPod playing music, hoping the device will soothe the children to sleep. Another possible explanation relates to the degree of interactivity of iPods. Unlike tablet computers, which involve more interactive use (e.g., using apps), iPods involve more passive use (e.g., listening to music). A recent review by Hale and Guan (2015) showed that the use of interactive media devices was more strongly associated with sleep difficulties

Table 2. Regression analysis of the relation between children's overall electronic media use and evening electronic media use and napping, total sleep time, and sleep consolidation.

Overall Electronic Media Use	Napping			Total Sleep Time			Sleep Consolidation		
	B	*SE*	β	*B*	*SE*	β	*B*	*SE*	β
Step 1									
Mother's education	.51	2.29	.02	2.96	3.24	.05	−.00	.00	−.03
Mother's employment	8.38	6.42	.11	−7.90	8.21	−.05	−.01	.01	−.11
Household income	.02	2.33	.00	−5.01	2.97	$-.10^+$	.00	.00	.02
Child's age	−10.70	3.79	−.21**	−15.39	4.70	−.17**	.02	.01	.24**
Childcare attendance	1.90	1.46	.10	.24	1.80	.01	−.00	.00	$-.13^+$
R^2	$.03^+$			.03**			.04*		
Step 2									
TV viewing	3.87	1.15	.25**	1.56	1.48	.06	−.00	.00	−.23**
Incr. R^2/R^2	.06***/.08**			.00/.03**			.06**/.09**		
Step 3									
Tablet use	1.51	1.53	.08	−1.98	1.85	−.06	−.00	.00	$-.14^+$
Smartphone use	6.95	3.86	$.14^+$	−5.27	3.38	−.08	−.01	.01	−.17*
Game player use	−.45	2.80	−.02	.21	2.98	.00	.00	.00	.05
Laptop use	−.94	2.88	−.03	−.43	3.21	−.01	−.00	.00	−.02
iPod use	−2.19	3.21	−.06	3.33	5.09	.04	.00	.00	.08
Incr. R^2/R^2	.02/.08**			.01/.03*			.04/.11**		
F	2.56**			2.10*			3.18**		

Evening Electronic Media Use	Napping			Total Sleep Time			Sleep Consolidation		
	B	*SE*	β	*B*	*SE*	β	*B*	*SE*	β
Step 1									
Mother's education	.22	2.30	.01	2.45	3.24	.04	.00	.00	−.01
Mother's employment	7.58	6.53	.10	−7.47	8.23	−.05	−.01	.01	−.09
Household income	−.76	2.34	−.03	−5.37	2.97	$-.10^+$	.00	.00	.06
Child's age	−11.60	3.87	−.23**	−15.21	4.70	−.17**	.02	.01	.26**
Childcare attendance	1.31	1.50	.07	.19	1.80	.01	−.00	.00	−.10
R^2	$.03^+$			.03**			.04*		
Step 2									
Evening TV viewing	5.58	2.93	$.14^+$	−.74	3.68	−.01	−.01	.00	$-.14^+$
Incr. R^2/R^2	.03*/.05*			.00/.03**			.03*/.06**		
Step 3									
Evening tablet use	4.86	4.28	.09	−5.28	5.85	−.05	−.01	.01	−.16*
Evening smartphone use	26.34	11.80	.17*	−12.64	9.90	−.07	−.04	.01	−.20**
Evening game player use	.97	8.35	.01	−.21	10.32	−.00	.00	.01	.01
Evening laptop use	−6.61	9.43	−.06	−10.93	11.09	−.05	.00	.01	.01
Evening iPod use	−1.82	11.12	−.01	27.23	18.25	.08	.01	.01	.06
Incr. R^2/R^2	.04/.06*			.01/.03*			.06*/.11**		
F	2.16*			2.16*			3.08**		

Note. $^+p < .10$. $^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.
Analyses control for mother's education, mother's employment, household income, child's age, and childcare attendance

than the use of more passive media devices. This may explain our findings regarding tablets and iPods. However, we did not observe any relation between children's use of other interactive devices, such as smartphones, game players, and laptops and their bedtimes. Moreover, children's television use, considered to be a more passive device, was associated with later bedtimes. As such, it may not be the degree of interactivity of devices that matters but instead other attributes, such as the device's screen size. In our prior work, we found that electronic media with relatively larger screen sizes, such as tablet computers and televisions, were more consistently associated with compromised sleep compared with other devices, such as game players and iPods (Nathanson & Beyens, 2018). Perhaps small screen sizes attenuate the impact of exposure to short-wavelength blue light. Continued research is needed to understand why certain types of media are related to sleep outcomes among children.

