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Early Childhood Media Exposure and Self-Regulation: Bidirectional Longitudinal Associations

Abstract

Objective: To investigate: 1) prospective associations between media exposure (television viewing, computers, and electronic games) at 2 years and self-regulation at 4 and 6 years, and 2) bidirectional associations between media exposure and self-regulation at 4 and 6 years. We hypothesized that media exposure and self-regulation would show a negative prospective association and subsequent bidirectional inverse associations. **Methods:** Data from the nationally-representative Longitudinal Study of Australian Children when children were aged 2 years ($n = 2786$) and 4/6 years ($n = 3527$) were used. Primary caregivers reported children's weekly electronic media exposure. A composite measure of self-regulation was computed from caregiver-, teacher-, and observer-report data. Associations were examined using linear regression and cross-lagged panel models, accounting for covariates. **Results:** Lower television viewing and total media exposure at 2 years were associated with higher self-regulation at 4 years (both $\beta = -0.02$; 95% confidence interval [CI], -0.03 to -0.01). Lower self-regulation at 4 years was also significantly associated with higher television viewing ($\beta = -0.15$; 95% CI, -0.21 to -0.08), electronic game use ($\beta = -0.05$; 95% CI, -0.09 to -0.01), and total media exposure ($\beta = -0.19$; 95% CI, -0.29 to -0.09) at 6 years. However, media exposure at 4 years was not associated with self-regulation at 6 years. **Conclusions:** Although media exposure duration at 2 years was associated with later self-regulation, and self-regulation at 4 years was associated with later media exposure, associations were of small magnitude. More research is needed to examine content quality, social context, and mobile media use and child self-regulation.

Disciplines

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Title: Early childhood media exposure and self-regulation: Bi-directional longitudinal associations

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Early childhood media exposure and self-regulation: Bi-directional longitudinal associations

ABSTRACT

Objective: To investigate: i) prospective associations between media exposure (television viewing, computers, and electronic games) at 2 years and self-regulation at 4 and 6 years, and ii) bi-directional associations between media exposure and self-regulation at 4 and 6 years. We hypothesized that media exposure and self-regulation would display a negative prospective association and subsequent bi-directional inverse associations.

Methods: Data from the nationally-representative Longitudinal Study of Australian Children (LSAC) when children were aged 2 (n=2786) and 4/6 years (n=3527) were used. Primary caregivers reported children's weekly electronic media exposure. A composite measure of self-regulation was computed from caregivers-, teacher-, and observer-report data. Associations were examined using linear regression and cross-lagged panel models, accounting for covariates.

Results: Lower television viewing and total media exposure at 2 years were associated with higher self-regulation at 4 years (both β -0.02; 95% confidence interval [CI] -0.03, -0.01). Lower self-regulation at 4 years was also significantly associated with higher television viewing (β -0.15; 95% CI -0.21, -0.08), electronic game use (β -0.05; 95% CI -0.09, -0.01), and total media exposure (β -0.19; 95% CI -0.29, -0.09) at 6 years. However, media exposure at 4 years was not associated with self-regulation at 6 years.

Conclusions: Although media exposure duration at 2 years was associated with later self-regulation, and self-regulation at 4 years was associated with later media exposure, associations were of small magnitude. More research is needed examining content quality, social context, and mobile media use and child self-regulation.

64 **Key words:** Preschool, toddler, television, electronic screen behavior, self-control

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67 **What's New:** Although higher levels of media exposure were associated with poorer self-

68 regulation in early childhood, and poorer early self-regulation was associated with higher media

69 exposure, associations were relatively small. The context and content of early childhood media use

70 requires further investigation.

