

Children's Television Viewing and Cognitive Outcomes

A Longitudinal Analysis of National Data

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Objective: To test the independent effects of television viewing in children before age 3 years and at ages 3 to 5 years on several measures of cognitive outcomes at ages 6 and 7 years.

Design: Using data from a nationally representative data set, we regressed 4 measures of cognitive development at ages 6 and 7 years on television viewing before age 3 years and at ages 3 to 5 years, controlling for parental cognitive stimulation throughout early childhood, maternal education, and IQ.

Results: Before age 3 years, the children in this study watched an average of 2.2 hours per day; at ages 3 to 5 years, the daily average was 3.3 hours. Adjusted for the covariates mentioned earlier, each hour of average daily television viewing before age 3 years was associated with deleterious effects on the Peabody Individual Achievement Test Reading Recognition Scale of 0.31 points (95%

confidence interval [CI], -0.61 to -0.01 points), on the Peabody Individual Achievement Test Reading Comprehension Scale of 0.58 points (95% CI, -0.94 to -0.21 points), and on the Memory for Digit Span assessment from the Wechsler Intelligence Scales for Children of -0.10 points (95% CI, -0.20 to 0 points). For the Reading Recognition Scale score only, a beneficial effect of television at ages 3 to 5 years was identified, with each hour associated with a 0.51-point improvement in the score (95% CI, 0.17 to 0.85 points).

Conclusions: There are modest adverse effects of television viewing before age 3 years on the subsequent cognitive development of children. These results suggest that greater adherence to the American Academy of Pediatrics guidelines that children younger than 2 years not watch television is warranted.

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A LARGE NUMBER OF STUDIES have reported deleterious effects of children's television viewing on outcomes such as obesity, inactivity, attentional problems, aggression, and sleep patterns.¹⁻⁴ In the important domain of cognitive development, however, the evidence is considerably more ambiguous; some research has shown television viewing of noneducational programs to be harmful to children's school readiness and cognitive outcomes, but other research has shown educational television to be beneficial. A number of experimental studies have shown that children who watch episodes of educational television, such as *Sesame Street*, *Mr Rogers' Neighborhood*, and *Blue's Clues*, demonstrate improvements in educational domains immediately afterward.⁴⁻⁷ Conversely, other experimental studies have shown short-term detriments in children who watch noneducational television.^{8,9} Taken together, one might conclude that measured and appro-

priate use of television can have a positive impact on children's cognition. Yet a major unanswered question in this research is whether parents direct their children's television use in a way that maximizes its potential benefits. In other words, at a population level, is television viewing by young children, on balance, beneficial with respect to cognitive outcomes?

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This question is important given that much of the viewing by children is not consistent with its educational purpose. Children aged 3 to 5 years, which is the age targeted by *Sesame Street* and many other educational programs, watch an average of 2 hours or more of television or videos per day,¹⁰⁻¹² and much of this is not devoted to children's educational programming.^{13,14} Among younger children, 59% of children younger than 2 years regularly watch

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television every day, and these children watch 1.3 hours of television per day,¹⁰ despite the fact that there is no programming of proven educational value targeted at this age range. The American Academy of Pediatrics (Elk Grove Village, Ill) recommends no screen time for children younger than 2 years and only high-quality, age-appropriate viewing thereafter.¹⁵ Clearly, a very substantial portion of television as it is actually watched by children does not meet these recommendations.

Very few longitudinal studies of television viewing among children and subsequent cognitive outcomes have been reported in the literature.^{7,16,17} Their results are somewhat conflicting. They have demonstrated small beneficial effects of educational television viewing over the medium-term for children of a lower socioeconomic status (SES) and negative, though generally not significant, effects of noneducational programming. However, these studies have by and large been conducted with adolescents, are in limited populations, and/or use very old data.

