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The Social Stratification of Early TV Consumption and Children's Cognitive, Language and Behavioral Development

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NON-TECHNICAL SUMMARY

The socio-economic status of families plays an important role in shaping parenting behavior and children's activities. Research shows, for example, that parents with higher socio-economic status spend more time reading to children whereas children from lower socio-economic backgrounds watch more television. These differences in so-called high-brow and low-brow activities are often cited as one of the reasons underlying the disadvantages in academic achievement and educational attainment observed for children from families with lower socio-economic status. Nonetheless, the immediate consequences of these activities, particularly of watching television, for children's cognitive and behavioral development are still the subject of controversial scientific and public debate.

In this paper, we used data on children living in Scotland and born between June 2004 and May 2005 to address three questions: (1) Are there differences in the growth of children's weekly television consumption from age two to age four depending on their parents' education? (2) Is early television consumption associated with differences in vocabulary, reasoning ability, and behavioral problems at age 5? (3) Does this association differ by parents' education?

Our analyses showed that television consumption was indeed higher for children of parents with lower education and also grew faster over time. But in the sample under study, we found no associations of television consumption with cognitive and language development and only very small ones with conduct problems and prosocial behavior. These associations with behavior were slightly larger for children whose parents attained lower secondary education or less. Given that we were able to account for many important drivers of both television consumption and child development, these results suggest that the impact of TV consumption on children's development is less pronounced than often assumed and may not play a major role in explaining socio-economic differences in children's academic achievement and educational attainment.
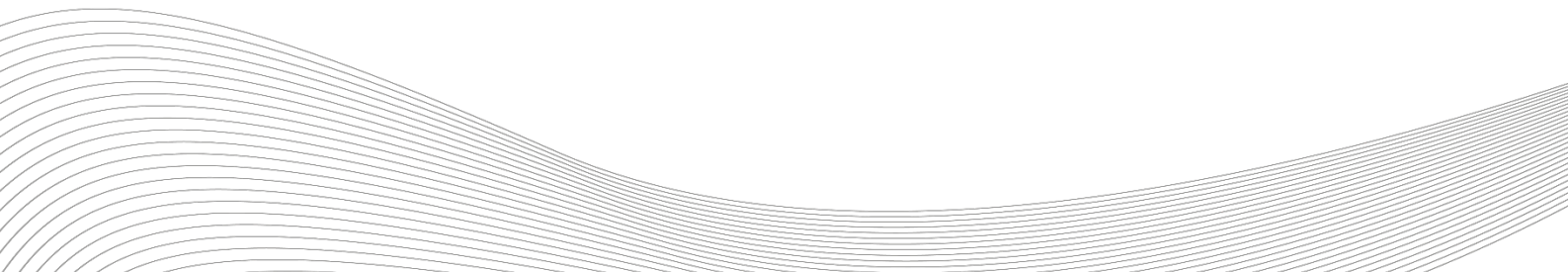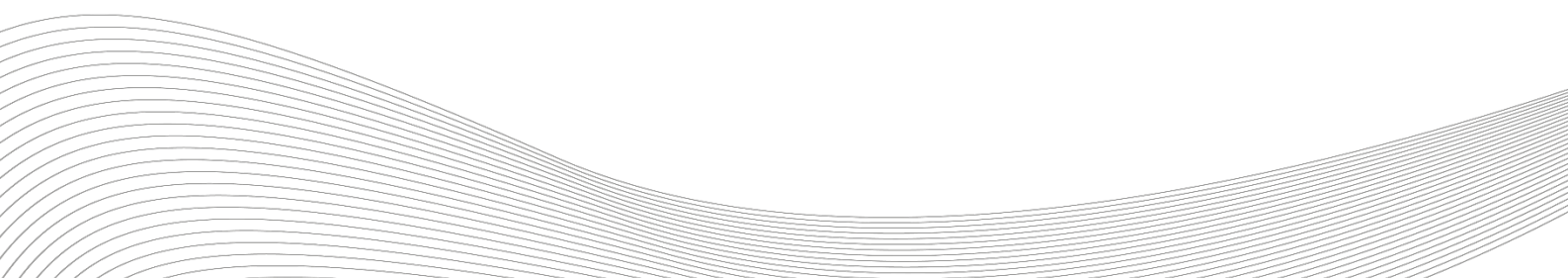
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ABSTRACT

The association between children's TV consumption and their development is subject of controversial scientific and public debate. Heavy TV consumption may be detrimental to children as flashing lights, quick edits and scene changes are overstimulating to developing brains. It may also involve less time children spent on more stimulating activities and interactions with their parents. In the present analysis, we use data from the 2004/5 birth cohort of the Growing Up in Scotland study and investigate the relationship between weekly hours of TV consumption – measured at the ages 2 to 4 and cumulatively – and children's language, cognitive and behavioral outcomes at age 5. Our analysis shows a gap in TV consumption by parental education that grows across early childhood. However, we did not find any substantive association between TV consumption and children's inductive reasoning and expressive language ability. There were small associations between TV consumption and conduct problems and prosocial behavior, particularly for children with lower educated parents. Nonetheless, these results suggest that the impact of TV consumption on children's development is less pronounced than often assumed.

Introduction

There is ample evidence of social stratification in leisure activities with so-called highbrow activities (e.g., reading books, attending exhibitions) being more common among higher social classes and lowbrow activities (e.g., TV consumptions, sporting events) being more frequent among lower social classes (Altintas 2012; Bihagen and Katz-Gerro 2000; Gracia 2015; Notten and Kraaykamp 2009b). Children in different social strata, therefore, are exposed to different patterns of cultural consumption which may in turn shape their own preferences (Notten, Kraaykamp, and Konig 2012). Moreover, highbrow activities have been found to be beneficial for life course outcomes such as educational attainment, while lowbrow activities have been found to be detrimental to children's school outcomes (Aschaffenburg and Maas 1997; Bourdieu and Passeron 1970; DiMaggio 1982; Dumais 2002; De Graaf, De Graaf, and Kraaykamp 2000; Kraaykamp and Eijck 2010; Lareau 2003; Notten and Kraaykamp 2009a, 2010). These activities may thus play an important role in the intergenerational transmission of social inequality.

However, the specific consequences of different activities for the development of children's abilities and behavior are still subject of heated debates, particularly in case of TV consumption. While the American Academy of Pediatrics (AAP, 2011) advises parents to avoid the use of media for children under the age of 24 months, this recommendation is solely based on experts stressing that other activities may be more stimulating than TV consumption for children's development. Although empirical literature on the impact of infant TV viewing on language and cognitive development has emerged over time (see the overviews by Anderson and Pempek 2005; Christakis 2009), the evidence for a causal relationship between TV consumption and developmental outcomes and for harmful effects of media exposure on infants and toddlers remains ambiguous (e.g. Donnellan and Ferguson 2014; Ferguson and Donnellan 2014; Zimmerman 2014).

Most observational studies used cross-sectional data and relied on single snapshot measures of infants' and toddlers' TV consumption. Exposure to TV, however, may vary over time so it is important to investigate whether its effects depends on children's age and on whether the exposure was sustained over a longer period. Therefore, the AAP recommends researchers use prospective, longitudinal studies to estimate the long-term effects of early media exposure on developmental outcomes (American Academy of Pediatrics 2011: 1044; see also Anderson and Pempek 2005: 519). While a few studies used longitudinal information and measure TV consumption at different points in time (e.g. Zimmerman and Christakis 2005),

they did not address cumulative effects of TV consumption through childhood and time-variant confounding (in addition to time-constant confounding). That is to say, children's TV consumption may change in response to their development or other dynamic factors like parental employment or place of residence.

In the current study, we investigated the consequences of TV consumption throughout early childhood for children's language ability, inductive reasoning ability, and behavioral development at the age of five. It contributes to the existing literature on media exposure and child development in several important ways. Firstly, we used a comparatively large, nationally representative sample of Scottish children that allowed us to gauge social stratification in the level and trajectory of TV consumption across early childhood along with its time-specific and cumulative effects. Secondly, we were able to account for a rich set of covariates that may influence both TV consumption and developmental outcomes such as family structure, socio-economic status, and mothers' concern about her child's development. Lastly, we integrated the social stratification and child development literature by examining whether developmental consequences of TV consumption were moderated by parental education. None of the existing studies on TV consumption and child development addressed potential effect heterogeneity by social background.

TV consumption and children's developmental outcomes

TV consumption during childhood can have a direct impact on children's development through the formal features of television or an indirect impact by decreasing play activities or parent-child interactions. The direct effect is the so-called "video deficit" (Anderson and Pempek 2005: 511) among young children. Research has shown that young children are able to easily imitate live demonstrations but struggle at imitating video demonstrations (Barr and Hayne 1999; Hayne, Herbert, and Simcock 2003). Only repeated exposure to televised demonstrations increases children's ability in imitating from television (Barr et al. 2010; Barr, Muentener, and Garcia 2007). In another line of research, two-year-old children have been successful in an object retrieval task when watching a toy being hidden through a window but performed very poorly when they watched the hiding event on TV (Schmitt and Anderson 2002; Suddendorf 2003; Troseth and DeLoache 1998). Children who interact with a native speaker also have a better language acquisition compared to learning language from a screen and this was even the case when the native speaker was recorded on tape (Grieser

and Kuhl 1988; Hirsh-Pasek et al. 1987; Krcmar, Grela, and Lin 2007; Kuhl, Tsao, and Liu 2003; Nelson et al. 1989).

Exposure to formal features of television such as flashing light, rapid scene changes, quick edits and auditory cuts could be overstimulating to developing brains (Christakis 2009:11). It may therefore train infants and toddlers to expect immediate and intense environmental input and therefore shortens concentration span and makes life in reality less exciting (Singer and Singer 1983). As a consequence, heavy exposure to television may induce attentional or other behavioral problems in early childhood or adolescence (Christakis 2009). In particular violent TV content prompts children to imitate aggressive behavior, desensitizes them to violence and aggression and is associated with depression and anxiety (Huesmann et al. 2003; Singer et al. 1998).