All in all, the unique relationships of different types of electronic media with children's bedtimes emphasize that media is a multi-dimensional construct that comprises a wide range of devices that can affect children in distinct ways. Not all electronic media use coincides with a delay in bedtime, and not all electronic media use coincides with earlier bedtimes. And still, even when media use coincides with earlier bedtimes (as we found with iPods), questions remain as to whether using media at around bedtime might ultimately result in better sleep. In fact, our prior work suggests the opposite, indicating a trend toward increased daytime sleepiness for preschoolers spending more time using iPods at around bedtime (Nathanson & Beyens, 2018).

Besides relationships with bedtimes and wake times, the current study also found that heavier television viewing was associated with more napping. There are several possible explanations for this finding. First, television exposure and nap time may coincide because parents use television to help their children fall asleep during mid-day rest periods. The majority of American preschoolers either nap or are encouraged to nap (Weissbluth, 1995), perhaps due to cultural beliefs about the value of napping for development. As a result, caregivers may rely on sleep-aids, like television, to assist children in falling asleep at scheduled nap times. Alternatively, children may unintentionally fall asleep in front of the television. Although children have a reduced need for naps as they mature, research has found that youngsters will fall asleep mid-day if placed in situations that are conducive to sleep (e.g., mandatory rest periods at daycare centers; Ward, Gay, Anders, Alkon, & Lee, 2007). The sedentary nature of television watching may therefore encourage napping even if it is not needed. Indeed, Jones and Ball (2013) found that a majority of three-year-olds in their sample engaged in opportunistic napping, such as falling asleep in the living room while watching television. The exact role that media plays in napping should be explored in future research.

In addition, we found that television exposure, tablet use, and smartphone use were all related to less consolidated sleep. In other words, these forms of media exposure were all related to less mature sleep patterns among

preschoolers. As children transition out of infancy, a greater proportion of their total sleep time occurs overnight (Iglowstein et al., 2003). Moreover, total sleep time gradually declines as children age and yet, increases in cognitive function occur with maturation. This suggests that the total amount of sleep is less important to cognitive development compared with the ratio of sleep that occurs at night. In fact, some studies (e.g., Bernier et al., 2013; Dionne et al., 2011) have found that sleep consolidation was the best predictor of linguistic and cognitive outcomes among children compared with measures of nighttime sleep or daytime sleep alone. As a result, one of the reasons why electronic media exposure may be problematic for young children's health is its impact on sleep consolidation. The association between media exposure and sleep consolidation, to date, has not been explored and represents an important step toward understanding the relationship between media use and children's health outcomes.

A limitation of this study is that data were obtained through parent report. Since both children's media use and sleep behavior may be difficult to estimate, mothers' reports can be biased. Rather than using parent report, future research may consider using observations or time diaries to gain more accurate data. In addition, because the data of this study are cross-sectional, it was not possible to assess the causality of the relation between preschoolers' electronic media use and sleep. Therefore, it is unknown if children's electronic media use leads to delayed bedtimes, or if delayed bedtimes create more opportunities for children to use electronic media. Intervention studies that examine whether reducing children's media use can improve the timing of children's sleep would be worthwhile.

Across the lifespan, the relation between electronic media use and sleep time appears to undergo interesting developmental trajectories. While screen time shifts sleep time in the preschool years, screen time displaces sleep time in childhood and adolescence (Arora et al., 2014; Nuutinen et al., 2013; 2014; Van den Bulck, 2004), but, again, shifts sleep time in adulthood (Custers & Van den Bulck, 2012; Exelmans & Van den Bulck, 2016). However, the implications for time-shifted sleep in preschoolers compared to adults may be quite different, since the brain is undergoing rapid development during the preschool-age years. In addition, the coincidence of electronic media use with less mature sleep patterns among preschoolers may have implications for their cognitive development. The widespread use of electronic media and the increasing popularity of mobile media devices among children warrant further investigations into the potential consequences of electronic media for children's sleep.

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