There are also reasons to believe that the effects of television may in fact be different by different levels of parental education and cognitive ability.^{13,16,18-20} Jordan¹⁹ has proposed an "ecological" paradigm for media research, in which the effects of television viewing may be different within distinct sociocultural niches. Indeed, a longitudinal Swedish study reports that "high achievers" used television as a complement to school learning, whereas "low achievers" used television as a substitute for it.¹⁶ Similarly, a study of 326 young children found that parental education is negatively related to hours watched overall.¹³ Other studies have found effect modification of the effects of television viewing on educational outcomes by the SES of the parents.^{14,21} As a result, television viewing in a general population may serve to exacerbate disparities in cognitive outcomes between high-SES and low-SES households.

Heavy television viewing by children is worrisome because of the possible negative effects of such viewing on cognitive outcomes. A randomized trial of television reduction among 6-year-olds showed a modest, but significant, improvement in performance IQ and attention time on cognitive tasks associated with experimentally induced reductions in television viewing over a 6-week period.²² First graders who depended heavily on television and video games for narrative foundations in a story-writing workshop were less able than other students to develop their skills throughout the course of the workshop, and the problem was disproportionately characteristic of minority students.²³ Television and video have been shown to discourage reflection and interpretation and to depress imagination and creativity.^{4,24,25}

The major question begged by the literature demonstrating the educational potential of television, together with the literature showing poor selectivity in viewing, is whether television, as it is actually viewed in American households, is good or bad for cognitive development. If early television viewing has a net negative effect, parents may need to be advised to undertake greater efforts to steer their children toward educational television and/or reduce overall television viewing time.

Much of the existing research on these issues is 20 years old or more. Given the major changes in both the con-

tent and the style of broadcast television over this period,^{19,26} as well as the emergence of new media technology, outdated research in this field must be treated with even more than the usual caution.²⁷

In the current project, we sought to answer the following questions: (1) Is television viewing among children who are younger (ie, <3 years) than the target age (3-5 years) for preschool educational programs harmful for children's cognitive development? (2) For children aged 3 to 5 years—for whom considerable educational programming exists—does television viewing on average have positive effects for cognitive development?

METHODS

DATA

Data from this study were drawn from the National Longitudinal Survey of Youth 1979 Children and Young Adults (NLSY-Child), an outgrowth of the original National Longitudinal Survey of Youth 1979 (NLSY '79). The NLSY '79, sponsored by the US Department of Labor, began with a nationally representative sample of almost 12 700 individuals aged 14 to 22 years in 1979 who have been interviewed annually or biennially since.^{28,29} African American and Latino individuals were oversampled to provide statistical power for analyses involving these important subgroups, and population weights are available to draw valid national inference. The NLSY-Child, begun in 1986 and conducted biennially, is an extensive collection of information for more than 11 000 children of the female respondents to the NLSY '79 regarding developmental assessment, family background, home environment, and health history.³⁰ Information for the NLSY-Child is obtained from both the mother and child, depending on the child's age. The records from NLSY '79 and NLSY-Child are linkable via the mother's sample identification number. Data from both the 1986-2000 NLSY-Child and NLSY '79 were pulled for this study using the CHRR Database Investigator Software (Build 1.4, 1.57; Center for Human Resources Research, Ohio State University, Columbus).

Our sample consisted of all children who were approximately 6 years of age (5 years 6 months to 7 years 6 months) with complete data at the time of 1 of the 4 most recent survey wave interviews (1994, 1996, 1998, or 2000). For one of the outcomes, the assessment tool was available only for those 7 years or older so we used children who were aged 7 years to 8 years 6 months. The University of Washington (Seattle) institutional review board determined that this research was exempt from institutional review board review because it uses only previously collected, delinked data.

OUTCOME MEASURE

Our primary outcome measures were components of the Peabody Individual Achievement Test (PIAT), assessed at or within 6 months of age 6 years. We used the 3 tests available in the NLSY: mathematics, reading recognition, and reading comprehension. These are well-known and commonly used, validated and normed measures.³⁰ One-month test-retest reliability in this age range of the mathematics, reading recognition, and reading comprehension scores are 0.74, 0.81, and 0.78, respectively. Correlation of these scores with the full PIAT assessment is 0.72, 0.78, and 0.70.³⁰ The age-standardized scores were used for each of these measures. Reading recognition measures the ability to sound out and pronounce words, whereas the reading comprehension score measures the ability to read a sentence and match the overall meaning of the sentence to 1 of 4 pictures.

