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Effect of Television on Child Cognitive Outcome

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Is the 'Idiot's Box' Raising Idiocy?
Effect of Television on Child Cognitive Outcome

Abstract

There is a widespread belief that exposure to television has harmful effects on children's cognitive development. While a few studies on historical data contradict this belief most research that uses recent data points to a negative correlation between hours of television viewing and cognitive outcomes. The causality, however, is far from established. Using the National Longitudinal Survey of Youth (NLSY) we study children between 5 and 18 years of age during late 1990s and early 2000s. We find strong evidence of negative correlations between hours of television watched and cognitive test scores. However, once parent's characteristics and unobserved family and child characteristics are taken into account these correlations go away. Based on family and child fixed effect estimates we conclude that hours of television viewed *per se* do not have any impact on children's test scores. Our conclusion is robust to different model specifications and instrumental variable estimates addressing potential measurement errors in the variable measuring television hours. Despite the conventional wisdom and the ongoing populist movement, proactive policies to reduce children's television exposure are not likely to improve children's cognitive development and academic performance.

Keywords: Television, child cognitive outcome, test score, panel estimation, instrumental variables.

JEL Classification: I, I2, J, J1, J13

1. INTRODUCTION

In 1950 only ten percent of the households in the United States had a television set; by 1980 it rose to 98 percent and it has not declined since. American children between 2 and 17 years of age watch an average of 25 hours of television each week, with one in five watching for more than 35 hours [Gentile and Walsh, 2002]. The daily estimated hours of television watched by a typical child is almost double the suggested guideline by American Academy of Pediatrics (AAP); AAP recommends two hours or less of quality programming in a given day for children of age two and above, and for children under age two it suggests that television be avoided altogether.[1]

It has become a conventional wisdom that television, in general, and higher exposure to television, in particular, has an adverse effect on children's cognitive development, and that television is at least partly responsible for the widespread deterioration in the youth school performances.[2] The perception of a link between television and child outcomes is very much alive and growing in the policy arena. Barack Obama in his stump speeches throughout the 2007-08 campaign seasons called upon the parents to assume personal responsibility regarding their children's education and turn the television off. In fact, there is an emerging movement to steer policy makers to initiate proactive policies. Grants are available for a "TV-free America" from organizations such as *Media Transparency* who are backed by some of the largest philanthropies in the country.[3] The organization called *Center for Screen-Time Awareness* claims that since 1995 more than twenty-four million people have participated in "TV-Turnoff" weeks, which is also endorsed by the AAP.[4]

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[1] *AAP Policy*: http://aappolicy.aappublications.org/cgi/content/full/pediatrics;104/2/341.

[2] Gentzkow and Shapiro [2008] discuss the academic literature on these perceptions. Some of the media coverage on these issues and the popular movements can be found in the following sources: *More TV = Less Reading* at http://aapgrandrounds.aappublications.org/cgi/content/extract/17/6/68-a; *Children and Watching TV* at http://www.aacap.org/cs/root/facts_for_families/children_and_watching_tv (official website of American Academy of Child and Adolescent Psychiatry); *AAP News* at http://www.aap.org; Federal Communications Commission (FCC), Fact Sheet, 1995, http://www.fcc.gov/Bureaus/Mass_Media/Factsheets/kidstv.txt; *Kill Your Television* at turnoffyourtv.com; Also, in web-logs such as http://www.csun.edu/science/health/docs/tv&health.html.

[3] See http://www.mediatransparency.org/recipientgrants.php?recipientID=6805.

[4] See http://www.screentime.org.

Yet, whether there exists a *causal* relationship between hours of television watched and children's cognitive outcomes remains to be established. Studies of historical data do not support a negative effect of television: Gortmaker et al. [1990] and Gentzkow and Shapiro [2008] study the childhood of the baby boom generation and their television viewing behavior in the 1960s to find no such causal effect. In this paper we focus on the children of the baby boomers and their television viewing behavior in the 1990s and 2000s. We ask whether television watching has causal negative effects on children's cognitive development or whether the observed negative correlations are results of intervening factors such as parental income and education, parental television viewing behavior, or unobserved child and family characteristics that are correlated with both hours of television watching and measures of the child's cognitive development. Based on family and child fixed effect estimates we conclude that hours of television viewed *per se* do not have any impact on children's test scores. Our conclusion is robust to different model specifications and instrumental variable estimates addressing potential measurement errors in the variable measuring television hours.