71

INTRODUCTION

Children's self-regulation – the ability to control their behavior, emotional reactions, and social interactions despite contrary impulses and distraction¹ – predicts their academic success, and health, wealth, and criminal convictions in adulthood.² Early childhood is a foundational period of self-regulatory development,³ and individuals who improve in self-regulation across childhood display improved adult outcomes.² Targeting modifiable environmental factors that influence development of self-regulation in early childhood is therefore suggested as a viable means to reduce societal costs and increase population health.^{1, 2}

One hypothesized determinant of early childhood self-regulation is time spent engaged with electronic media, such as television viewing and electronic games. The ubiquity of electronic devices has resulted in high levels of media exposure among young children in the United States⁴ and internationally.⁵ The 2016 American Academy of Pediatrics guidelines recommend that electronic media exposure not displace other enriching activities or social interactions, not be used as a chief way to calm children down, and be limited to no more than 1 hour/day for 2 to 5 year-old children.⁶ Yet, nationally-representative data from the United States indicate that 2 to 4 year-olds accumulate, on average, almost 2 hours of electronic media use per day.⁴ Australian guidelines also recommend that screen time should be limited to no more than 1 hour/day for 2 to 5 year-old children,⁷ whereas the most recent national data indicate that 2 to 4 year-olds accumulated, on average, approximately 1.5 hours of electronic media use per day in 2011-2012.⁸

Recent guideline changes in the United States reflect concern that using electronic media as a tool to distract children or regulate their behaviors⁹ may diminish children's opportunities to develop the internal mechanisms required to calm themselves in the long-term.^{10, 11} Furthermore, the transactional associations between media exposure and self-regulation in early childhood¹² – in which more dysregulated young children consume more media,¹³ which in turn may influence their

development of self-regulation – need to be examined. Few studies have investigated associations between media exposure and self-regulation in young children,^{13, 14} and none have examined longitudinal reciprocal associations. Understanding these associations could inform approaches to enhance self-regulatory abilities or achieve developmentally-appropriate levels of media exposure. Therefore, the purpose of this study was to examine: i) prospective associations between media exposure at 2 years and self-regulation at 4 and 6 years, and ii) bi-directional associations between media exposure and self-regulation at 4 and 6 years. We hypothesized that media exposure and self-regulation would display a negative prospective association and subsequent bi-directional inverse associations.

Methods

Participants

Data were drawn from the Birth (B) cohort of the nationally-representative Longitudinal Study of Australian Children (LSAC; N = 4606), for which the design and methods have been previously described.¹⁵ Specifically, this study used data from Waves 2 (2006), 3 (2008), and 4 (2010), when children were aged 2-3, 4-5 and 6-7 years, respectively (hereafter referred to as 2, 4, and 6 years). Data on children's media use were collected at all three waves, however items to form a self-regulation composite score were collected only at 4 and 6 years. It is noted that the caregiver-reported measures of media exposure were completed prior to the widespread uptake of mobile media devices such as electronic tablets. As such, the assessment of media exposure did not include mobile phones and tablets; devices to which young children now have considerable access.⁴ However, recent survey data show that TV programming remains the primary mode of media consumption for young children, whether viewed on large or handheld screens.⁴ As such, analysis of these data still has relevance to modern media. The Australian Institute of Family Studies Ethics

Committee approved LSAC. Both primary caregivers and teachers provided written informed consent for participation.

Variables

Electronic media exposure. Primary caregivers completed questionnaire items asking them to report the total number of hours that their child spent: i) watching television/DVDs/videos (television viewing), ii) using a computer, and iii) playing electronic games separately for a typical weekday and weekend day. Weekday and weekend values were weighted, summed and averaged to provide daily estimates of time in individual behaviors and total media exposure (sum of television viewing, computer use, and electronic game use).