Because of a technical error in coding the data, valid data were available on a smaller sample of children for the reading tests than for the mathematics test.³⁰ Because this was a technical problem related to data acquisition, and not the result of response willingness on the part of the participants, it is assumed that the missing reading scores were missing at random and therefore not biasing our findings.

Age 6 years was chosen to measure the outcomes because it represents the age at which many children begin first grade. Television viewing typically drops off at this time, because children devote more time to school and have less free time.⁴ As such, it is approximately the earliest age at which preschool television viewing is largely complete. Subanalyses tested the effects of early television viewing with the outcomes measured at age 5 years and age 7 years (not reported) and found very similar results to those reported herein.

As a secondary outcome of interest, we also used the Memory for Digit Span assessment from the Wechsler Intelligence Scale for Children (hereafter referred to as Digit Span). Digit Span assesses short-term memory and involves asking children to repeat back to the interviewer a list of numbers, either in the order given or in reverse order. As such, it measures the important cognitive domain of short-term memory. Age-standardized scores were used in this analysis. The overall completion rate of the Digit Span measure was 89%, with African American children somewhat more likely to complete the measure than white or Latino children. The Digit Span has been used previously in analyses of the determinants of cognitive outcomes.³⁰

PRIMARY PREDICTORS

Our primary predictor of interest was the hours of television watched per day prior to age 6 years. In each survey year, the mother was asked how much television the child watched on a typical weekday and on a typical weekend day. (In 2000, the mother was asked about Saturday and Sunday separately.) We created the average daily amount by multiplying the weekday response by 5, the weekend response by 2 (or for 2000 adding the Saturday and Sunday responses), adding these 2 results, and then dividing by 7.

When parents reported that their child watched more than 16 hours per day, they were dropped from the analysis because the response was not credible. However, a *t* test of the scores on each of the outcomes revealed that for all the outcomes except Digit Span, all scores were lower among the children with unreasonably high TV hours than among the children with values in the reasonable range, and these differences were significant at *P* < .001. For Digit Span, the scores were also lower for the children with the unreasonable values, but the differences were not significant.

For each child, 3 television viewing variables were created. "television younger than 3 years" was created as the average of the television viewing amount in survey waves when the child was younger than 3 years. "Television age 3 to 5 years" was created as the average of the television viewing amount in survey waves when the child was aged 3 to 5 years. "Television age 6 years" was the television viewing amount for the survey wave when the child was within 6 months of being aged 6 years. The correlation coefficient (ρ) between "television younger than 3 years" and "television age 3 to 5 years" was 0.47; between "television age 3 to 5 years" and "television age 6 years" was 0.60; and between "television younger than 3 years" and "television age 6 years" was 0.29.

To clarify the effects of television viewing at different ages, viewing in each of the 2 age ranges was dichotomized according to whether the child watched less than or more than 3 hours

per day at each age. This process created 4 distinct categories of children according to their viewing histories: (1) those who watched less than 3 hours per day before age 3 years and less than 3 hours per day at age 3 to 5 years (low-low television); (2) those who watched less than 3 hours per day before age 3 years, followed by greater than 3 hours per day at age 3 to 5 years (low-high television); (3) those who watched greater than 3 hours per day before age 3 years, followed by less than 3 hours per day at age 3 to 5 years (high-low television); and (4) those who watched greater than 3 hours per day both before and after age 3 years (high-high television). These categories were then included in a second analysis of the data instead of the linear variables representing television viewing.

COVARIATES

Several important variables had the potential to confound the relationship between early television viewing and cognitive outcomes. It is possible that parents who allow their children to watch large amounts of television, especially at early ages, are systematically different than parents who do not and that these differences may also be associated with cognitive outcomes.