TV consumption may indirectly affect children's development by reducing parent-child interactions and spending less time in activities that are beneficial for children's cognitive ability, language growth and behavioral development. Both in terms of language acquisition and inductive reasoning ability parent-child interactions and a stimulating learning environment are deemed conducive in the early ages of a child (Nisbett et al. 2012; Shonkoff and Phillips 2000). Children's vocabulary growth is particularly prone to the immediate environment with more and better linguistic input by parents and caretakers resulting in more advanced vocabulary (Hurtado, Marchman, and Fernald 2008; Huttenlocher 1998; Weisleder and Fernald 2013; Zimmerman et al. 2009). It is also known that children's self-regulation of emotion, attention and behavior is interrelated and heavily reliant on their relationship with and support by caregivers. Young children "may be particularly vulnerable to emotion-linked disorders when parent-child relationships are insecure, coercive, or otherwise troubled." (Shonkoff and Phillips 2000: 109). Aside from parent-child interactions, self-directed play is as important for children's development. For instance, results from a randomized controlled trial have shown that block play improves language development among low- and middle-income toddlers (Christakis, Zimmerman, and Garrison 2007).

A negative link between children's TV consumption and parent-child interactions was evident in several empirical studies (Christakis et al. 2009; Mendelsohn et al. 2008; Tanimura, Okuma, and Kyoshima 2007). The quantity and quality of parent-child interactions not only decreased when children actively watched TV but were also lower in the presence of background television which is characterized by content that is not designed towards children, they pay little active attention to and being left on with the toddler present

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(Kirkorian et al. 2009; Pempek, Kirkorian, and Anderson 2014). Harmful effects of TV consumption on language development can be mitigated by parental co-viewing and more frequent and higher quality interactions (Fender et al. 2010; Mendelsohn et al. 2010). At the same time, they increase attention and responsiveness to media exposure (Barr et al. 2010; Fidler, Zack, and Barr 2010).

TV consumption in children's households also interferes with child activities that are known to have beneficial effects on developmental outcomes. Background television significantly reduces the length of toy play and children's attention towards play (Schmidt et al. 2008; Setliff and Courage 2011). It further reduces parental engagement with their children's play (Courage et al. 2010). Moreover, Armstrong and Greenberg (1990) found that background television limits children's cognitive processing capacity when exercising difficult and complex tasks. Other studies found that heavy TV consumption has a detrimental impact on children's time spent on reading or being read to and their reading comprehension (Koolstra and van der Voort 1996; Koolstra and Voort 1997; Rideout, Hamel, and Kaiser 2006; Vandewater et al. 2005).

Despite these findings on the relationships between TV consumption, parent-child interactions and child activities, the literature on the effects of TV consumption on children's language and cognitive outcomes provides mixed evidence. While several studies found detrimental effects of heavy exposure to TV during early childhood on language, cognitive or math skills (Byeon and Hong 2015; Chonchaiya and Pruksananonda 2008; Huang and Lee 2010; Richert et al. 2010; Tomopoulos et al. 2010; Zimmerman and Christakis 2005; Zimmerman, Christakis, and Meltzoff 2007), other studies found that television viewing in early childhood is not associated with language or cognitive skills (Gentzkow and Shapiro 2008; Robb, Richert, and Wartella 2009; Schmidt et al. 2009). With regard to behavioral problems, there appears to be more robust evidence on a positive association with TV viewing (Cheng et al. 2010; Christakis et al. 2004; Lillard et al. 2015; Miller et al. 2007; Mistry et al. 2007; Nathanson et al. 2014; Parkes et al. 2013) although a few studies did not provide evidence for this link (Foster and Watkins 2010; Stevens and Muslow 2006). The effect of infancy TV consumption on children's development may also depend on the content of the program. Adult TV has been found to have negative effects on infant cognitive ability or language development (Okuma and Tanimura 2009). In contrast, child-informative programs are either positively (Barr et al. 2010; Wright et al. 2001) or at least not negatively (Tomopoulos et al. 2010) associated with these outcomes.

Effect moderation by social background

In recent years, it has been demonstrated that the effects of various detrimental childhood conditions are less harmful for children from advantaged socio-economic background (Bernardi 2014; Grätz 2014; Torche and Echevarría 2011). This is because parents from higher social backgrounds are able to compensate potential disadvantages with other resources or counteracting activities. Similarly, we argue that parents from higher socio-economic backgrounds are able to compensate for children's TV consumption with other more cognitively stimulating resources (e.g. expensive toys) and activities (e.g. reading to children, museum visits). Moreover, they might anticipate the potentially harmful effects of TV consumption and increase the quality of the programs and that of other time spent with their children, for instance, by talking a lot to their children or by carefully considering the choice of play activities. Due to this compensatory effect among children from higher socio-economic backgrounds, we expect TV consumption to be more harmful for children from lower socio-economic backgrounds whose parents lack resources for compensation.

Data and Methods

Data and Sample

For our empirical analysis, we used Birth Cohort 1 from the Growing Up in Scotland (GUS) study (ScotCen Social Research 2013), which includes children born between June 2004 and May 2005 and living in Scotland at the time of sampling. Data collection first took place in April 2005 through May 2006 when children were around ten months old and was conducted annually until children were six years old and biannually afterwards (Anderson et al. 2007). In our study, we used information from the first five waves of data collection.

The original sample consisted of all babies with eligible birth dates from 130 randomly selected geographic areas. Date of birth and place of residence were obtained from Child Benefit records, which held 97% of Scottish residents with children at this time. Altogether, 5,217 children (80% of 6,583 initially contacted) were successfully recruited. Our analytical sample excluded minority populations with insufficient case numbers and thus consisted of singleton births by White, opposite-sex or single parents, and for which mothers were the survey respondents at the first interview. Starting at Wave 2, in which consistent reporting of children's TV consumption started, we followed the remaining 3,736 children until the fifth wave of data collection or until the child was lost to follow-up. Cases were considered lost to

follow-up as soon as they temporarily or permanently dropped out of the survey, changed to a primary respondent other than the mother, or were observed with missing values on either of the covariates or TV consumption. Our analyses on the association between TV consumption and developmental outcomes measured at age five was based on 2,687 children.

Measures

Around their third and fifth birthday, children were assessed by a *Naming Vocabulary* and a *Picture Similarities* tasks, both part of the British Ability Scales, Second Edition (Elliott, Smith, & McCulloch, 1996; Elliott, Smith, & McCulloch, 1997). *Naming Vocabulary* measures expressive language ability and knowledge of nouns by asking children to identify different objects in a colored picture booklet. The *Picture Similarities* assessment captures children's inductive reasoning ability and asks them to match a picture card (e.g. an animal) to one of four other picture cards (e.g. a house, a person, a car or another animal) based on whether they see any conceptual or elementary link. We used measures provided by GUS, which correct for differences in item difficulty.

In wave 5, GUS provides parents' responses to Goodman's (1997) Strengths and Difficulties Questionnaire (SDQ), a validated and widely used instrument for measuring children's socio-emotional and behavioral development between the ages of four to sixteen. Respondents rate 25 statements about their children as 'Certainly true', 'Somewhat true', or 'Not true'. The statements are combined into five scales, each built on five items, capturing the following constructs: hyperactivity, emotional symptoms, conduct problems, peer relations, and prosocial behavior. In order to detect relationships between TV consumption and particular aspects of behavioral and socio-emotional difficulties, we considered the five scales as separate outcomes in our analysis.

Children's amount of TV consumption was measured as the total number of hours children watch TV during an average week at the ages of two, three, and four. We generated this measure from information on hours of TV consumption during an average weekday, an average weekend, and the number of days on which the child watched TV during the week. In order to capture the cumulative impact of TV consumption on cognitive and behavioral outcomes, we also considered the average hours of children's TV consumption across ages two to four.

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Covariate selection was guided by theoretical considerations about which factors may affect the amount of children's TV consumption at a given time while at the same time influencing children's cognitive and behavioral outcomes at a later point (see Table S1 and Table S2 in the Appendix for summary statistics on all variables). Some of these covariates were time-invariant, either because they cannot change over time or were measured only in the first or second wave. We included indicators of the child's sex, mother's age at birth ('younger than 20', '20 to 29', '30 to 39', '40 or older', provided by GUS as categorical variable only), highest educational degree of the parents at first interview ('no qualification', 'lower secondary education', 'upper secondary education', 'vocational and postsecondary education certificates or diplomas', 'higher education'), mothers' views on the importance of educational activities (e.g., reading, writing, painting) at age 2 ('very important' coded 1; 'quite important', 'neither important nor unimportant', 'not really important', 'not at all important' coded 0), and mother-child relationship at age 1. The latter was measured using four items from Condon and Corkindale's (1998) Maternal Postnatal Attachment Scale. The items cover the mother's feelings of annoyance/irritation, (in)competence, (im)patience and resentment in relation to her child, with ranked responses ranging from 'Almost all the time' to 'Never'. After splitting the answer categories into positive and negative ones, we counted the positive answers across items. A score of four was coded as '1', indicating good mother-infant attachment, while a score below 4 was regarded as problematic attachment and coded as '0'.

In addition to these time-constant covariates, a child's television consumption in a given year likely depends on time-variant characteristics, in particular, maternal employment status, family structure, maternal and child health, and economic resources and opportunities. GUS collected mothers' self-reported employment status at each interview as full-time employed, part-time employed, or not working. Family structure was measured by the number of siblings living in the household ('none', 'one', 'two or more') and by whether the mother has no partner, is married, or living in a cohabitation. Maternal health was measured by an indicator of whether the mother reported that she was not in good health ('fair' and 'poor' vs. 'excellent', 'very good', and 'good'), respectively. To account for economic resources and opportunities we controlled for household income, the type of region (less than 10,000 residents; 10,000 to 124,999 residents; 125,000 residents and more), and whether the current residential area was located in the lowest quintile of the Scottish Index of Multiple Deprivation (SIMD), a composite measure of local area poverty. Finally, we included two

variables that may affect children's TV consumption but may at the same time be affected by earlier TV consumption. These are the child's health ('very good', 'good', 'fair', 'bad', 'very bad') and mothers' concern about their child's development ('no concerns', 'some concerns', 'a lot of concerns',) in a given year.

Analytical Strategy

Our analysis proceeded in three steps. Firstly, we described social stratification in TV consumption between the ages two to four. For this purpose, we used growth curve modelling (Raudenbush and Bryk 2002; Singer and Willett 2009) in which time points (level 1) are nested within individual children (level 2) and which is commonly used when modelling the variability in developmental trajectories between children with different socio-economic backgrounds (Mollborn et al. 2014; Potter and Roksa 2013). In our case, we analyzed the growth in reported hours of weekly TV consumption across three points in time (ages 2-4) for children with varying levels of parental education using the following model:

$$tv_{it} = \beta_0 + \beta_1 age_{it} + \beta_2 age_{it}^2 + \beta_3 sex_i + \sum_{k=4}^{K} \beta_k edu_i$$

$$+ \sum_{l=9}^{L} \beta_l edu_i \times age_{it} + \varepsilon_{0it} + \varepsilon_{1i} + \varepsilon_{2i} \times age_{it}. \tag{1}$$

This model includes a random intercept for children's age, ε_{1i}, a random slope for the linear age trend, ε_{2i}, and captures variation in the growth of TV consumption by parental education by including an interaction between parental education and the linear time trend. Children's sex is the only control variable in this analysis.