Self-Regulation. Children's self-regulation at 4- and 6-years of age was assessed using survey items (Table 1), which closely paralleled those used by Moffitt et al.², to create a robust, reliable, and strongly predictive self-regulation factor. Constituent items of this factor index the extent to which children can control their thinking and attention (e.g., sees tasks through to the end), behaviour (e.g., restless, overactive, cannot stay still for long), and emotions (e.g., often has temper tantrums). Following the protocols of Moffitt et al.,² parent- (11 items), teacher- (8 items), and observer-report (1 item) ratings of children's self-regulation were standardized and then averaged to create a single composite score ($M \sim 0$, $SD \sim 0.5$), with lower values reflecting more self-regulation problems. Standardization was necessary because items were rated on a scale from 1 to 3, 1–5, or 1–6, to indicate frequency or degree of the identified behaviour. The resulting factor maintained comparable significant inter-item correlations and strong internal consistency ($\alpha = 0.82$ in the current study) as that reported in Moffitt et al.² study ($\alpha = 0.86$). While the current factor was created in a constrained age range, compared to Moffitt et al.'s² factor that combined data taken between ages 3 and 11 years, further analysis of the factor presented in this paper indicated that it

strongly predicted a wide range of outcomes in adolescence.¹⁶ Specifically, a 1-SD lower self-regulation score at 4 or 6 years was related to a ~1.5-2.5 times greater risk of self-harm, suicidal ideation, school truancy, mental health issues, smoking, violent and property offences, and alcohol use in adolescence (14-15y).¹⁶ As such, psychometric reliability and longitudinal predictive validity both support the appropriateness of this factor. Further, the correlation between self-regulation at age 4 and age 6 was high ($r = 0.63$).

< insert Table 1 here >

Demographic Factors and Covariates. To account for factors that might confound associations,¹⁷ several covariates were entered in models, including child age and sex. Family income was coded as: <AUD\$1000/week (low); AUD\$1000-\$1999/week (medium); and, >AUD\$2000/week (high).¹⁸ The primary caregiver's highest level of education was categorised as "less than or equal to high school" or "tertiary" education. Because parenting behaviors may influence children's self-regulatory capacities,¹⁷ and hostile parenting contributes to and exacerbates conduct problems in children,¹⁹ parenting hostility was included as a covariate in analyses. Using a 10-point Likert scale (1 = "not at all" to 10 = "all the time"), caregivers reported on five items, modified from previous surveys,^{20, 21} relating to how they felt or behaved with their child (e.g., I have lost my temper with this child).²² Items were summed and averaged to give final values.

Analytic Strategy

Longitudinal associations between electronic media exposure at 2 years and self-regulation at 4 and 6 years were examined using linear regression models in Stata v.13 (Stata Corporation,

College Station, TX). Interactions were used to investigate if associations varied by child sex, primary caregiver education and exposure to hostile parenting (dichotomously coded as “high exposure” (top 20% of sample) and “other” (remaining 80%)).²² Because items to form a self-regulation composite score were not collected at 2 years, investigation of bi-directional associations at this age were not possible. Bidirectional associations between media exposure and self-regulation at 4 and 6 years were investigated using cross-lagged panel models in Mplus version 7.²³ Cross-lagged models are a suitable analytic approach for simultaneously examining bidirectional relationships between variables over time. This is because they test stability paths (e.g., media exposure at 4 years and media exposure at 6 years), concurrent paths (e.g., media exposure at 4 years and self-regulation at 4 years), and cross-lagged paths (e.g., media exposure at 4 years and self-regulation at 6 years; self-regulation at 4 years and media exposure at 6 years). Separate models were conducted for total media exposure, television viewing, computer use, and electronic game use. The multiple group function in Mplus was used to test for interactions; that is, whether the cross-lagged associations varied by child sex, primary caregiver education and exposure to hostile parenting, using sequential testing of each cross-lagged path. For example, to examine sex differences, the lagged paths were constrained to be equal for boys and girls (fully constrained model). The model was then retested with one path unconstrained, and the χ^2 difference relative to the fully constrained model was derived. If statistically significant, the unconstrained path differed significantly between boys and girls. Findings and interactions were considered statistically significant at $P < 0.05$.