Certain parents may be either less invested than others in their children's cognitive development or simply less aware of the American Academy of Pediatrics guidelines and the potential adverse effects of television viewing. Such parents may be more permissive in allowing their children access to large amounts of television time and also less likely to spend time reading to their children, taking them to museums and zoos, and so forth. To control for this confounding by parental preferences and investment in cognitive outcomes, we included a measure of parental cognitive stimulation, from the Home Observation for Measurement of the Environment-Short Form, assessed at ages younger than 3 years, 3 to 5 years, and 6 years. This scale has been shown to have good psychometric properties and has been used extensively in child development research.³⁰⁻³² These subscales include both maternal-report and interviewer-report items. The cognitive stimulation score generally includes items related to outings, reading, playing, and parental roles in teaching a child.

A second possible source of confounding was in innate cognitive ability passed from parents to children. If parents with high ability are more likely to restrict their children's television viewing, then failure to control for the resulting confounding will overstate the effects of television viewing on cognitive outcomes. We included several measures of parental ability: a measure of the intellectual environment of the mother's home while growing up; the mother's education level; and the mother's score on the Armed Forces Qualifying Test, which is a validated test of intelligence and general aptitude used by the US military.²⁹ As the measure of the mother's intellectual background, we used the number of magazines and newspapers to which the mother's parents subscribed at the mother's initial interview, that is, when she was 14 to 22 years of age. This is a crude measure, but it represents an important potential control for the ability and cognitive achievement of the grandparents and the mother.

We also controlled for the child's race/ethnicity, since these have been shown to be correlated both with the outcome measures³⁰ and with the type and quantity of television viewing.^{13,20,21}

Finally, we controlled for whether the child's parents were native speakers of Spanish or some other non-English language, since this has been shown to be related to the type and quantity of television viewing²⁰ and is presumably also associated with performance on the outcome measures. (A Spanish-language assessment was available in the NLSY.)

Table 1. Descriptive Statistics

Variable	Sample Size	Mean (SD)*
Outcomes		
PIAT mathematics score at age 6 y	1797	102.33 (12.93)
PIAT reading recognition score at age 6 y	1789	106.21 (11.85)
PIAT reading comprehension score at age 6 y	1031	108.13 (10.13)
Wechsler Digit Span Memory score at age 7 y	1150	9.98 (2.91)
Main predictors		
Television viewing, hours per day, at age <3 y	1797	2.20 (2.22)
Television viewing, hours per day, ages 3-5 y	1797	3.29 (2.18)
Television viewing, >3 h/d at age <3 y and 3-5 y (high-high group [base category])	1797	20
Television viewing ≤3 h/d at <3 y and television viewing >3 h/d at ages 3-5 y (low-high group)	1797	26
Television viewing >3 h/d at age <3 y and television viewing ≤3 h/d at ages 3-5 y (high-low group)	1797	5
Television viewing ≤3 h/d at age <3 y and television viewing ≤3 h/d at ages 3-5 y (low-low group)	1797	49

Abbreviation: PIAT, Peabody Primary Achievement Test.

*For binary variables, the "Mean (SD)" column contains the percentage of the sample having these attributes.

In earlier versions of the model, additional covariates were included. Paternal education, household income, participation in Head Start, the mother's working status, urban/rural residence, the mother's age, and the number of children in the household were all found not to meaningfully or statistically affect the estimated results and accordingly were dropped from the final model.

ANALYSIS

The analytical approach was multivariate regression analysis, using the NLSY survey weights and the Huber-White estimator of variance³³ to adjust for the fact that more than 1 child was assessed in several households. (There were an average of 1.6 children per household.)

In addition, effect modification of the television effect by SES (more than or less than the median income) was formally tested in each of the models and was found to be significant only for the mathematics outcome. Accordingly, the same regression was executed separately for lower than median- and higher than median-income households for mathematics. Sex, race/ethnicity (nonwhite vs white), and language (native English-speaking household vs native speakers of a non-English language) were each independently tested and found not to be significant effect modifiers of the relationship between television viewing and any of the outcomes.

RESULTS

Table 1 presents descriptive statistics of the variables used in the study. The mean number of hours per day of television viewing was 2.2 for children younger than 3 years. Children aged 3 to 5 years watched an average of

3.29 hours per day, and children aged 6 years watched an average of 3.54 hours per day. Twenty percent of children were in the high-high television viewing-history pattern; 26% in the low-high television group; 5% in the high-low television group; and 49% in the low-low television group.

