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

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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.

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

3
4
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ABSTRACT

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

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

52 **Results:** Lower television viewing and total media exposure at 2 years were associated with higher
53 self-regulation at 4 years (both β -0.02; 95% confidence interval [CI] -0.03, -0.01). Lower self-
54 regulation at 4 years was also significantly associated with higher television viewing (β -0.15; 95%
55 CI -0.21, -0.08), electronic game use (β -0.05; 95% CI -0.09, -0.01), and total media exposure (β -
56 0.19; 95% CI -0.29, -0.09) at 6 years. However, media exposure at 4 years was not associated with
57 self-regulation at 6 years.

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

62

63

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

65

66

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.

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INTRODUCTION

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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

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

105

106

Methods

107 Participants

108 Data were drawn from the Birth (B) cohort of the nationally-representative Longitudinal
109 Study of Australian Children (LSAC; N = 4606), for which the design and methods have been
110 previously described.¹⁵ Specifically, this study used data from Waves 2 (2006), 3 (2008), and 4
111 (2010), when children were aged 2-3, 4-5 and 6-7 years, respectively (hereafter referred to as 2, 4,
112 and 6 years). Data on children’s media use were collected at all three waves, however items to form
113 a self-regulation composite score were collected only at 4 and 6 years. It is noted that the caregiver-
114 reported measures of media exposure were completed prior to the widespread uptake of mobile
115 media devices such as electronic tablets. As such, the assessment of media exposure did not include
116 mobile phones and tablets; devices to which young children now have considerable access.⁴
117 However, recent survey data show that TV programming remains the primary mode of media
118 consumption for young children, whether viewed on large or handheld screens.⁴ As such, analysis
119 of these data still has relevance to modern media. The Australian Institute of Family Studies Ethics

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

122

123 **Variables**

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

130 *Self-Regulation.* Children's self-regulation at 4- and 6-years of age was assessed using survey
131 items (Table 1), which closely paralleled those used by Moffitt et al.², to create a robust, reliable,
132 and strongly predictive self-regulation factor. Constituent items of this factor index the extent to
133 which children can control their thinking and attention (e.g., sees tasks through to the end),
134 behaviour (e.g., restless, overactive, cannot stay still for long), and emotions (e.g., often has temper
135 tantrums). Following the protocols of Moffitt et al.,² parent- (11 items), teacher- (8 items), and
136 observer-report (1 item) ratings of children's self-regulation were standardized and then averaged to
137 create a single composite score ($M \sim 0$, $SD \sim 0.5$), with lower values reflecting more self-regulation
138 problems. Standardization was necessary because items were rated on a scale from 1 to 3, 1–5, or
139 1–6, to indicate frequency or degree of the identified behaviour. The resulting factor maintained
140 comparable significant inter-item correlations and strong internal consistency ($\alpha = 0.82$ in the
141 current study) as that reported in Moffitt et al.² study ($\alpha = 0.86$). While the current factor was
142 created in a constrained age range, compared to Moffitt et al.'s² factor that combined data taken
143 between ages 3 and 11 years, further analysis of the factor presented in this paper indicated that it

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

150

151 < insert Table 1 here >

152

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

164

165 **Analytic Strategy**

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

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

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

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

197

198 **Results**

199 **Descriptive Statistics**

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

210

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

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

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

217

218 < insert Table 2 here >

219

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

221 ***Total media exposure***

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

232

233 < insert Figure and Table 3 here >

234

235 ***Television Viewing***

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

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

242

243 ***Computer Use***

244 Computer use at 4 years was not associated with self-regulation at 6 years, and self-
245 regulation at 4 years was not associated with computer use at 6 years (Table 3; Supplementary
246 Figure 2). However, associations between self-regulation at 4 years and computer use at 6 years
247 differed by caregiver education ($P = 0.048$). Among children of tertiary educated caregivers, a one
248 unit (2.3 standard deviation) increase in self-regulation between 4 and 6 years of age was
249 marginally associated with a 2.4 min/day mean decrease in computer use ($\beta -0.04$; 95% CI -0.08,
250 0.005); associations were in the opposite direction in children of high school educated caregivers (β
251 0.04; 95% CI -0.1, 0.10). Associations did not vary by child sex or hostile parenting.