1.1. Television: past versus present

While Gortmaker et al. [1990] and Gentzkow and Shapiro [2008] give us an historical perspective on the issue, it is important to point out that the period that we focus on, 1990-2002, provides a context that is different in a number of important ways.[5] First, from the supply side, the1990s and the 2000s are completely different eras compared to the 1960s. Table 1 shows that in 1965 there was no cable television. By 1990, more than 50 percent of the households had weird cable and almost 30 percent had paid cable; by 2000, more than 75 percent of the households acquired wired cable. Also, in 1965 less than 25 percent of the households had multiple television sets, whereas 65 percent and 76 percent of the households in 1990 and 2000, respectively, had multiple television sets. In fact, 36

[5] We contrast our paper with Gortmaker et al. [1990] and Gentzkow and Shapiro [2008] in subsection 1.3.

percent of the children in the U.S. in early 2000s had a television in their bedrooms [Rideout, Vandewater, and Wartella, 2003].

Secondly, since the sixties, the families have gone through significant transformations. Female labor force participation in the U.S. in 1965 was 45 percent, which crossed the 75 percent mark during the 90s.[6] Coupled with the fact that the average family size shrunk by 15 percent over the same period,[7] the family's need to use television as a babysitting device and its ability to control the amount of time the child is exposed to television are likely to be vastly different.

And finally, over the last twenty years, significant developments have taken place in the program content and the monitoring technology of television. In 1990, Federal Communications Commission (FCC) enacted the Children's Television Act (CTA) which requires each broadcast television station in the United States to serve the educational and informational needs of children through its overall programming, including programs specifically designed to serve these needs ("core programming"). CTA imposes limits on the amount of time that may be devoted to advertisements during children's programs and establishes rules to provide parents and the public with information about these programming. Around the same time when the Telecommunications Act of 1996 gave the broadcasting industry an opportunity to establish a system for rating, the FCC also ruled that all television sets 13 inches or larger, manufactured after 1999, must have V-Chip technology that enables blocking of programs based on rating. In addition, Cable subscribers may request a "lockbox" from cable operators to prevent viewing of any channel.[8]

While the interaction between the family and its television during our sample period (1990-2002) is very different from that of the sixties, over the last two decades, the state of overall screen media itself has been witnessing significant ongoing transformation.

[6] Bureau of labor Statistics (BLS): Labor force participation rate (annual average) of women 25 to 54 years of age was 45.2% in 1965, 74% in 1990, and 75.3% in 1994.
[7] U.S. Census.
[8] See http://www.fcc.gov for details on CTA, V-Chips and other measures.

However, despite a heightened interest in new media such as computers and video games, television remains by far the dominant screen media for the time period that we study in this paper (Table 2).

1.2. Television and child cognitive development

Two arguments have been put forward as to why television viewing should have a causal effect on child cognitive development.[9] First is the *time displacement* argument. Watching too much television takes time away from essential learning activities such as reading, homework, and structured play activities [Koolstra and Van der Voort 1996]. There is, however, a significant voice that contends this view and argues that television can in fact be a useful tool in children's learning [Huston and Wright 1998]; today's children enter kindergartens with a larger vocabulary than the pre-television generations. The "time displacement" rebuttal to this argument is that even if television is considered a learning device, it is a poor learning device. The passive nature of television watching, lack of interaction of the viewer, and lack of control of the learner on content, pace, and ordering of the material, makes it inferior to traditional devices such as reading. Besides, a large number of skills such as fine motor skills and gross motor skills cannot be learnt from television at all [Borden 1997]. Also, the strong association of television with leisure and relaxation may have a profound effect on learning by lowering the intellectual involvement in processing the information presented in television programs.[10] The *Kaiser Family Foundation* Reports [Rideout, Vandewater, and Wartella, 2003] present strong negative correlations between television watching and reading. Some studies also show negative effects of television on measures of creativity, divergent thinking, and ideational fluency of children [Anderson et al. 2001].

[9.] Anderson et al. [2001] has a detailed literature review of the issues of television and child cognitive development.