Secondly, we estimated the associations between children's developmental outcomes and TV consumption at ages two to four separately and the average TV consumption in that time period. In order to interpret the estimated associations as causal effects of TV consumption, alternative explanations for these associations need to be addressed, mainly confounding (i.e., association between TV consumption and developmental outcomes through common causes) and attrition bias (Elwert and Winship 2014; Winship and Mare 1992). We addressed confounding by controlling for the measured covariates outlined above while assuming that there are no (strong) unmeasured confounders and accounted for attrition bias by using attrition weights (see below). We began by estimating associations for TV consumption at specific ages using weighted linear regression models controlling for prior TV consumption and the covariates described above. We then continued to estimate the associations between average weekly TV consumption through the ages of two to four with developmental outcomes also using weighted linear regression models.

While the inclusion of time-constant factors in these models is straightforward, controlling for time-varying covariates can be methodologically challenging (Robins and Hernán 2009). This is because time-varying confounders (in our case, child health and concern about the child's development) are possibly affected by prior TV consumption and thus mediate some of the effect of TV consumption on developmental outcomes (see Figure S1 in the Appendix). Controlling for these covariates would then lead to over-control bias (i.e., underestimating the cumulative effect of TV consumption). In addition, the effect of TV consumption on our outcomes may be biased if accounting for time-varying confounders opens up non-causal pathways via (unmeasured) common causes of time-varying confounders and developmental outcomes. Therefore, we used a two-stage regression-with-residuals (RWR) approach (Wodtke and Almirall 2017) which adjusts for time-varying confounders without inducing over-control bias and endogenous selection bias. In the first stage, we regressed time-varying covariates child health, H_t, and concern about the child's development, C_t, at ages three and four on past TV consumption, X_{t-1}, time-constant covariates, Z_0, and past time-varying covariates, Z_{t-1}. From these models we obtained the residuals, H_t^* and C_t^* for both variables:

$$H_t^* = H_t - E(H_t|X_{t-1}, Z_0, Z_{t-1}) \tag{2}$$

$$C_t^* = C_t - E(C_t|X_{t-1}, Z_0, Z_{t-1}). \tag{3}$$

For age two, residuals for both variables were obtained by centering around the unconditional mean. In the second stage, we estimated the following weighted linear regression models,

$$Y_5 = \beta_0 + \beta_1\bar{X}_t + \boldsymbol{\beta_2 Z_0} + \boldsymbol{\beta_3 Z_t} + \beta_4 H_t^* + \beta_5 C_t^* + \varepsilon, \tag{4}$$

where the respective (standardized) developmental score at age five, Y_5, is a function of the average TV consumption through ages two to four, $\bar{X}_t$, a vector of time-constant covariates, Z_0, a vector of time-varying covariates Z_t, and the residualized time-varying confounders H_t^* and C_t^*. Because these residuals are independent of prior TV consumption, their adjustment does not induce over-control bias while at the same time eliminating confounding by these variables (for an illustration see Figure S2 in the Appendix), assuming that the confounder models are correctly specified. To take into account the additional uncertainty from estimating residuals, all model parameters and their standard errors were obtained through bootstrapping.

In our final analysis, we re-estimated the models for average TV consumption separately for children whose parents obtained an education below upper secondary and those whose

children did obtain upper secondary or more. This was to assess social stratification in the effect of cumulative TV consumption on developmental outcomes.

In all our analyses, we corrected for nonrandom loss to follow-up (and resulting attrition bias) by estimating stabilized inverse probability of attrition weights (Robins, Hernan, & Brumback, 2000),

$$saw_i = \prod_{t=3}^{5} \frac{P(A_{it}=0|A_{i(t-1)}=0, X_{i(t-1)}, Z_{i0})}{P(A_{it}=0|A_{i(t-1)}=0, X_{i(t-1)}, Z_{i0}, Z_{i(t-1)})}, \tag{5}$$

that is, the ratio of the probability that the individual is not lost to follow-up at time t conditional on prior TV consumption and time-constant covariates and the same probability conditional also on time-variant covariates at time t-1 multiplied over years three to five. We used logistic regression models to calculate these probabilities (see Table S3 in the Appendix). Using these weights in the analyses described above creates a pseudo-population in which loss to follow-up is independent of measured covariates.

FIGURE 1. PREDICTED WEEKLY HOURS OF TV CONSUMPTION, BY AGE AND PARENTAL EDUCATION, OBTAINED FROM GROWTH CURVE MODEL WITH RANDOM INTERCEPTS AND RANDOM LINEAR AGE TREND (SEE MODEL 5 IN TABLE S4 IN THE APPENDIX)

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Results

Social stratification of early TV consumption

Figure 1 shows the predicted weekly hours of television across ages two to four for different parental education groups (see Model 5 in Table S4 in the appendix). At age two, there was already a gap of almost 1.5 hours in weekly TV consumption between children whose parents had a degree and children whose parents had either no qualification or a lower secondary qualification. Children whose parents attained upper secondary education or vocational/postsecondary certificates took an intermediate position. Subsequently, average weekly TV consumption increased across all five groups. But this increase was more pronounced for children whose parents had a lower education. In other words, the gap in weekly TV consumption by parental education widened as children grew older. At age four, children whose parents had a degree watched almost 10 hours of TV during a week, on average, compared to 14 hours for children whose parents had no qualification and around 12 hours for the other three groups. Overall, these results support the claim that children's TV consumption (as an example of a lowbrow activity) is socially stratified and more common among families in the lower social stratum. In the next step, we probed the association of TV consumption with different developmental outcomes.

FIGURE 2. ASSOCIATIONS BETWEEN WEEKLY HOURS OF TV AT AGES TWO TO FOUR AND CHILDREN'S (STANDARDIZED) OUTCOMES AT AGE 5 (WITH 90% AND 95% CONFIDENCE INTERVAL).
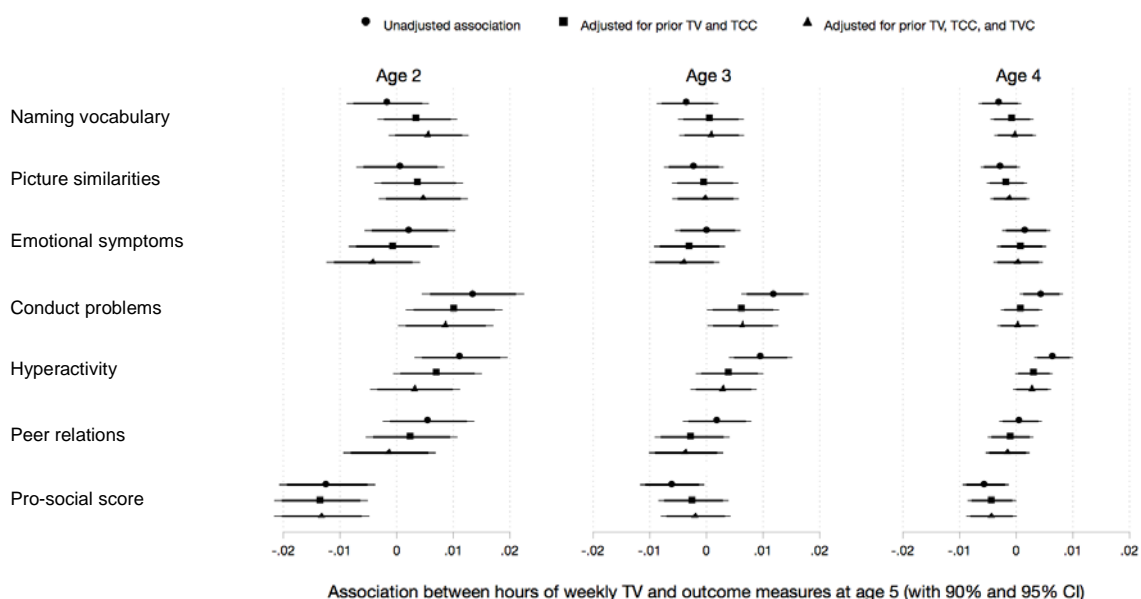
Note. TCC = time-constant covariates, TVC = time-varying covariates.

Early TV consumption and developmental outcomes

First, we considered the associations between TV consumption at specific ages and children's developmental outcomes at age five. For each outcome and measurement of TV consumption, Figure 2 shows the unadjusted association, the association after adjusting for prior TV consumption and time-constant covariates (TCC), and the association after additionally adjusting for time-varying covariates (TVC). For the two ability measures and the pro-social score, higher values indicate better development, for all other measures they indicate worse development (see Table S5 in the appendix for the full results).

In case of Naming Vocabulary, an indicator of *expressive language ability*, the unadjusted associations at each age were negative but small (age 2: β=-0.002, SE=0.004; age 3: β=-0.003, SE=0.003; age 4: β=-0.003, SE=0.002). These negative associations vanished (age 4: β=-0.000, SE=0.002) or transformed into small positive associations (age 2: β=0.006, SE=0.004; age 3: β=0.001, SE=0.003) after adjusting for prior TV consumption, TCC and TVC.

For *inductive reasoning ability* as measured by the picture similarities score a similar pattern emerged. We found small negative marginal associations at ages 3 and 4 (age 3: β=-0.002, SE=0.003; age 4: β=-0.003, SE=0.002) and a small positive association at age 2 (β=0.001, SE=0.004). Adjusting for the different sets of covariates reduced the negative associations at ages 3 and 4 and slightly increased the positive association at age 2.

The associations between children's weekly TV consumption at each considered age and later *emotional problems* were positive but also very small in the unadjusted case (age 2: β=0.002, SE=0.004; age 3: β=0.000, SE=0.003; age 4: β=0.002, SE=0.002). After adjusting for prior TV consumption and all measured time-constant and time-varying confounders, the associations reduced (age 4: β=0.000, SE=0.002) or became slightly negative (age 2: β=-0.004, SE=0.004; age 3: β=-0.004, SE=0.003).