For bi-directional analyses between electronic media exposure and self-regulation at 4 and 6 years, a total of 1079 children had missing data for electronic media use at both time points and were excluded from analyses. The remaining children ($N = 3527$) had electronic media and self-regulation data for at least one of the two time points, and missing data were handled using full

information maximum likelihood.²⁴ Approaches such as full information maximum likelihood avoid uncertainties from estimating data and provide unbiased estimates of missing parameters in large samples while retaining natural variability in missing data.²⁴ For longitudinal associations between electronic media exposure at 2 years and self-regulation at 4 and 6 years (N = 2786), a further 741 children were missing data on electronic media use at 2 years, and were excluded from analyses.

Results

Descriptive Statistics

The sample included 2786 children at 2 years and 3527 children at 4/6 years (Supplementary Table 1). Children who were excluded due to missing data at 2 years or 4/6 years were more likely to have lower family income ($P < 0.001$), and lower primary caregiver education ($P < 0.001$) than those included in analyses. No significant differences were observed by sex or for hostile parenting. The highest level of education for primary carers was less than or equal to high school for 35.8%-39.2% of participants, while 17%-18.6% had weekly household incomes of <AUD\$1000/week. Average television viewing increased slightly from 2 to 4 years and then decreased slightly from 4 to 6 years, whereas computer and electronic game use increased with increasing age, resulting in total media exposure increasing from approximately 2 to 2.5 hours/day from 2 to 6 years (Supplementary Table 2).

Total Media Exposure at 2 years and Self-Regulation at 4 and 6 years

Total media exposure and television viewing at 2 years were associated with self-regulation at 4 years, but not at 6 years (Table 2). The associations, however, were weak: a 60-minute/day lower exposure to total media or television viewing at 2 years was associated with a 0.02 unit (0.04

standard deviations) higher self-regulation score at 4 years. Associations did not vary by sex, caregiver education or hostile parenting.

< insert Table 2 here >

Bi-directional Associations Between Media Exposure and Self-regulation at 4 and 6 years

Total media exposure

Total media exposure at 4 years was not associated with self-regulation at 6 years; however, self-regulation at 4 years was associated with total media exposure at 6 years (Figure; Table 3). A one unit (2.3 standard deviation) increase in self-regulation between 4 and 6 years of age was associated with an 11.4 minute/day mean decrease in total media exposure. Associations between self-regulation at 4 years and total media exposure at 6 years did not vary by child sex or hostile parenting, but did vary by caregiver education ($P = 0.046$). Among children of tertiary educated caregivers, a one unit (2.3 SD) increase in self-regulation between 4 and 6 years of age was associated with a 16.2 min/day mean decrease in total media exposure ($\beta -0.27$; 95% confidence interval [CI] -0.39, -0.16), whereas associations were not significant among children of high school educated caregivers ($\beta -0.07$; 95% CI -0.23, 0.10).

< insert Figure and Table 3 here >

Television Viewing

Although television viewing at 4 years was not associated with self-regulation at 6 years, self-regulation at 4 years was associated with television viewing at 6 years (Table 3; Supplementary Figure 1). A one unit (2.3 standard deviation) increase in self-regulation between 4 and 6 years of

age was associated with a 9 min/day mean decrease in television viewing. Associations between self-regulation at 4 years and total media exposure at 6 years did not vary by child sex, caregiver education or hostile parenting.

Computer Use

Computer use at 4 years was not associated with self-regulation at 6 years, and self-regulation at 4 years was not associated with computer use at 6 years (Table 3; Supplementary Figure 2). However, associations between self-regulation at 4 years and computer use at 6 years differed by caregiver education ($P = 0.048$). Among children of tertiary educated caregivers, a one unit (2.3 standard deviation) increase in self-regulation between 4 and 6 years of age was marginally associated with a 2.4 min/day mean decrease in computer use ($\beta -0.04$; 95% CI -0.08, 0.005); associations were in the opposite direction in children of high school educated caregivers ($\beta 0.04$; 95% CI -0.1, 0.10). Associations did not vary by child sex or hostile parenting.