Table 2 presents the results of the regressions of the PIAT mathematics, reading recognition, and reading comprehension scores on the predictors and the potential confounders for each of the 2 models. In the linear model, the amount of television viewing was not associated at any age with the child's performance on the Mathematics Scale at age 6 years. Television viewing before age 3 years was associated with a deleterious effect on both reading recognition and reading comprehension, with each additional hour per day leading to a reduction in scores of 0.31 and 0.58, respectively (95% confidence interval [CI], -0.61 to -0.01 and -0.94 to -0.21). By contrast, television viewing at ages 3 to 5 years was associated with an increase in reading comprehension scores of 0.51 per hour per day viewed (95% CI, 0.17 to 0.85). In the model with television viewing included as categorical variables, the low-high television viewing pattern improved mathematics, reading recognition, and reading comprehension scores, respectively, by 2.74 (95% CI, 0.89 to 4.60), 1.85 (95% CI, 0.15 to 3.55), and 3.92 (95% CI, 1.89 to 5.95) over the high-high television group. The low-low television viewing pattern improved mathematics and reading comprehension scores by 2.03 (95% CI, 0.24 to 3.83) and 2.32 (95% CI, 0.43 to 4.22) over the high-high television group. The scores of the high-low pattern were statistically indistinguishable from those of the high-high group in these domains. The scores of the low-low television and low-high television groups were statistically indistinguishable from each other.

Table 3 presents the results of the regression of Digit Span outcome on the television variables and potential confounders. Again, in the linear model, early television viewing was associated with an adverse effect on Digit Span, with each hour per day viewed associated with a 0.10 decrease in the score (95% CI, -0.20 to 0). There was no significant benefit for viewing at ages 3 to 5 years (P value = .16). In the categorical model, only the results for the low-low television group were significant, with an effect of 0.59 (95% CI, 0.03 to 1.15) over the high-high group.

Table 4 presents the results of the regressions of the PIAT mathematics scores for the lower than median-income and higher than median-income subsamples separately. In the lower than median-income subsample, each hour per day of television viewing before age 3 years in the linear model was associated with a 0.45 decrement in the mathematics score (95% CI, -0.85 to -0.04); television viewing at the other ages was not significant. In the categorical model, only the low-low television viewing pattern was significant, with a benefit of 2.96 points (95% CI, 0.34 to 5.58 points) relative to the high-high group. In the higher than median-income subsample, television viewing was not significant in the linear model. In the categorical model, only the low-high television viewing pattern was significant, with an effect of 2.98 (95% CI, 0.20 to 5.75) vis-à-vis the high-high group.

Table 2. Regressions of Cognitive Outcome Scores at Age 6 Years on Early Television Viewing*

	PIAT Mathematics Score	PIAT Reading Recognition Score	PIAT Reading Comprehension Score
Model with television viewing included as linear covariates			
Television viewing, hours per day at < 3 y	-0.17 (-0.50 to 0.16)	-0.31 (-0.61 to -0.01)	-0.58 (-0.94 to -0.21)
Television viewing, hours per day at ages 3-5 y	-0.01 (-0.41 to 0.39)	0.51 (0.17 to 0.85)	0.28 (-0.12 to 0.68)
<i>R</i> ²	0.21	0.15	0.12
Model with television viewing included as discrete categories			
High viewing followed by high viewing (base category)			
High viewing followed by low viewing	1.99 (-0.97 to 4.96)	-0.91 (-3.56 to 1.74)	1.66 (-1.82 to 5.13)
Low viewing followed by high viewing	2.74 (0.89 to 4.60)	1.85 (0.15 to 3.55)	3.92 (1.89 to 5.95)
Low viewing followed by low viewing	2.03 (0.24 to 3.83)	0.01 (-1.74 to 1.75)	2.32 (0.43 to 4.22)
<i>R</i> ²	0.21	0.15	0.13
Sample size	1797	1795	1034

Abbreviation: PIAT, Peabody Primary Achievement Test.