We also found small unadjusted positive associations between weekly hours of TV consumption at early ages and *peer relations* at age 5 (age 2: β=0.006, SE=0.004; age 3: β=0.002, SE=0.003; age 4: β=0.001, SE=0.002). Likewise, they turned into slightly negative associations after accounting for prior TV consumption and TCC and TVC (age 2: β=-0.001, SE=0.004; age 3: β=-0.004, SE=0.003; age 4: β=-0.002, SE=0.002).

Positive and more substantive unadjusted associations emerged for *conduct problems* (age 2: β=0.013, SE=0.005; age 3: β=0.012, SE=0.003; age 4: β=0.004, SE=0.002). After adjusting

for prior TV consumption and TCC, associations at all ages reduced (age 2: β=0.010, SE=0.004; age 3: β=0.006, SE=0.003; age 4: β=0.001, SE=0.002). Further adjusting for TVC appeared to have only little impact on the associations between TV consumption and conduct problems. While the adjusted association was close to zero at age 4 (SE=0.002), it remained stronger at age 2 (β=0.009, SE=0.004) and at age 3 (β=0.006, SE=0.003).

Figure 2 also revealed positive associations between the amount of early TV consumption and *hyperactivity* at age 5 when unadjusted (age 2: β=0.011, SE=0.004; age 3: β=0.010, SE=0.003; age 4: β=0.007, SE=0.002). However, these reduced markedly after adjusting for the available covariates, particularly at ages 2 and 3 (age 2: β=0.003, SE=0.004; age 3: β=0.003, SE=0.003; age 4: β=0.003, SE=0.002).

FIGURE 3. ASSOCIATIONS BETWEEN AVERAGE WEEKLY HOURS OF TV THROUGH AGES TWO TO FOUR AND CHILDREN'S (STANDARDIZED) OUTCOMES AT AGE FIVE (WITH 90% AND 95% CONFIDENCE INTERVAL).
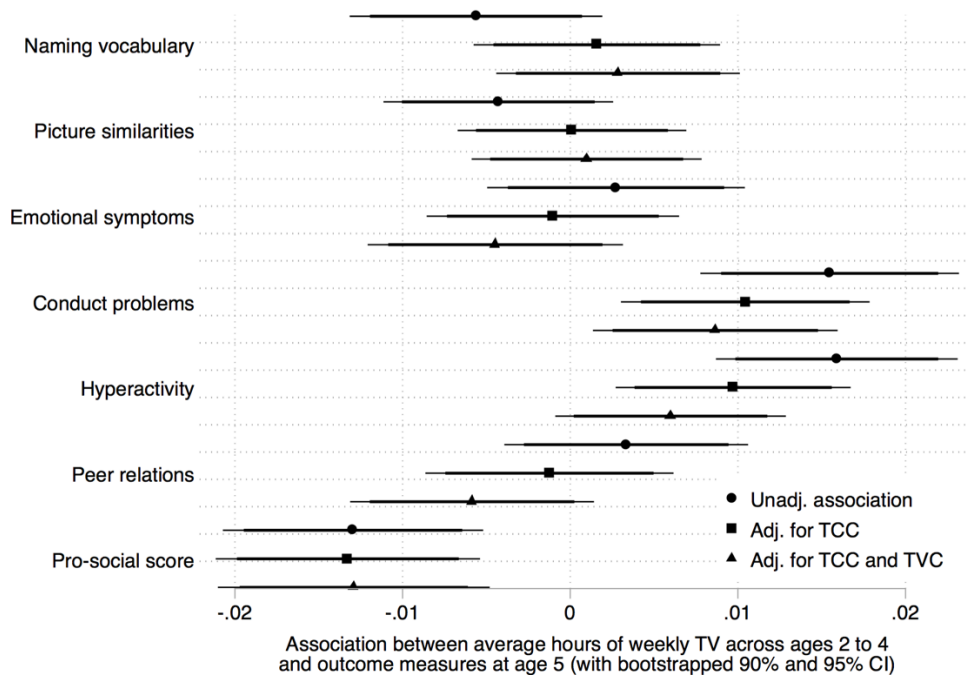
Note. TCC = time-constant covariates, TVC = time-varying covariates.

Finally, Figure 2 provides estimates for marginal and adjusted associations between children's TV consumption and pro-social behavior at age 5. We found a negative relation for each age looking at unadjusted associations (age 2: β=-0.0012, SE=0.004; age 3: β=-0.006, SE=0.003; age 4: β=-0.005, SE=0.002). Again, covariate adjustment reduced these associations with the exception of age 2. Nonetheless, these associations remained relatively substantive at all ages (age 2: β=-0.013, SE=0.004; age 3: β=-0.002, SE=0.003; age 4: β=-0.004, SE=0.002).

FIGURE 4. ASSOCIATIONS BETWEEN AVERAGE WEEKLY HOURS OF TV THROUGH AGES TWO TO FOUR AND CHILDREN'S (STANDARDIZED) OUTCOMES AT AGE FIVE (WITH 90% AND 95% CONFIDENCE INTERVAL) BY PARENTAL EDUCATION.

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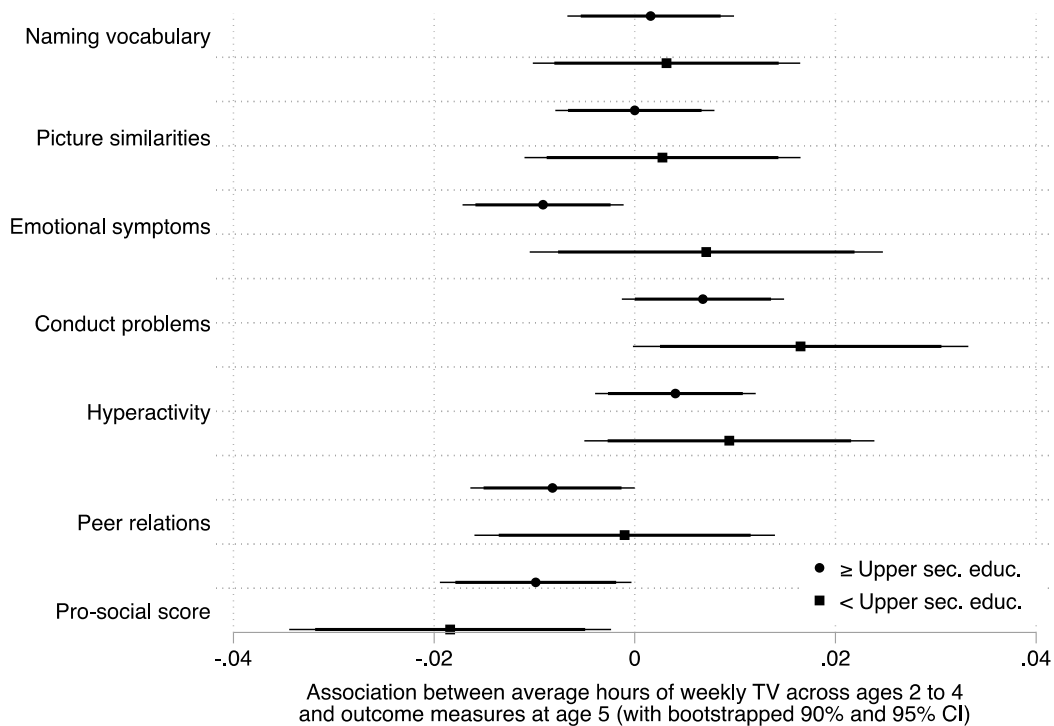
In the next step, we estimated associations between average TV consumption across ages two to four and children's developmental outcomes at age 5. Figure 3 summarizes the respective results and reproduces the patterns found in the previous analyses. There were only small associations between cumulative TV consumption and children's expressive language ability, inductive reasoning ability, and emotional symptoms, both before and after covariate adjustment. While positive for the marginal association, the association between average weekly hours of TV and peer relationship problems turned slightly negative after adjusting for the measured covariates. Again, the more substantive associations were found for conduct problems, hyperactivity, and the pro-social score. The positive association between cumulative exposure to TV consumption and children's conduct problems at age 5 remained after covariate adjustment. For hyperactivity, we found a positive association with cumulative TV consumption that decreased after adjusting for covariates. Lastly, we found a negative association between cumulative TV consumption and pro-social behavior which remained almost the same after accounting for time-constant and time-varying covariates.

Variation by parental education

In our final analysis, we investigated variation in the association between average weekly TV consumption and children's developmental outcomes by parental education. To this aim, we ran the RWR models that adjust for all TCC and TVC separately for children whose parents had at least upper secondary education and those who parents had an education below. The results shown in Figure 4 provide some evidence for our theoretical considerations. The positive association for conduct problems and the negative association for pro-social behavior were indeed stronger for children whose parents had less than upper secondary education. Furthermore, the association for emotional symptoms was negative for children of parents with higher upper secondary education, whereas for the other group it was positive. The results for hyperactivity also point to a stronger association for children of parents who did not obtain upper secondary education. For the other developmental outcomes, there are hardly any differences between both groups. Overall, these results need to be interpreted with caution given the large confidence intervals particularly for children whose parents obtained an education below upper secondary.

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Discussion

The aim of this paper was to investigate social stratification in TV consumption during early childhood and its consequences for the development of language, inductive reasoning, and different behavioral problems. Thereby, we contributed to the debate on the role of lowbrow activities for differences in life outcomes. We improved upon most previous studies on the relation between TV consumption and child development by using a large and representative sample of Scottish children and by accounting for a richer set of time-constant and time-varying covariates. Most importantly, we also considered the cumulative effect of TV consumption through early childhood and investigated differences in the association between TV consumption and children's outcomes by parental education.

We found evidence for social stratification in both level and growth of TV consumption across the age of two to four. An initial gap between children whose parents had no qualification and children whose parents had a degree of around 1.3 hours grew to roughly 4 hours at age 4. However, for the children in our sample, TV consumption, both at different ages and as average over all ages, was only weakly associated with different developmental outcomes with the most pronounced associations for conduct problems and pro-social behavior. But even those associations were small compared to those for other covariates such as children' sex or mothers' views on the importance of educational activities (see Table S5 in the appendix). For example, the difference in pro-social score between boys and girls was roughly equivalent to the difference associated with 21 hours of TV per week at age 2. The pro-social score of children with mothers who regarded educational activities as important was 0.23 standard deviations higher than that of other children, a difference associated with roughly 16 hours of TV per week at age 2. Although our final analyses revealed stronger associations between cumulative TV consumption and behavioral problems for children whose parents had lower education, these associations still remained comparatively moderate.