Electronic Games

Electronic game use at 4 years was not associated with self-regulation at 6 years, however, self-regulation at 4 years was associated with electronic game use at 6 years (Table 3; Supplementary Figure 3). A one unit (2.3 standard deviation) increase in self-regulation between 4 and 6 years of age was associated with a 3 min/day mean decrease in electronic game use. Associations between self-regulation at 4 years and electronic game use at 6 years did not vary by child sex or hostile parenting, but did vary by caregiver education ($P = 0.046$). Among children of tertiary educated caregivers, a one unit (2.3 standard deviation) increase in self-regulation between 4 and 6 years of age was associated with a 4.8 min/day mean decrease in electronic game use ($\beta -$

0.08; 95% CI -0.12, -0.04); associations were not significant among children of high school educated caregivers (β 0.0; 95% CI -0.07, 0.07).

Discussion

Low self-regulation abilities² and excessive media exposure^{11, 25, 26} in early childhood have been linked to subsequent development and health outcomes in children. This study is the first in children aged 2 to 6 years to simultaneously investigate this topic transactionally, to examine if early media exposure is detrimentally associated with young children's subsequent ability to self-regulate, or if children with low self-regulatory ability subsequently spend more time being exposed to media. Although lower media exposure at 2 years was associated with better self-regulation at 4 years, and better self-regulation at 4 years was associated with lower media exposure at 6 years, associations were of small magnitude, and media exposure at 4 years was not associated with self-regulation at 6 years.

One previous study among infants also found that early self-regulatory abilities predicted later media exposure,¹³ although the effect appeared to be stronger in that study compared to our results. Radesky and colleagues¹³ found that 39% of 7450 9-month-olds in the US nationally-representative Early Childhood Longitudinal Study had moderate/severe regulatory difficulties, and those children were exposed to 9 minutes/day more media at 2 years than children without difficulties. In our study, children needed to experience a large improvement in self-regulation between 4 and 6 years – equivalent to two standard deviations from the population mean or an increase from the ~2nd to the 50th percentile - to display a decrease in television viewing or total media exposure of 9 or 11 minutes/day, respectively, over the same period. However, several methodological differences between the studies, such as the sample age, assessment of self-regulation, and the analytical approach, are likely to have contributed to differences in findings.

286 To our knowledge, this is the first longitudinal study to investigate if media exposure at 2 or
 287 4 years has a detrimental impact on children's subsequent ability to self-regulate. Although there
 288 are plausible mechanisms,^{10, 27, 28} media exposure at 4 years did not predict self-regulation at 6
 289 years. Likewise, although the associations between total media exposure and television viewing at 2
 290 years and self-regulation at 4 years were statistically significant, they may not have been clinically
 291 or behaviorally meaningful; a large difference in total media exposure or television viewing
 292 (60min/day or 80% of 1 SD) was associated with a relatively small difference in self-regulation
 293 (<5% of 1 SD). This suggests that other factors during early childhood may be stronger predictors
 294 of children's self-regulation than media exposure. For example, in our analyses, lower family
 295 income (standardised β 0.05; 95% CI 0.02, 0.07, $P = 0.001$), being a boy (standardised β 0.12; 95%
 296 CI 0.09, 0.15, $P < 0.001$), and being exposed to higher levels of hostile parenting (standardised β -
 297 0.09; 95% CI -0.11, -0.07, $P < 0.001$) at 4 years – all established predictors of self-regulation¹⁷ -
 298 were significantly and detrimentally associated with a child's self-regulation at 6 years, whereas
 299 media exposure was not. However, LSAC only assessed duration of media exposure, not other
 300 aspects of media use linked with child development, such as content quality,^{14, 27, 29} use of media to
 301 calm child distress,⁹ or use at meals or bedtime.³⁰ This study also used a composite measure of self-
 302 regulation, while other studies have examined constructs such as social-emotional development
 303 (including emotion regulation)^{9, 30} or executive functioning (including cognitive regulation).^{14, 29}