252

253 ***Electronic Games***

254 Electronic game use at 4 years was not associated with self-regulation at 6 years, however,
255 self-regulation at 4 years was associated with electronic game use at 6 years (Table 3;
256 Supplementary Figure 3). A one unit (2.3 standard deviation) increase in self-regulation between 4
257 and 6 years of age was associated with a 3 min/day mean decrease in electronic game use.
258 Associations between self-regulation at 4 years and electronic game use at 6 years did not vary by
259 child sex or hostile parenting, but did vary by caregiver education ($P = 0.046$). Among children of
260 tertiary educated caregivers, a one unit (2.3 standard deviation) increase in self-regulation between
261 4 and 6 years of age was associated with a 4.8 min/day mean decrease in electronic game use ($\beta -$

262 0.08; 95% CI -0.12, -0.04); associations were not significant among children of high school
263 educated caregivers (β 0.0; 95% CI -0.07, 0.07).

264

265

Discussion

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

275 One previous study among infants also found that early self-regulatory abilities predicted
276 later media exposure,¹³ although the effect appeared to be stronger in that study compared to our
277 results. Radesky and colleagues¹³ found that 39% of 7450 9-month-olds in the US nationally-
278 representative Early Childhood Longitudinal Study had moderate/severe regulatory difficulties, and
279 those children were exposed to 9 minutes/day more media at 2 years than children without
280 difficulties. In our study, children needed to experience a large improvement in self-regulation
281 between 4 and 6 years – equivalent to two standard deviations from the population mean or an
282 increase from the ~2nd to the 50th percentile - to display a decrease in television viewing or total
283 media exposure of 9 or 11 minutes/day, respectively, over the same period. However, several
284 methodological differences between the studies, such as the sample age, assessment of self-
285 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

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

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

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

344

345 **Conclusion**

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

354

355

356

357 **Abbreviations:** LSAC - Longitudinal Study of Australian Children

358

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360 partnership between the Department of Families, Housing, Community Services and
361 Indigenous Affairs (FaHCSIA), the Australian Institute of Family Studies (AIFS) and the
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365

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451

452

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).

460 **Table 1**

461

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

463

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 tasks 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)

464

465

466

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.

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

469

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)

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

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

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

474 *Significant at $p < 0.05$.

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

476

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

478 **6 years**

479

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

480

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

481

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

482

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

483

* Significant at $p < 0.05$.

484

^a Differed significantly by caregiver education.

485

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)

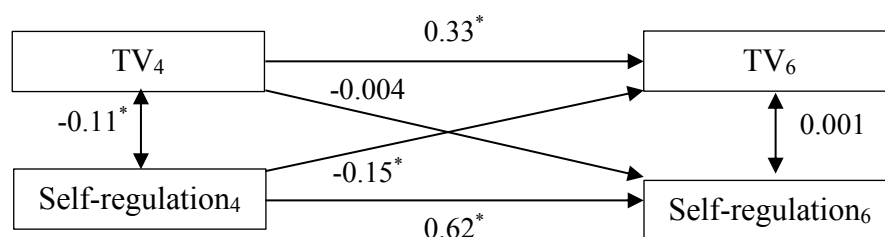
*Other children are 3 year-olds/5 year-olds

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

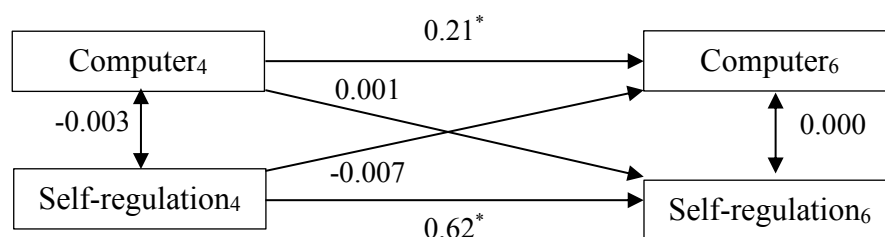
^aN = 2786; ^bN = 3527; ^crange = -2.26 to 0.99; ^drange = -2.25 to 0.93

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



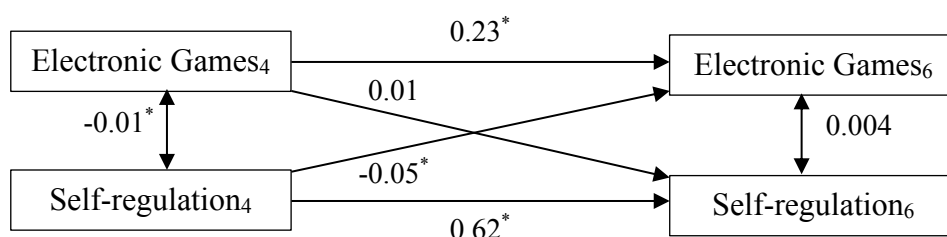
Unstandardized β coefficients are presented. The subscript numbers indicate the participants' age (4 or 6 years).

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).