Overall, our results thus only provided very limited evidence for a negative effect of TV consumption on children's vocabulary, inductive reasoning ability, and behavioral development. They are not in line with previous observational studies that claimed a strong impact of early TV consumption on cognitive and language development (Byeon and Hong 2015; Chonchaiya and Pruksananonda 2008; Huang and Lee 2010; Tomopoulos et al. 2010; Zimmerman and Christakis 2005; Zimmerman et al. 2007) but are consistent with studies that found only a weak link between TV consumption and hyperactivity-inattention (Foster and

Watkins 2010; Parkes et al. 2013; Stevens and Muslow 2006), emotional problems, and peer relationship problems (see also Parkes et al. 2013).

Of course, these causal interpretations of our estimates rest on the strong and untestable assumption that there are no (strong) unmeasured confounders. To gain some insights about the potential role of unmeasured confounding we exploited the fact that language ability and inductive reasoning were already measured at age three. Therefore, we were able to estimate the association between TV consumption at age four and *change* in these test scores. Additionally, we also estimated the association conditional on the test scores at age three. These supplementary analyses also did not reveal any substantial association between TV consumption and these ability measures (see Table S6 in the appendix). This, and the number of important (time-varying) covariates included in our analyses provide some confidence that the amount of confounding bias is limited.

Nonetheless, there are several additional caveats that need to be considered when interpreting the results. Firstly, our study is restricted to the amount of TV consumption during a normal week and we do not consider the content and context of children's TV consumption. However, there is ample evidence suggesting that what children watch and how they watch determines the impact TV consumption has on children's development (Christakis 2009). Children raised in different socio-economic environment may not only differ in terms of quantity of TV consumption but also with regard to quality of content and parental presence and interactions and these differences may explain why TV consumption has a stronger impact on conduct problems and prosocial behavior for children whose mothers have lower qualifications.

Secondly, children's TV consumption was self-reported by their mothers and some mothers may overestimate and some may underestimate how much TV their children watch during a normal week. Hence, we cannot exclude the possibility of attenuation bias in our study. However, it seems more likely that, if so, mothers underestimate the amount of TV consumption among their children. Comparing different ways of measuring TV consumption, Borzekowski and Robinson (1999) did not find any indication of a social desirability bias with regard to self-reported TV consumption. There is also no reason to assume that this bias is more pronounced among mothers with lower education or that the accuracy of self-reported TV consumption varies between mothers with different qualifications, i.e. random measurement error differs between our considered groups.

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Thirdly, we did not consider TV consumption among infants below age 2 and among children above age four. Hence, our results are restricted to a specific age group. Associations between weekly hours of TV consumption and developmental outcomes may differ when considering TV watching in the earliest stage of the life course or for children starting primary school and beyond.

Under the premise to provisionally accept the causal assumptions and ignore the caveats of our study, we found only limited evidence for any harmful (or beneficial) effects of children's TV consumption on their developmental outcomes. Our theoretical considerations discussed two potential mechanisms for why TV consumption may be detrimental to children's development: A direct effect via characteristics of television and an indirect effect via less frequent engagement in more stimulating interactions and activities.

The (small) differential impact of TV consumption on conduct problems/prosocial behavior by maternal education hints - if at all - at the indirect mechanism. Lower-educated mothers may not have the resources, time or family support to compensate for their children's hours spent on TV consumption by engaging them in other meaningful ways. Lower quality and quantity of parent-child interactions and activities may lead to children's conduct problems and anti-social behavior. Alternatively, children's direct experience of TV consumption may differ between mothers of varying education. It may well be the case that highly educated mothers watch TV together with their children, more carefully choose the type of program and engage with their children throughout the duration of the program while due to constraints lower educated mothers leave their children unattended in front of the TV.

What do these results imply for the cultural consumption literature? While there is a social gradient in the amount of TV consumption in children's early ages, the harmful consequences of TV for children's development are less pronounced than often assumed. Children's TV consumption may have a small impact on educational attainment and may to some extent explain social inequalities in education not directly via differences in early cognitive and language development but via behavior that may not conform to school norms and expectations (Duncan and Magnuson 2011) or may impede learning (DiPrete and Jennings 2012). Our results may also highlight the necessity to put concepts such as lowbrow and highbrow cultural activities under close scrutiny and to assess their impact on children's development empirically before drawing ad-hoc conclusions on their role in social stratification processes.

While our study measures TV consumption in a longitudinal way and thus makes an important contribution to the literature, future research should be concerned with the long-term impact of TV consumption patterns throughout early childhood and adolescence on educational attainment and other life course outcomes such as health. Furthermore, it may be worthwhile to differentiate the cumulative impact of TV watching on children's developmental outcomes by content and context of children's TV consumption.

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Appendix

Note. TCC = time-constant covariates, TVC = time-varying covariates. Cumulative effect of TV consumption equals black arrows.
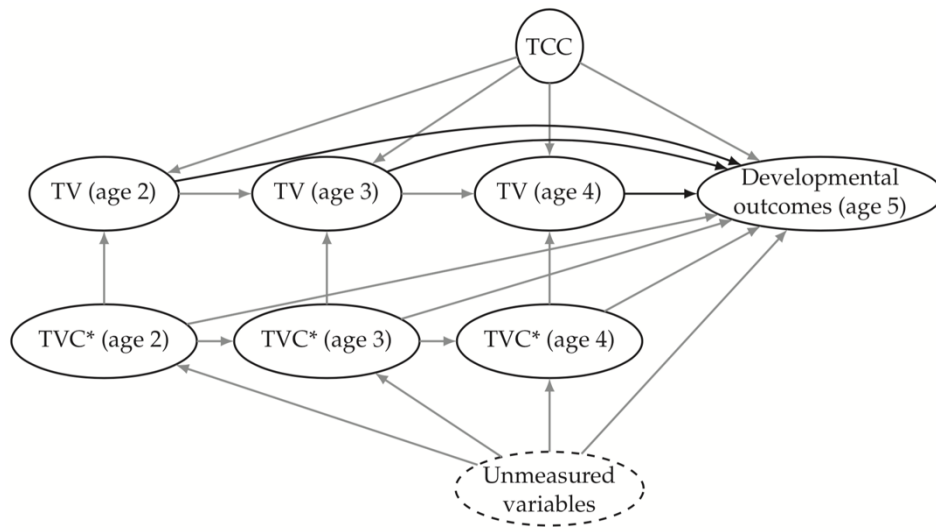
Note. TCC = time-constant covariates, TVC = time-varying covariates. Cumulative effect of TV consumption equals black arrows.

Table S1. *Summary statistics for time-constant variables (N = 2,687)*

	Mean/proportion	SD	Min	Max
Naming vocabulary (age 5)	110.62	14.49	10	161
Picture similarities (age 5)	83.43	11.33	10	119
Emotional symptoms (age 5)	1.15	1.37	0	9
Conduct problems (age 5)	1.66	1.40	0	8
Hyperactivity (age 5)	3.53	2.24	0	10
Peer relations (age 5)	0.92	1.28	0	8
Pro-social score (age 5)	8.26	1.61	1	10
SDQ total score (age 5)	7.26	4.33	0	29
Child is male	0.51		0	1
Mother's age at birth				
Younger than 20 years	0.04		0	1
20 to 29 years	0.35		0	1
30 to 39 years	0.58		0	1
40 years or older	0.03		0	1
Highest parental education at birth				
No qualification	0.04		0	1
Lower sec.	0.18		0	1
Upper sec.	0.20		0	1
Voc. and postsec.	0.15		0	1
Higher	0.43		0	1
Educ. activities very important (age 2)	0.85		0	1
Good maternal-infant attachment (age 1)	0.86		0	1

Note. Statistics pertain to children who have been continuously observed until age 5 and are weighted to correct for non-random loss to follow-up.

Table S2. *Summary statistics for time-varying variables by age of child (N = 2,687)*

	Age 2	Age 3	Age 4
TV (hrs/week)	4.15	8.39	11.95
Mother not in good health	0.11	0.12	0.13
Maternal employment status			
Full-time	0.19	0.20	0.20
Part-time	0.45	0.44	0.45
Not working	0.36	0.36	0.35
Number of siblings in the home			
None	0.42	0.32	0.24
One	0.38	0.46	0.51
Two or more	0.20	0.22	0.25
Mother's relationship status			
Married	0.64	0.65	0.66
Cohabitation	0.22	0.20	0.20
No partner	0.14	0.15	0.14
Household income (in 1,000 GBP)	24.02	24.80	25.22
Region type			
Fewer than 10,000 residents	0.35	0.33	0.32
10,000 to 124,999 residents	0.31	0.33	0.34
125,000 or more residents	0.34	0.34	0.34
Lives in deprived area	2.80	2.79	2.80
Child health	1.38	1.32	1.35
Maternal concern about development	1.12	1.12	1.12

Note. Statistics pertain to children who have been continuously observed until age 5 and are weighted to correct for non-random loss to follow-up.

Table S3. *Summary of pooled logistic regression models predicting loss to follow-up at t+1 used to estimate*

stabilized attrition weight (N = 9,892 person-years from 3,736 children)

	Numerator	Denominator
Child is male	0.036	0.033
	(0.066)	(0.067)
Mother's age at birth (Ref.: less than 20 years)		
20 to 29 years	-0.347**	-0.202
	(0.127)	(0.135)
30 to 39 years	-0.740***	-0.494***
	(0.131)	(0.147)
40 years or older	-0.343	-0.137
	(0.209)	(0.219)
Highest parental education at birth (Ref.: Higher)		
No qualification	0.814***	0.383*
	(0.147)	(0.162)
Lower sec.	0.668***	0.396***
	(0.091)	(0.107)
Upper sec.	0.387***	0.245*
	(0.096)	(0.104)
Voc. and postsec.	0.062	-0.063
	(0.115)	(0.121)
Educ. activities very important	-0.100	-0.070
	(0.088)	(0.089)
Good maternal-infant attachment	0.064	0.103
	(0.096)	(0.097)
Child's age (Ref.: Two years)	0.000	0.000
Three years	-0.315***	-0.305***
	(0.080)	(0.081)

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	Numerator	Denominator
Four years	-0.540***	-0.525***
	(0.092)	(0.094)
TV at t (hrs/week)	-0.001	-0.002
	(0.005)	(0.005)
Child health at t		0.012
		(0.054)
Maternal concern about development at t		0.006
		(0.085)
Mother not in good health at t		0.156
		(0.093)
Maternal employment status at t(Ref.: Full-time)		
Part-time		-0.053
		(0.098)
Not working		-0.022
		(0.104)
Number of siblings in the home at t (Ref.: None)		
One		0.053
		(0.082)
Two or more		0.079
		(0.103)
Mother's relationship status at t (Ref. No partner)		
Married		-0.425***
		(0.107)
Cohabitation		-0.338***
		(0.102)
Household income at t (in 1,000 GBP)		-0.005
		(0.004)

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	Numerator	Denominator
Region type at t (Ref.: Fewer than 10,000 residents)		
10,000 to 124,999 residents		0.043
		(0.085)
125,000 or more residents		0.102
		(0.085)
Lives in deprived area at t		0.063[*]
		(0.027)
Intercept	-1.663[***]	-1.632[***]
	(0.183)	(0.272)

Note. [*] $p < .05$, [**] $p < .01$, [***] $p < .001$. Robust standard errors in parentheses.