304 Our results indicated that associations between self-regulation at 4 years and total media
 305 exposure, computer use, and electronic game use at 6 years were stronger among children of tertiary
 306 educated rather than high school educated caregivers. This is despite the fact that children of high
 307 school educated caregivers were exposed to ~30 minutes/day more television and total media at
 308 each age compared to children of tertiary educated caregivers (e.g., television viewing at 4 years:
 309 168 ± 103 minutes/day vs. 133 ± 83 minutes/day, respectively). This finding is somewhat in

contrast to cross-sectional findings indicating that associations between television viewing and school readiness skills, including executive functions, were stronger in children of lower-income than higher-income families.³¹ One potential explanation is that households of tertiary educated caregivers may be more likely to have rules to limit media exposure, which contributes to lower overall levels in that group.³² These limits might be particularly effective among young children with strong self-regulatory capacity who may be able to adhere to them. However, tertiary educated caregivers may still use electronic media as a coping mechanism if their child has self-regulatory difficulties, or such children may demand media more. In contrast, in households of high school educated caregivers, higher amounts of media exposure may be more common for children overall, and not dependent on child behavioral characteristics.

Our study has several strengths, including the large, longitudinal sample, the age range of 2 to 6 years spanning a critical period for both self-regulatory development³ and the establishment of media behaviors,¹¹ and the analytic approach capable of investigating bi-directional associations. However, participants excluded due to missing data were more likely to have lower family incomes and lower caregiver education than those included in analyses, which may limit the representativeness of our findings. Because children of lower SES families in our sample tended to be exposed to higher levels of electronic media and also displayed poorer self-regulation, it is possible that missing data may have impacted the findings. Further, self-regulation was not assessed using direct child assessment. However, a highly comparable multi-source index has been successfully used as a robust predictor of a range of real-world outcomes in prior research.² Likewise, children's electronic media use and exposure to hostile parenting were also parent-reported, using instruments with unknown psychometric properties, and thus vulnerable to biases. However, our finding that hostile parenting at 4 years was more strongly related to children's self-regulation at 6 years than family income provides supporting evidence of that tool's usefulness. As

previously noted, LSAC provided data on the types of media devices that children used and the duration of media they were exposed to, but information on other aspects of children’s media use that may potentially influence their self-regulation, such as the media content or the surrounding social context, that may potentially influence children’s self-regulatory capabilities, were not available. Furthermore, the LSAC data used in our analyses pre-dated the widespread ownership of mobile electronic devices, which are likely to be more potent than traditional fixed devices, given that they can be readily available to calm a distressed child, potentially negating their need to self-regulate, and thus the development of impulse control skills. These data might therefore be considered a useful baseline for comparison with data collected following the proliferation of mobile digital media.

Conclusion

Although lower media exposure at 2 years was associated with better self-regulation at 4 years, and better self-regulation at 4 years was associated with lower media exposure at 6 years, associations were relatively small. While effect sizes might not be clinically significant for individual children, they may be important on a population scale, and more research is needed regarding child self-regulation and media use context (e.g., co-viewing, use during meals or bedtime) and content (e.g., educational quality, linear programming versus interactive mobile applications). Yet, other psychosocial and parenting-related factors remain stronger determinants of early childhood self-regulation and should therefore continue to be targets of intervention.

Abbreviations: LSAC - Longitudinal Study of Australian Children

358

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453 Figure Captions

454

455 **Figure. Cross-lagged model examining associations between total media exposure and self-**
456 **regulation between 4 and 6 years of age**

457

458 Unstandardized β coefficients are presented. The subscript numbers indicate the participants' age (4 or 6
459 years).