[10.] See Salomon [1983], Huston and Wright [1998], and Singer and Singer [1998] for more detailed discussions of these issues.

The second argument relates to the plasticity of the child's brain. The brain continues to develop rapidly through the first few years of the child's life and a significant plasticity exists during this period [Barkovich *et. al.* 1988; Yamada et. al. 2000]. The types and intensity of visual and auditory experiences that children have early in life may have profound influences on brain development [Wallace et. al. 1992; Greenough, Black and Wallace 1987]. Waldman, Nicholson and Adilov [2006] call it an "environmental trigger" that creates hurdles in cognitive development with possible long term developmental consequences. A commonly tested hypothesis is that television may shorten children's attention spans [Singer 1980; Healy 1990] or lead to Attention Deficit Hyperactivity Disorder (ADHD), a condition characterized by short attention, hyperactivity, and impulsivity problems [Christakis et. al. 2004; Hartmann 1996]. Koolstra and Van der Voort [1996] found that television viewing leads to lack of reading and reduction in concentration among children.

1.3. Contributions of this paper

Our paper makes several contributions to the existing academic research on the effect of television watching on child cognitive skill formation. *First*, most studies are often limited to specific aspects of cognitive development such as reading [Koolstra and Van der Voort 1996], ADHD [Christakis et. al. 2004; Hartman 1996], autism [Waldman, Nicholson and Adilov 2006], or stand-alone measures of creativity, divergent thinking, ideational fluency, etc. [Anderson *et al.* 2001]. Studies that look at comprehensive measures of cognitive development such as test scores are rare. Notable exceptions are Zavodny [2006], Gaddy [1986], Gortmaker et al. [1990] and Gentzkow and Shapiro [2008].[11] We use Peabody Individual Achievement Test (PIAT) mathematics and reading test scores as measures of child cognitive development. These tests cover a wide variety of mainstream as

[11] However, as already discussed Gortmaker et al. [1990] and Gentzkow and Shapiro (2008) use historical data. We contrast our paper with Gaddy [1986] and Zavodny [2006] below.

well as advanced skills and proficiencies ranging from deductive and ideational to assortative, recognitive, matching, and general reading skills. These tests are highly reliable and widely used as assessments of children's cognitive development [Center for Human Resource Research (CHRR) 2002]. In addition, the NLSY provides extensive information on the child and the family that allows us to incorporate an exhaustive set of demographic, economic and geographical variables, including mothers work hours and parents' monitoring of the child's television watching. These variables are extremely rare in general and, to the best of our knowledge, non-existent in panel studies.

Secondly, a common limitation of the existing studies of child outcomes is that they do not estimate a causal relationship between television and child outcomes. Some of the most widely cited studies such as *Kaiser Family Foundation* Reports [Rideout, Vandewater, and Wartella, 2003] are purely descriptive in nature examining simple correlations between television watching and reading. Intervening characteristics such as family income, parent's cognitive skills, parental supervision, education and family structure, etc., may very well be the reasons behind such correlations. While some studies did control for some of the intervening variables they failed to address the issue that cognitive outcome measures may be correlated with unobserved child and parent characteristics [Christakis et. al. 2004; Koolstra and Van der Voort 1996]. In our study, we exploit the within-child and within-sibling variation in test scores and hours of television watched to estimate child and family fixed effect models. This allowed us to eliminate any time-invariant child and family characteristics such as child's innate ability, parent's ambitions and motivations, etc., that jointly determines hours of television watched and cognitive outcomes. In addition, we control for a wide range of time varying child, parental and geographic characteristics that may be correlated with possible time-varying unobservables.[12]

[12] A considerable amount of studies with experimental settings, while improve upon the cross-sectional studies, suffer from some of the same limitations discussed above. Johnson *et al.* [2002] emphasize the limitation of short observation period, or age spans, of the existing experimental studies. Also, most of these experiments are not fully random but subject to parental consent. In Robinson [1999], 198 third and fourth grade students

Both Zavodny [2006] and Gaddy [1986] use panel data to analyze the effect of television on test scores. While Zavodny [2006] does follow the individual for a longer period of time and calculate fixed effect estimates, Gaddy [1986] uses observations over only two time-points and assumes that lagged test scores proxy for unobserved heterogeneity and includes that in the OLS regression. Both Zavodny [2006] and Gaddy [1986], however, focus on older teenagers and young adults. We believe that an investigation of the effects of television on children needs to include the formative years, i.e., childhood and preteen years. This is particularly important in light of the arguments in the literature regarding the interaction between television and the child's brain development. In our sample we have information over the age range 5 to 18 years and, therefore, we are able to look at the subsamples of children (aged 10 years or less) and preteens (aged between 10 and 13 years) to allow for the possibility that the impact of television is different at different stages of the child's life. We can also study whether television viewing in an earlier stage has any effect in the cognitive outcomes of some later stage.