Table S4. *Summary of growth curve models predicting hours of weekly TV consumption across ages two to four (N = 9,892 person-years from 3,736 children)*

	M0	M1	M2	M3	M4	M5
Age of child		3.959***	3.957***	4.603***	4.603***	4.206***
		(0.094)	(0.093)	(0.236)	(0.236)	(0.259)
(Age of child)^2				-0.332*	-0.332*	-0.335*
				(0.133)	(0.133)	(0.133)
Child is male					-0.083	-0.079
					(0.155)	(0.153)
Highest parental education at birth						
(Ref.: Higher)						
No qualification						1.321*
						(0.528)
Lower sec.						1.455***
						(0.245)
Upper sec.						0.482*
						(0.229)
Voc. and postsec.						0.605*
						(0.247)
(Age of child) × (Parental education)						
No qualification						1.262*
						(0.567)
Lower sec.						0.542*
						(0.246)
Upper sec.						0.857***
						(0.258)
Voc. and postsec.						0.597*
						(0.303)

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	M0	M1	M2	M3	M4	M5
Intercept	7.800***	4.225***	4.225***	4.131***	4.174***	3.604***
	(0.091)	(0.086)	(0.086)	(0.082)	(0.116)	(0.136)
Variance intercept	8.675	12.901	0.889	0.892	0.892	0.760
	(0.986)	(0.035)	(0.495)	(0.497)	(0.497)	(0.454)
Variance slope (Age of child)			11.106	11.106	11.109	11.038
			(2.159)	(2.159)	(2.159)	(2.147)
Covariance(Slope, intercept)			3.142	3.148	3.149	2.897
			(0.611)	(0.612)	(0.612)	(0.620)

Note. $^{*} p < .05$, $^{**} p < .01$, $^{***} p < .001$. Robust standard errors in parentheses.

Table S5. *Summary of WLS models predicting developmental outcomes from hours of weekly TV consumption and covariates across ages two to four (N = 2,687 children)*

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Naming vocabulary						
Hours of TV/week (age 2)	0.004	0.003	0.003	0.006	0.004	0.004
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Hours of TV/week (age 3)		0.001	0.001		0.001	0.002
		(0.003)	(0.003)		(0.003)	(0.003)
Hours of TV/week (age 4)			-0.001			-0.000
			(0.002)			(0.002)
Child is male	-0.163	-0.163	-0.163	-0.138	-0.151	-0.143
	(0.038)	(0.038)	(0.038)	(0.037)	(0.038)	(0.037)
Mother's age at birth						
(Ref.: less than 20 years)						
20 to 29 years	0.010	0.010	0.010	0.094	0.042	0.032
	(0.113)	(0.113)	(0.113)	(0.118)	(0.112)	(0.114)
30 to 39 years	0.129	0.130	0.129	0.211	0.159	0.129
	(0.113)	(0.114)	(0.114)	(0.122)	(0.116)	(0.118)
40 years or older	0.183	0.183	0.183	0.286	0.214	0.203
	(0.179)	(0.179)	(0.179)	(0.196)	(0.189)	(0.182)
Highest parental education at						
birth (Ref.: Higher)						
No qualification	-0.601	-0.602	-0.600	-0.361	-0.383	-0.391
	(0.089)	(0.089)	(0.089)	(0.100)	(0.100)	(0.101)
Lower sec.	-0.407	-0.408	-0.407	-0.258	-0.278	-0.279
	(0.054)	(0.054)	(0.054)	(0.061)	(0.061)	(0.062)
Upper sec.	-0.249	-0.249	-0.248	-0.177	-0.203	-0.214
	(0.056)	(0.056)	(0.056)	(0.058)	(0.058)	(0.059)

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Voc. and postsec.	-0.129	-0.130	-0.129	-0.067	-0.084	-0.088
	(0.052)	(0.052)	(0.052)	(0.054)	(0.055)	(0.055)
Educ. activities very important	0.272	0.273	0.274	0.192	0.212	0.216
	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)
Good maternal-infant attachment	0.158	0.159	0.158	0.135	0.124	0.120
	(0.060)	(0.060)	(0.060)	(0.058)	(0.059)	(0.057)
Child health at t				-0.095	-0.057	-0.096
				(0.034)	(0.036)	(0.035)
Maternal concern about development at t				-0.299	-0.204	-0.289
				(0.065)	(0.071)	(0.069)
Mother not in good health at t				-0.084	-0.061	-0.067
				(0.068)	(0.061)	(0.058)
Maternal employment status at t (Ref.: Full-time)						
Part-time				0.095	0.062	0.054
				(0.054)	(0.054)	(0.050)
Not working				0.025	0.102	0.013
				(0.059)	(0.059)	(0.054)
Number of siblings in the home at t (Ref.: None)						
One				-0.191	-0.167	-0.137
				(0.043)	(0.045)	(0.049)
Two or more				-0.283	-0.328	-0.314
				(0.060)	(0.060)	(0.063)
Mother's relationship status at t (Ref. No partner)						

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Married				-0.016	0.101	0.109
				(0.073)	(0.069)	(0.067)
Cohabitation				-0.040	0.118	0.088
				(0.072)	(0.069)	(0.069)
Household income				0.005	0.003	0.002
				(0.002)	(0.002)	(0.002)
Region type at t (Ref.: Fewer than 10,000 residents)						
10,000 to 124,999 residents				-0.133	-0.154	-0.154
				(0.046)	(0.045)	(0.046)
125,000 or more residents				-0.171	-0.193	-0.192
				(0.044)	(0.046)	(0.046)
Lives in deprived area				-0.005	-0.023	-0.023
				(0.017)	(0.016)	(0.016)
Constant	-0.225	-0.231	-0.226	0.274	0.170	0.403
	(0.131)	(0.134)	(0.135)	(0.199)	(0.205)	(0.193)
R^2	0.066	0.066	0.066	0.110	0.100	0.108

Picture similarities

	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Hours of TV/week (age 2)	0.004	0.004	0.004	0.005	0.006	0.005
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)
Hours of TV/week (age 3)		-0.000	0.000		-0.000	0.001
		(0.003)	(0.003)		(0.003)	(0.003)
Hours of TV/week (age 4)			-0.002			-0.001
			(0.002)			(0.002)
Child is male	-0.135	-0.135	-0.134	-0.114	-0.118	-0.120
	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Mother's age at birth (Ref.: less than 20 years)						
20 to 29 years	0.034	0.034	0.034	0.036	0.008	0.014
	(0.118)	(0.118)	(0.118)	(0.120)	(0.119)	(0.120)
30 to 39 years	0.140	0.140	0.140	0.105	0.076	0.081
	(0.119)	(0.119)	(0.119)	(0.125)	(0.124)	(0.124)
40 years or older	0.195	0.195	0.193	0.159	0.129	0.170
	(0.151)	(0.151)	(0.151)	(0.156)	(0.156)	(0.155)
Highest parental education at birth (Ref.: Higher)						
No qualification	-0.329	-0.329	-0.325	-0.090	-0.137	-0.127
	(0.104)	(0.104)	(0.104)	(0.115)	(0.116)	(0.114)
Lower sec.	-0.232	-0.232	-0.229	-0.068	-0.095	-0.088
	(0.055)	(0.055)	(0.055)	(0.063)	(0.062)	(0.063)
Upper sec.	-0.153	-0.153	-0.151	-0.060	-0.086	-0.082
	(0.056)	(0.056)	(0.056)	(0.059)	(0.059)	(0.059)
Voc. And postsec.	-0.047	-0.047	-0.045	0.029	0.014	0.026
	(0.056)	(0.056)	(0.056)	(0.059)	(0.059)	(0.059)
Educ. Activities very important	0.221	0.221	0.222	0.169	0.188	0.195
	(0.057)	(0.058)	(0.058)	(0.057)	(0.057)	(0.058)
Good maternal-infant attachment	0.079	0.079	0.078	0.061	0.046	0.054
	(0.060)	(0.060)	(0.060)	(0.060)	(0.060)	(0.060)
Child health at t				-0.043	-0.003	-0.032
				(0.032)	(0.033)	(0.032)
Maternal concern about development at t				-0.266	-0.278	-0.239
				(0.066)	(0.064)	(0.069)

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Mother not in good health at t				0.083	-0.013	-0.053
				(0.070)	(0.067)	(0.062)
Maternal employment status at t (Ref.: Full-time)						
Part-time				-0.011	-0.028	0.029
				(0.052)	(0.053)	(0.051)
Not working				-0.024	0.075	0.085
				(0.059)	(0.057)	(0.056)
Number of siblings in the home at t (Ref.: None)						
One				-0.055	-0.035	-0.010
				(0.046)	(0.048)	(0.052)
Two or more				-0.109	-0.094	-0.084
				(0.061)	(0.062)	(0.065)
Mother's relationship status at t (Ref. No partner)						
Married				0.043	0.080	-0.000
				(0.072)	(0.067)	(0.068)
Cohabitation				0.079	0.051	-0.113
				(0.071)	(0.069)	(0.071)
Household income				0.006	0.004	0.006
				(0.002)	(0.002)	(0.002)
Region type at t (Ref.: Fewer than 10,000 residents)						
10,000 to 124,999 residents				-0.039	0.005	0.000
				(0.047)	(0.047)	(0.047)
125,000 or more residents				-0.061	-0.056	-0.064
				(0.046)	(0.046)	(0.047)