*Values are expressed as coefficient (95% confidence interval) unless otherwise indicated. Regressions were adjusted for television viewing at age 6 years; parental cognitive stimulation at ages 0 to 3 years, 3 to 5 years, and at 6 years; non-English native language; race/ethnicity; and mother's education and IQ.

Table 3. Regression of Short-term Memory Outcome at Age 7 Years on Early Television Viewing*

	Wechsler Digit Span Memory Score at Age 7 y
Model with television viewing included as linear covariates	
Television viewing, hours per day at age < 3 y	-0.10 (-0.20 to 0)
Television viewing, hours per day at ages 3-5 y	0.09 (-0.04 to 0.22)
<i>R</i> ²	0.07
Model with television viewing included as discrete categories	
High viewing followed by high viewing (base category)	
High viewing followed by low viewing	0.30 (-0.67 to 1.27)
Low viewing followed by high viewing	0.52 (-0.07 to 1.12)
Low viewing followed by low viewing	0.59 (0.03 to 1.15)
<i>R</i> ²	0.07
Sample size	1150

*Values are expressed as coefficient (95% confidence interval) unless otherwise indicated. Regressions were adjusted for television viewing at age 6 years; parental cognitive stimulation at ages 0 to 3 years, 3 to 5 years, and 6 years; non-English native language; race/ethnicity; and mother's education and IQ.

COMMENT

This analysis has shown a consistent pattern of negative associations between television viewing before age 3 years and adverse cognitive outcomes at ages 6 and 7 years. The inclusion of extensive controls for parental preferences, ability, and investment in their children's cognitive development suggests that these associations may in some direct or indirect way be causal.

However, the causal mechanism of such an effect, if any, is not clear. It might be that children younger than 3 years who spend more time watching television spend less time in other activities, such as imaginative free play, interactions with adults, and so forth, that would be ben-

Table 4. Regressions of PIAT Mathematics Scores at Age 6 Years on Early Television Viewing: Stratified Analysis by SES*

	Lower Than Median-Income Sample	Higher Than Median-Income Sample
Model with television viewing included as linear covariates		
Television viewing, hours per day at age < 3 y	-0.45 (-0.85 to -0.04)	0.25 (-0.29 to 0.79)
Television viewing, hours per day at ages 3-5 y	-0.04 (-0.57 to 0.49)	0.03 (-0.54 to 0.60)
<i>R</i> ²	0.21	0.16
Model with television viewing included as discrete categories		
High viewing followed by high viewing (base category)		
High viewing followed by low viewing	1.06 (-2.92 to 5.05)	3.21 (-1.25 to 7.67)
Low viewing followed by high viewing	2.56 (-0.01 to 5.14)	2.98 (0.20 to 5.75)
Low viewing followed by low viewing	2.96 (0.34 to 5.58)	1.34 (-1.23 to 3.90)
<i>R</i> ²		
Sample size	896	901

Abbreviations: PIAT, Peabody Primary Achievement Test; SES, socioeconomic status.

*Values are expressed as coefficient (95% confidence interval) unless otherwise indicated. Regressions were adjusted for television viewing at age 6 years; parental cognitive stimulation at ages 0 to 3 years, 3 to 5 years, and 6 years; non-English native language; race/ethnicity; and mother's education and IQ. Median split did not mediate the associations in the other domains studied.

eficial to their cognitive development. Or, it may be that the content of the television they watch is deleterious to their cognitive development. Finally, it may be that the medium itself is deleterious, whether because of aspects

of the production (eg, the pacing and rapid scene changes) or the simple fact of looking in a single direction at a single stimulus for a long time. This analysis sheds no light on these issues and clearly begs more focused research into these potential causal pathways.

Very little, if any, educational content was available for children younger than 3 years in the years when the children in this study were that age (1990-1996)—a situation that continues today. Yet children younger than 3 years in this sample were watching an average of 2.2 hours of television per day. Parents may believe that even at young ages television generally can be educational, yet this study suggests that television for very young children is not helpful for cognitive development and may indeed be harmful.