A key concern in estimating a fixed effect model is the amount of within-group variation present in the dependent and key independent variables. Often times, the panel studies that follow their subjects for a short period of time or have few observations for each group have little within group variation.[13] Our sample period spreads over twelve years within which time seven waves of biennial data were collected. In our sample, at least fifty percent of the overall variations in reading and mathematics test scores, and average daily hours of television watched are within-family or within-child variations. Table 3 reports the variations in the key variables (details are discussed in the data section 3).

Finally, we address the issue of measurement errors in the reported hours of television viewing. In the NLSY79 Child Survey, mothers report information on the hours of

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who obtained parental consent constituted the sample. In Krcmar and Cooke [2001], only 23 percent of the children returned with a consent form. Last but not the least, most of these studies do not account for family or mothers characteristics.

[13] Both Gaddy [1986] and Gortmaker et al. [1990] use information from two interviews over a four year period.

television watched by their children. A child may spend a considerable portion of the day outside of the mother's direct supervision with access to a television. For example, mothers account of the child's television watching while the child is at a friend's or a relative's house is likely to be inaccurate. Given the high rate of female labor force participation and the prevalence of multiple television sets (including sets in the child's room) during our sample period, the possibility of measurement errors in mother's account of the child's television watching is potentially more severe now than it was before. Measurement error is a serious concern in the fixed-effect estimation strategy because it exacerbates the measurement error bias in the estimates [Griliches 1979]. Moreover, measurement errors will induce correlation between reported hours of television watched and the error term in an equation, thereby making hours of television watched endogenous. We use instrumental variables proposed by Lewbel [1997] to remove possible endogeneity in hours of television watched. One important drawback of Gortmaker et al. [1990] – which uses panel data of children from two interviews with a four-year gap in between, and uses the same methodology as Gaddy [1986] – is that in their first interview television viewing was reported by parents and in the second interview by the children. While they acknowledge the potential for measurement error problems they do not address any bias in the estimated coefficient.

In the existing research, use of instrumental variable(s) to address endogeneities are extremely rare. In studying the childhood of baby boomers in 1960s, Gentzkow and Shapiro [2008] look at the effects of number of years of ownership of television on test scores. Since they use this indirect measure instead of a direct measure such as number of hours of television watched, they perceive that the possibility of measurement errors can be high. They exploit the heterogeneity in the timing of television's introduction to different local markets to develop an instrument. The econometric methodology in Waldman, Nicholson and Adilov [2006] does include instrumental variable estimates, but the study is done at the county level and not at the individual child level, and can only be interpreted as indirect

evidence. Moreover, they examine the relationship between television exposure and autism among children and not the test scores as we do.

Our findings are robust to a number of alternative specifications that include allowing for non-linear effects, separate regressions for boys and girls, issues of behavioral problems of children, etc.

The rest of the paper is divided into the following sections. Section 2 discusses the econometric issues and section 3 explains the data. Section 4 presents the results and findings, which is followed by the concluding remarks in Section 5.

2. ECONOMETRIC METHODOLOGY

We estimate a Becker-type production function for cognitive outcomes or skills [Aaronson 1998; Hanushek 1979; Todd and Wolpin 2003] where television watching appears as an "input". Let,

$$(1) \qquad Y_{ijt} = \beta_0 + \beta_1 TV_{ijt} + \beta_2 C_{ijt} + \beta_3 F_{ijt} + \beta_4 L_{ijt} + \alpha_i + \alpha_j + \varepsilon_{ijt},$$