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Lives in deprived area				-0.039	-0.040	-0.032
				(0.016)	(0.016)	(0.016)
Constant	-0.216	-0.215	-0.203	0.151	0.116	0.093
	(0.142)	(0.145)	(0.146)	(0.186)	(0.182)	(0.198)
R^2	0.031	0.031	0.032	0.053	0.052	0.052
Conduct problems						
Hours of TV/week (age 2)	0.010	0.007	0.006	0.009	0.004	0.006
	(0.004)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)
Hours of TV/week (age 3)		0.006	0.006		0.006	0.006
		(0.003)	(0.003)		(0.003)	(0.003)
Hours of TV/week (age 4)			0.001			0.000
			(0.002)			(0.002)
Child is male	0.182	0.183	0.182	0.162	0.152	0.160
	(0.038)	(0.038)	(0.038)	(0.038)	(0.037)	(0.037)
Mother's age at birth						
(Ref.: less than 20 years)						
20 to 29 years	-0.194	-0.192	-0.193	-0.153	-0.167	-0.173
	(0.117)	(0.117)	(0.117)	(0.117)	(0.115)	(0.114)
30 to 39 years	-0.257	-0.254	-0.254	-0.170	-0.190	-0.192
	(0.116)	(0.117)	(0.117)	(0.119)	(0.117)	(0.116)
40 years or older	-0.256	-0.256	-0.255	-0.178	-0.188	-0.225
	(0.155)	(0.155)	(0.155)	(0.155)	(0.156)	(0.152)
Highest parental education at						
birth (Ref.: Higher)						
No qualification	0.564	0.553	0.551	0.305	0.331	0.346
	(0.115)	(0.115)	(0.116)	(0.121)	(0.120)	(0.121)

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Lower sec.	0.226	0.218	0.216	0.058	0.076	0.068
	(0.058)	(0.058)	(0.058)	(0.064)	(0.063)	(0.063)
Upper sec.	0.057	0.056	0.054	-0.030	0.011	0.007
	(0.053)	(0.053)	(0.053)	(0.055)	(0.055)	(0.055)
Voc. And postsec.	0.040	0.034	0.033	-0.035	-0.002	-0.017
	(0.055)	(0.055)	(0.055)	(0.057)	(0.057)	(0.057)
Educ. Activities very important	-0.233	-0.226	-0.227	-0.192	-0.181	-0.190
	(0.060)	(0.060)	(0.060)	(0.059)	(0.059)	(0.058)
Good maternal-infant attachment	-0.246	-0.240	-0.240	-0.211	-0.172	-0.190
	(0.058)	(0.058)	(0.058)	(0.057)	(0.058)	(0.057)
Child health at t				0.044	0.047	0.064
				(0.032)	(0.036)	(0.034)
Maternal concern about development at t				0.254	0.425	0.365
				(0.062)	(0.063)	(0.055)
Mother not in good health at t				0.161	0.242	0.192
				(0.072)	(0.069)	(0.065)
Maternal employment status at t (Ref.: Full-time)						
Part-time				-0.019	0.005	-0.030
				(0.051)	(0.050)	(0.050)
Not working				0.010	-0.005	0.019
				(0.057)	(0.055)	(0.055)
Number of siblings in the home at t (Ref.: None)						
One				0.050	0.088	0.069
				(0.044)	(0.044)	(0.048)

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Two or more				0.063	0.150	0.131
				(0.059)	(0.058)	(0.060)
Mother's relationship status at t (Ref. No partner)						
Married				-0.129	-0.152	-0.109
				(0.073)	(0.070)	(0.070)
Cohabitation				-0.093	-0.128	-0.079
				(0.073)	(0.072)	(0.072)
Household income				-0.005	-0.002	-0.003
				(0.002)	(0.002)	(0.002)
Region type at t (Ref.: Fewer than 10,000 residents)						
10,000 to 124,999 residents				-0.078	-0.029	-0.048
				(0.046)	(0.045)	(0.046)
125,000 or more residents				-0.015	0.012	0.005
				(0.046)	(0.046)	(0.046)
Lives in deprived area				0.027	0.023	0.028
				(0.016)	(0.015)	(0.016)
Constant	0.429	0.380	0.373	0.157	-0.212	-0.154
	(0.135)	(0.137)	(0.138)	(0.185)	(0.187)	(0.179)
R^2	0.055	0.057	0.057	0.079	0.101	0.093
Emotional symptoms						
Hours of TV/week (age 2)	-0.000	0.001	0.001	-0.004	-0.002	-0.001
	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
Hours of TV/week (age 3)		-0.003	-0.003		-0.004	-0.004
		(0.003)	(0.003)		(0.003)	(0.003)

	TCC			+ TVC		

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Hours of TV/week (age 4)			0.001			0.000
			(0.002)			(0.002)
Child is male	0.003	0.003	0.002	-0.027	-0.039	-0.021
	(0.039)	(0.039)	(0.039)	(0.038)	(0.038)	(0.038)
Mother's age at birth						
(Ref.: less than 20 years)						
20 to 29 years	-0.230	-0.231	-0.231	-0.166	-0.184	-0.212
	(0.126)	(0.126)	(0.126)	(0.129)	(0.128)	(0.130)
30 to 39 years	-0.312	-0.313	-0.313	-0.171	-0.205	-0.245
	(0.124)	(0.124)	(0.124)	(0.132)	(0.131)	(0.133)
40 years or older	-0.148	-0.148	-0.147	0.015	-0.016	-0.086
	(0.172)	(0.172)	(0.172)	(0.179)	(0.177)	(0.177)
Highest parental education at						
birth (Ref.: Higher)						
No qualification	0.346	0.351	0.349	0.146	0.184	0.172
	(0.135)	(0.135)	(0.135)	(0.140)	(0.138)	(0.141)
Lower sec.	0.136	0.140	0.138	-0.007	0.012	-0.008
	(0.060)	(0.060)	(0.059)	(0.066)	(0.066)	(0.066)
Upper sec.	-0.011	-0.011	-0.012	-0.093	-0.063	-0.068
	(0.054)	(0.054)	(0.054)	(0.056)	(0.057)	(0.056)
Voc. and postsec.	0.019	0.022	0.021	-0.057	-0.024	-0.031
	(0.055)	(0.055)	(0.055)	(0.058)	(0.057)	(0.057)
Educ. activities very	0.011	0.008	0.007	0.034	0.037	0.035
important	(0.057)	(0.056)	(0.056)	(0.057)	(0.057)	(0.056)
Good maternal-infant	-0.319	-0.321	-0.321	-0.278	-0.247	-0.273
attachment	(0.066)	(0.066)	(0.066)	(0.065)	(0.065)	(0.065)

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Child health at t				0.137	0.213	0.125
				(0.035)	(0.038)	(0.035)
Maternal concern about development at t				0.225	0.269	0.249
				(0.072)	(0.075)	(0.059)
Mother not in good health at t				0.223	0.179	0.215
				(0.073)	(0.070)	(0.069)
Maternal employment status at t (Ref.: Full-time)						
Part-time				0.022	-0.009	-0.032
				(0.050)	(0.052)	(0.050)
Not working				0.092	0.059	0.044
				(0.059)	(0.060)	(0.059)
Number of siblings in the home at t (Ref.: None)						
One				-0.109	-0.022	0.028
				(0.046)	(0.047)	(0.051)
Two or more				-0.196	-0.092	-0.024
				(0.064)	(0.063)	(0.066)
Mother's relationship status at t (Ref. No partner)						
Married				0.095	0.024	-0.011
				(0.079)	(0.076)	(0.076)
Cohabitation				0.040	-0.024	-0.090
				(0.079)	(0.077)	(0.079)
Household income				-0.008	-0.004	-0.004
				(0.002)	(0.002)	(0.002)

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Region type at t (Ref.: Fewer than 10,000 residents)						
10,000 to 124,999 residents				-0.012	-0.018	-0.012
				(0.046)	(0.046)	(0.046)
125,000 or more residents				0.029	0.018	0.020
				(0.046)	(0.046)	(0.047)
Lives in deprived area				0.025	0.027	0.030
				(0.016)	(0.016)	(0.016)
Constant	0.499	0.522	0.515	0.040	-0.133	0.050
	(0.154)	(0.155)	(0.156)	(0.201)	(0.209)	(0.200)
R^2	0.028	0.028	0.028	0.061	0.069	0.060
Hyperactivity						
Hours of TV/week (age 2)	0.007	0.005	0.004	0.003	0.000	0.002
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Hours of TV/week (age 3)		0.004	0.003		0.003	0.002
		(0.003)	(0.003)		(0.003)	(0.003)
Hours of TV/week (age 4)			0.003			0.003
			(0.002)			(0.002)
Child is male	0.359	0.359	0.358	0.330	0.325	0.322
	(0.038)	(0.038)	(0.038)	(0.037)	(0.037)	(0.036)
Mother's age at birth (Ref.: less than 20 years)						
20 to 29 years	-0.124	-0.123	-0.124	0.037	0.068	0.019
	(0.104)	(0.104)	(0.104)	(0.106)	(0.105)	(0.100)
30 to 39 years	-0.279	-0.277	-0.276	0.006	0.035	-0.037
	(0.104)	(0.104)	(0.103)	(0.110)	(0.109)	(0.103)

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
40 years or older	-0.331	-0.331	-0.328	-0.044	-0.020	-0.150
	(0.141)	(0.141)	(0.140)	(0.145)	(0.142)	(0.134)
Highest parental education at birth (Ref.: Higher)						
No qualification	0.493	0.487	0.479	0.223	0.218	0.225
	(0.114)	(0.114)	(0.114)	(0.119)	(0.118)	(0.117)
Lower sec.	0.338	0.332	0.327	0.148	0.139	0.129
	(0.058)	(0.058)	(0.058)	(0.063)	(0.063)	(0.062)
Upper sec.	0.158	0.157	0.152	0.046	0.068	0.084
	(0.053)	(0.053)	(0.053)	(0.056)	(0.056)	(0.054)
Voc. And postsec.	0.158	0.154	0.150	0.059	0.085	0.076
	(0.056)	(0.056)	(0.056)	(0.058)	(0.058)	(0.057)
Educ. Activities very important	-0.178	-0.174	-0.177	-0.172	-0.166	-0.164
	(0.056)	(0.056)	(0.056)	(0.055)	(0.053)	(0.053)
Good maternal-infant attachment	-0.137	-0.133	-0.132	-0.086	-0.044	-0.056
	(0.057)	(0.057)	(0.057)	(0.056)	(0.055)	(0.053)
Child health at t				0.078	0.030	0.104
				(0.033)	(0.035)	(0.033)
Maternal concern about development at t				0.311	0.477	0.541
				(0.059)	(0.054)	(0.058)
Mother not in good health at t				0.218	0.250	0.232
				(0.073)	(0.068)	(0.063)
Maternal employment status at t (Ref.: Full-time)						
Part-time				-0.012	0.027	-0.023
				(0.051)	(0.050)	(0.049)