By contrast, this analysis suggests that television viewing at ages 3 to 5 years has a more beneficial effect, at least for the outcomes of reading recognition and short-term memory (Digit Span). *Sesame Street*, *Mr Rogers' Neighborhood*, and other educational television shows are targeted at 3- to 5-year-olds, so the finding of a positive effect in this age range is consistent with the experimental and observational literature that finds a positive effect of educational television for children in this age group.^{26,34} On the other hand, there is no beneficial effect on mathematics outcomes or reading comprehension. Because reading recognition and short-term memory are arguably the most basic of the cognitive outcomes studied, the implication would seem to be that the net effect of television viewing from a population perspective is limited in its beneficial impact.

The magnitude of these effects in the linear model is not large. Each hour of television viewing at any age is associated with changes (positive or negative, depending on the age) on the order of fractions of 1 SD in the outcomes. However, considering the wide range of television viewing hours (0-16) and the relatively large standard deviation in the hours of television viewing (more than 2 hours per day), there is a modest effect of television. Additional light is shed on the magnitude of the effects in the categorical model. The effect of having a viewing pattern of low-low television or low-high television as opposed to high-high television is in the range of 2 to 4 for reading and mathematics scores. For comparison purposes, the effect of a 1-SD increase in maternal intelligence as measured by the Armed Forces Qualifying Test ranges from 1.77 to 2.22 for these outcomes. To achieve this effect through maternal education would imply an additional 2.7 to 4.4 years of completed schooling. Accordingly, while the magnitudes of the association of heavy television viewing with cognitive outcomes are not enormous, they are commensurate with the magnitudes of large changes in maternal education and intelligence.

There are 2 potentially important features of this analysis. First, the television viewing measure used—maternal report of typical viewing hours—is known to be inaccurate. There are several different ways of assessing the amount of television viewed, including direct observation of participant viewing, assessment by a Portable People Meter (a device that is worn by the participant that picks up continuous, inaudible station identification information),³⁵ and daily time-use diaries that include the shows actually watched. The estimates of viewing time obtained by

these different methods vary considerably by method.^{36,37} Accordingly, while the measure of television viewing here has good validity, it is probably also burdened by substantial measurement error.^{36,37} However imperfectly television viewing was measured in this data set, the effect of random measurement error is to bias the results toward the null.³⁸ It is quite possible, therefore, that with more accurate data, more significant effects of television viewing on children's outcomes could be identified. Second, the same argument can be made for the outcome variables, which are brief instruments. A more thorough assessment of outcomes would reduce measurement error and would by some unknown margin increase our ability to detect an effect.

One of the contributions of this study is to recognize and explicitly model the heterogeneous effect of television viewing at different ages on children's outcomes. Television viewing in early childhood varies depending on age; for very young children the effects are negative, while for preschool children they can be constructive, at least in some domains.

The causal pathway through which television viewing may be deleterious to children's cognitive development has been suggested to work through the displacement by television of more valuable activities, such as reading.²² In this analysis, however, time spent reading and in other cognitively stimulating activities at several ages was explicitly controlled, so any adverse effects of television would presumably be attributable to some other pathway. One such possibility would be through the effects of the intense visual and aural stimuli of television on the development of children's brains, which is very rapid in the early years. The notion that early exposure to this medium can have adverse consequences on processing has been advanced for some time.^{1,8,9,39}

The results here are specific to the programming and cultural context of the United States. Programming in other countries differs to some extent from that available to US viewers, and those who view with subtitles may benefit more (or less) from the concurrent display of written and spoken languages, although such cultural effect modification is undoubtedly more pronounced for older viewers.⁴⁰

The American Academy of Pediatrics has issued guidelines urging parents to avoid any television or video viewing before age 2 years.¹⁵ It has previously been shown that parents are not able to follow this guideline,⁴¹ and we would argue that the guideline may need greater publicity. This analysis complements this earlier work by suggesting that viewing a heavy television diet entails modest, but statistically significant, consequences for subsequent development in several key cognitive domains.^{10,13} This analysis further suggests that parents may appreciate and benefit from better guidance on the kinds of high-quality content that is available on television and on ways of managing the context of television viewing to maximize its potential benefit for their children.

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