Table 1

Self-Regulation item correspondences between Moffitt et al. (2011)² and the current study

Factor	Moffitt et al. (2011) items	Corresponding LSAC items
Impulsive Aggression	Flies off handle (P/T) Fights (P/T) Requires attention (O)	Often has temper tantrums or hot tempers (P/T) Often fights with other children or bullies them (P/T) Often argumentative with adults (P/T)
Hyperactivity	Runs and jumps about (P/T) Cannot settle (P/T), restless (O) “On the go” as if “driven by a motor” (P/T) Difficulty sitting still (P/T) Has short attention span (P/T)	Restless, overactive, cannot stay still for long (P/T) Constantly fidgeting or squirming (P/T) If this child is upset, it is hard to comfort him/her (P/T)
Lack of Persistence & Inattention	Fails to finish tasks (P/T), trouble sticking to a task (S) Difficulty sticking to activity (P/T), brief attention to task (O) Lacks persistence in reaching goals (O) Easily distracted (P/T), difficulty paying attention (S)	The child likes to complete one task or activity before going on to the next (reversed) (P/T) Sees takes through to the end, good attention span (reversed) (P/T) The child stays with an activity (e.g., puzzle, construction, kit, reading) for a long time (reversed) (P/T) Easily distracted, concentration wanders (P/T/O)
Impulsivity	Acts before thinking (P/T), impulsive (O) Has difficulty awaiting turn (P/T) Shifts excessively between activities (P/T) Difficulty waiting turn (S) Talking while others are still talking (S) Low frustration tolerance (O)	Can stop and think things out before acting (reversed) (P/T) Shares readily with other children (reversed) (P/T) Degree of negative mood (withdrawn, uncooperative, sulky, seeming upset, angry) to interview (O)

Note. Factor names parallel those adopted by Moffitt et al. (2011). Notation following items indicates the source of the data. P = parent rating. T = teacher rating. O = observer rating. S = self-rating.

Table 2. β Coefficients for Associations Between Media Exposure at 2 years and Self-Regulation at 4 years and 6 years (n = 2786)

Media exposure ₂	Self-regulation ₄		Self-regulation ₆	
	Unstandardized β (95% CI)	Standardized β (95% CI)	Unstandardized β (95% CI)	Standardized β (95% CI)
Total Media exposure	-0.02 (-0.03, -0.004)*	-0.05 (-0.08, -0.01)*	-0.01 (-0.02, 0.004)	-0.02 (-0.06, 0.01)
Television Viewing	-0.02 (-0.03, -0.006)*	-0.05 (-0.08, -0.02)*	-0.01 (-0.03, 0.002)	-0.03 (-0.06, 0.004)
Computer	-0.02 (-0.08, 0.05)	-0.01 (-0.04, 0.03)	0.02 (-0.05, 0.01)	0.01 (-0.02, 0.05)
Electronic Games	0.04 (-0.06, 0.13)	0.01 (-0.02, 0.05)	0.06 (-0.05, 0.16)	0.02 (-0.02, 0.05)

Subscript numbers represent children's age (2, 4 or 6 years).

Coefficients are from linear regression models adjusted for children's age and sex, caregiver education, family income and hostile parenting.

Coefficients represent change in media exposure (60min/day).

*Significant at $p < 0.05$.

Associations did not differ by child sex, primary parent education or exposure to hostile parenting

Table 3. β Coefficients for Cross-Lagged Models Examining Associations Between Media Exposure and Self-Regulation at 4 years and 6 years

Path	Total Media exposure		Television Viewing		Computer		Electronic Games	
	Unstandardized β (95% CI)	Standardized β (95% CI)	Unstandardized β (95% CI)	Standardized β (95% CI)	Unstandardized β (95% CI)	Standardized β (95% CI)	Unstandardized β (95% CI)	Standardized β (95% CI)
Stability paths								
Media ₄ → Media ₆	0.38 (0.36, 0.41)*	0.41 (0.38, 0.44)*	0.33 (0.30, 0.35)*	0.40 (0.37, 0.42)*	0.21 (0.18, 0.24)*	0.22 (0.19, 0.25)*	0.23 (0.20, 0.27)*	0.20 (0.17, 0.24)*
Self-regulation ₄ → Self-regulation ₆	0.62 (0.59, 0.64)*	0.57 (0.55, 0.60)*	0.62 (0.59, 0.64)*	0.57 (0.55, 0.60)*	0.62 (0.59, 0.64)*	0.57 (0.55, 0.60)*	0.62 (0.59, 0.64)*	0.57 (0.55, 0.60)*
Cross-lagged paths								
Media ₄ → Self-regulation ₆	-0.002 (-0.01, 0.01)	-0.01 (-0.03, 0.02)	-0.004 (-0.02, 0.01)	-0.01 (-0.04, 0.02)	0.001 (-0.03, 0.03)	0.001 (-0.02, 0.03)	0.01 (-0.02, 0.04)	0.01 (-0.02, 0.03)
Self-regulation ₄ → Media ₆	-0.19 (-0.29, -0.09)* ^a	-0.06 (-0.09, -0.03)* ^a	-0.15 (-0.21, -0.08)*	-0.07 (-0.10, -0.04)*	-0.007 (-0.04, 0.03)	-0.007 (-0.05, 0.03)	-0.05 (-0.09, -0.01)* ^a	-0.04 (-0.08, -0.01)* ^a