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Not working				0.007	0.050	0.039
				(0.058)	(0.055)	(0.055)
Number of siblings in the home at t (Ref.: None)						
One				-0.167	-0.160	-0.107
				(0.043)	(0.044)	(0.048)
Two or more				-0.273	-0.260	-0.224
				(0.059)	(0.058)	(0.059)
Mother's relationship status at t (Ref. No partner)						
Married				-0.128	-0.218	-0.160
				(0.074)	(0.073)	(0.072)
Cohabitation				0.006	-0.093	-0.013
				(0.075)	(0.074)	(0.074)
Household income				-0.008	-0.005	-0.004
				(0.002)	(0.002)	(0.002)
Region type at t (Ref.: Fewer than 10,000 residents)						
10,000 to 124,999 residents				-0.049	0.011	-0.005
				(0.045)	(0.044)	(0.044)
125,000 or more residents				0.023	0.048	0.052
				(0.045)	(0.045)	(0.045)
Lives in deprived area				0.030	0.033	0.031
				(0.016)	(0.015)	(0.015)
Constant	0.146	0.116	0.094	-0.187	-0.434	-0.627
	(0.127)	(0.129)	(0.130)	(0.178)	(0.176)	(0.168)
R^2	0.080	0.081	0.081	0.124	0.145	0.155

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Peer relations						
Hours of TV/week (age 2)	0.003	0.004	0.004	-0.001	-0.000	0.002
	(0.004)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)
Hours of TV/week (age 3)		-0.003	-0.002		-0.004	-0.004
		(0.003)	(0.003)		(0.003)	(0.003)
Hours of TV/week (age 4)			-0.001			-0.002
			(0.002)			(0.002)
Child is male	0.143	0.143	0.144	0.110	0.109	0.106
	(0.038)	(0.038)	(0.038)	(0.037)	(0.037)	(0.037)
Mother's age at birth						
(Ref.: less than 20 years)						
20 to 29 years	-0.233	-0.233	-0.233	-0.111	-0.096	-0.104
	(0.117)	(0.117)	(0.117)	(0.121)	(0.120)	(0.118)
30 to 39 years	-0.329	-0.330	-0.330	-0.083	-0.078	-0.099
	(0.116)	(0.117)	(0.117)	(0.124)	(0.123)	(0.121)
40 years or older	-0.223	-0.223	-0.224	0.028	0.038	-0.042
	(0.162)	(0.162)	(0.162)	(0.169)	(0.166)	(0.163)
Highest parental education at						
birth (Ref.: Higher)						
No qualification	0.445	0.449	0.452	0.131	0.162	0.152
	(0.127)	(0.128)	(0.127)	(0.133)	(0.138)	(0.131)
Lower sec.	0.168	0.171	0.173	-0.063	-0.049	-0.080
	(0.057)	(0.057)	(0.057)	(0.064)	(0.065)	(0.064)
Upper sec.	0.059	0.060	0.062	-0.092	-0.067	-0.059
	(0.053)	(0.053)	(0.053)	(0.056)	(0.057)	(0.056)
Voc. And postsec.	0.153	0.155	0.156	0.020	0.055	0.043
	(0.060)	(0.060)	(0.060)	(0.060)	(0.060)	(0.060)

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Educ. Activities very important	-0.083	-0.086	-0.085	-0.053	-0.061	-0.057
	(0.057)	(0.057)	(0.057)	(0.058)	(0.057)	(0.057)
Good maternal-infant attachment	-0.218	-0.220	-0.221	-0.170	-0.138	-0.144
	(0.064)	(0.064)	(0.064)	(0.063)	(0.062)	(0.062)
Child health at t				0.063	0.059	0.147
				(0.033)	(0.036)	(0.037)
Maternal concern about development at t				0.423	0.445	0.446
				(0.070)	(0.074)	(0.076)
Mother not in good health at t				0.149	0.190	0.179
				(0.068)	(0.070)	(0.064)
Maternal employment status at t (Ref.: Full-time)						
Part-time				-0.036	-0.064	-0.024
				(0.050)	(0.050)	(0.049)
Not working				0.006	-0.003	0.037
				(0.059)	(0.057)	(0.055)
Number of siblings in the home at t (Ref.: None)						
One				-0.199	-0.212	-0.269
				(0.044)	(0.045)	(0.050)
Two or more				-0.178	-0.185	-0.272
				(0.062)	(0.064)	(0.065)
Mother's relationship status at t (Ref. No partner)						
Married				-0.011	-0.022	-0.002
				(0.075)	(0.072)	(0.074)

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Cohabitation				0.069	0.030	-0.022
				(0.076)	(0.074)	(0.075)
Household income				-0.010	-0.009	-0.010
				(0.002)	(0.002)	(0.002)
Region type at t (Ref.: Fewer than 10,000 residents)						
10,000 to 124,999 residents				-0.016	0.001	-0.007
				(0.048)	(0.047)	(0.046)
125,000 or more residents				-0.111	-0.086	-0.068
				(0.045)	(0.045)	(0.045)
Lives in deprived area				0.044	0.041	0.035
				(0.016)	(0.016)	(0.016)
Constant	0.379	0.398	0.405	-0.040	-0.053	-0.058
	(0.139)	(0.141)	(0.142)	(0.193)	(0.196)	(0.201)
R^2	0.034	0.034	0.034	0.084	0.093	0.106
Prosocial score						
Hours of TV/week (age 2)	-0.013	-0.012	-0.011	-0.013	-0.010	-0.011
	(0.004)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)
Hours of TV/week (age 3)		-0.002	-0.001		-0.002	-0.000
		(0.003)	(0.003)		(0.003)	(0.003)
Hours of TV/week (age 4)			-0.004			-0.004
			(0.002)			(0.002)
Child is male	-0.293	-0.293	-0.291	-0.280	-0.271	-0.268
	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Mother's age at birth (Ref.: less than 20 years)						
20 to 29 years	0.014	0.013	0.014	0.019	-0.006	0.003
	(0.108)	(0.107)	(0.107)	(0.109)	(0.109)	(0.108)
30 to 39 years	-0.069	-0.070	-0.072	-0.076	-0.112	-0.092
	(0.108)	(0.108)	(0.107)	(0.114)	(0.113)	(0.112)
40 years or older	0.001	0.001	-0.003	0.015	-0.020	0.021
	(0.139)	(0.139)	(0.139)	(0.143)	(0.144)	(0.143)
Highest parental education at birth (Ref.: Higher)						
No qualification	-0.080	-0.077	-0.065	0.027	0.037	0.031
	(0.107)	(0.106)	(0.107)	(0.116)	(0.115)	(0.117)
Lower sec.	-0.030	-0.026	-0.020	0.035	0.041	0.051
	(0.056)	(0.056)	(0.057)	(0.064)	(0.064)	(0.063)
Upper sec.	0.067	0.068	0.075	0.097	0.088	0.089
	(0.053)	(0.053)	(0.054)	(0.057)	(0.056)	(0.056)
Voc. and postsec.	0.022	0.024	0.030	0.038	0.021	0.042
	(0.055)	(0.056)	(0.056)	(0.058)	(0.058)	(0.058)
Educ. activities very important	0.228	0.226	0.229	0.209	0.197	0.204
	(0.056)	(0.057)	(0.057)	(0.057)	(0.057)	(0.056)
Good maternal-infant attachment	0.050	0.048	0.047	0.031	0.006	0.017
	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)	(0.057)
Child health at t				-0.066	-0.026	-0.059
				(0.034)	(0.035)	(0.033)
Maternal concern about development at t				-0.141	-0.337	-0.350
				(0.062)	(0.065)	(0.066)

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Mother not in good health at t				-0.034	-0.071	-0.042
				(0.068)	(0.066)	(0.062)
Maternal employment status at t (Ref.: Full-time)						
Part-time				-0.118	-0.109	-0.122
				(0.052)	(0.051)	(0.050)
Not working				-0.076	-0.125	-0.061
				(0.059)	(0.056)	(0.056)
Number of siblings in the home at t (Ref.: None)						
One				0.013	0.018	-0.017
				(0.045)	(0.046)	(0.049)
Two or more				-0.085	-0.079	-0.094
				(0.062)	(0.061)	(0.062)
Mother's relationship status at t (Ref. No partner)						
Married				0.066	0.046	0.063
				(0.071)	(0.069)	(0.070)
Cohabitation				0.027	-0.046	-0.019
				(0.071)	(0.072)	(0.072)
Household income				0.002	0.002	0.003
				(0.002)	(0.002)	(0.002)
Region type at t (Ref.: Fewer than 10,000 residents)						
10,000 to 124,999 residents				0.040	0.003	0.028
				(0.047)	(0.046)	(0.046)
125,000 or more residents				-0.035	-0.053	-0.050
				(0.047)	(0.047)	(0.047)

	TCC			+ TVC		
	Age 2	Age 3	Age 4	Age 2	Age 3	Age 4
Lives in deprived area				0.006	0.018	0.022
				(0.016)	(0.015)	(0.016)
Constant	-0.009	0.008	0.038	0.229	0.475	0.480
	(0.128)	(0.129)	(0.130)	(0.184)	(0.184)	(0.185)
R^2	0.037	0.037	0.038	0.047	0.061	0.065

Note. $^* p < .05$, $^{**} p < .01$, $^{***} p < .001$. Robust standard errors in parentheses.

Table S6. *Summary of WLS models predicting change in standardized developmental outcomes between ages three and five from hours of weekly TV consumption and covariates across at age 3 (N = 2,594 children)*

	M1	M2	M3	M4
Naming vocabulary				
Hours of TV/week (age 4)	-0.002	-0.002	-0.002	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Naming vocabulary (age 3)				-0.558***
				(0.024)
R^2	0.001	0.017	0.023	0.287
Picture similarities				
Hours of TV/week (age 4)	-0.004	-0.005*	-0.005*	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)
Picture similarities (age 3)				-0.750***
				(0.022)
Model includes:				
TCC		X	X	X
TVC (age 3)			X	X
R^2	0.001	0.009	0.021	0.372

Note. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors in parentheses; TCC = time-constant covariates; TVC = time-varying covariates