Subscript numbers represent children's age (4 or 6 years).

Coefficients are from cross-lagged panel models adjusted for children's age and sex, caregiver education, family income and hostile parenting

Coefficients represent change in media exposure (60min/day).

* Significant at $p < 0.05$.

^a Differed significantly by caregiver education.

Associations did not differ by child sex or exposure to hostile parenting

Supplementary Table 1. Sample Descriptive Characteristics

	2 years	4 years
N	2786	3527
Child		
2 year-olds/4 year-olds*, N (%)	2186 (78.5%)	2696 (76.4%)
Sex (Boys), N (%)	1431 (51.4)	1842 (52.2)
Primary caregiver		
Sex (Female), N (%)	2711 (97.3%)	3396 (96.3%)
Age (y)	34.2 (4.8)	35.7 (5.0)
Born in Australia/New Zealand, N (%)	2322 (83.3%)	2908 (84.2%)
English is main language spoken at home, N (%)	2499 (89.7%)	3168 (89.8%)
Primary parent education, N (%)		
≤ High school	998 (35.8%)	1383 (39.2%)
Tertiary qualification	1788 (64.2%)	2144 (60.8%)
Weekly family income, N (%)		
< \$1000	474 (17.0%)	656 (18.6%)
\$1000 - \$1999	1285 (46.1%)	1635 (46.4%)
≥ \$2000	1027(36.9%)	1236 (35.0%)
Hostile parenting, (range = 1-10)	3.4 (1.4)	3.4 (1.4)

*Other children are 3 year-olds/5 year-olds

Supplementary Table 2. Media Exposure and Self-regulation Descriptive Values

	2 years^a	4 years^b	6 years^b
TV viewing (min/d), mean (SD)	112.2 (75.2)	119.4 (74.7)	109.6 (61.9)
Computer use (min/d), mean (SD)	7.2 (14.9)	17.6 (31.7)	25.1 (30.1)
Electronic games (min/d), mean (SD)	2.8 (10.4)	10.3 (28.4)	24.3 (32.6)
Total media exposure (min/d), mean (SD)	122.3 (81.2)	147.3 (95.9)	159.0 (89.7)
Self-regulation (z score), mean (SD)	-	0.017 (0.496) ^c	0.019 (0.533) ^d

^aN = 2786; ^bN = 3527; ^crange = -2.26 to 0.99; ^drange = -2.25 to 0.93

Supplementary Figure 1. Cross-lagged model examining associations between television viewing and self-regulation between 4 and 6 years of age

Unstandardized β coefficients are presented. The subscript numbers indicate the participants' age (4 or 6 years).

Supplementary Figure 2. Cross-lagged model examining associations between computer use and self-regulation between 4 and 6 years of age

Unstandardized β coefficients are presented. The subscript numbers indicate the participants' age (4 or 6 years).

Supplementary Figure 3. Cross-lagged model examining associations between electronic game use and self-regulation between 4 and 6 years of age

Unstandardized β coefficients are presented. The subscript numbers indicate the participants' age (4 or 6 years).