where, Y_{ijt} is a child cognitive outcome measure (namely, reading or mathematics test scores) of child $i = 1, 2, ..., N$, of family $j = 1, 2, ..., M$, at time period $t = 1, 2, ..., T$. The measure of television viewing, TV_{ijt}, is the average hours of daily television watched by child *i* of family *j* at time *t*. Vector *C* includes child characteristics such as age, sex, race, etc. *F* contains mother/family characteristics such as mother's education, family income, family structure, etc.; *L* is geographic information such as whether the child lives in central city or suburbs, and macroeconomic characteristics of the location. α_i represents time-invariant unobservable traits of the child such as innate ability and α_j represents the time-invariant unobservable traits of mother/family that affects all children in the household in a similar way (e.g., parental motivation, ambition, attitude towards television viewing, etc.). Finally, ε_{ijt} captures all time-varying unobservables.

Our objective is to identify β_1, the effect of hours of television watched on test scores. A key problem is the possible correlation between time-invariant unobservables (α_i and α_j) and TV_{ijt}, that is, TV_{ijt} is potentially endogenous. For example, a child with lower innate ability (α_i) is more likely to both watch more television and score poorly in a test. Similarly, a child who lives in a household where parents are unmotivated and not very ambitious (a lower α_j) is likely to watch more television than a child whose parents are ambitious and highly motivated (a higher α_j). An estimate of the negative relationship between hours of television watched and the test scores will then also pick up the effect of low α_i (or low α_j) and not the effect of watching more television *per se*.

We adopt a fixed effect estimation strategy to identify β_1. Utilizing information on siblings in the household we estimate family fixed-effect regressions that remove the effect of unobserved time-invariant family traits α_j. Of course, an assumption underlying the family fixed effect regression is that either $\alpha_i = 0$ or $\text{cov}(TV_{ijt}, \alpha_i) = 0$. Availability of longitudinal information on children in our sample allows us to relax this assumption. We exploit the within-child variation to estimate child fixed-effect regressions. An advantage of the child fixed-effect over the family fixed-effect estimator is that it purges both child and family-specific time-invariant unobservable variables whereas family fixed-effect only purges the family-specific time-invariant unobservables.[14] If time-varying unobservables (such as unmeasured wealth) are correlated with hours of television watched, then estimates obtained from the fixed effect models will reflect the effects of such unobservables. We believe that our use of a rich set of time-varying control variables and the use of the

[14] A reason for using both child and family fixed-effect regression is that we do not know, a priori, whether it is more important to address child or family specific unboservables. Researchers often work with either a single cross-section of data with information on siblings or a longitudinal data that tracks only one child from a household over time. We hope that our analysis will shed lights on the nature of data needed to identify the causal effect of television on child outcomes.

instrumental variable would minimize the impact of such time-varying unobservables, if any.

It is often argued that the effect of the hours of television watched on child outcomes is non-linear [Williams *et.al.* 1982; Zavodny 2006]. That is, the effect on test scores of a marginal increase in hours of television watched may be smaller for a child who watches, say, two hour of television *vis-à-vis* the child who watches six hours of television. To detect the presence of such non-linear effects we estimate the following version of regression equation (1),

$$(2) \qquad Y_{ijt} = \delta_0 + \delta_1 DTV_{1,ijt} + \delta_2 DTV_{2,ijt} + \delta_3 DTV_{3,ijt} + \delta_4 C_{ijt} + \delta_5 F_{ijt} + \delta_6 L_{ijt} + \alpha_i + \alpha_j + \varepsilon_{ijt},$$

where, DTV_1, DTV_2, and DTV_3 are dummy variable for the following categories of television watching, respectively: more than 2 hours but less than or equal to 4 hours, greater than 4 hours but less than or equal to 6 hours, and greater than 6 hours (the omitted category is the group of children who watches less than or equal to 2 hours of television). The cut-off points – two, four, and six hours – come from the following: the American Association of Pediatrics (AAP) recommends less than or equal to 2 hours of television viewing for a typical child, an average child in the U.S. watches approximately 4 hours of television, and mean plus one standard deviation is approximately 6 hours of television in our sample. Therefore, DTV_1, DTV_2 and DTV_3 attempt to capture "moderate", "excessive" and "extreme" television watching behaviors, respectively. Similar to our analysis of the linear effect of television, we estimate $(\delta_1, \delta_2, \delta_3)$ by OLS, family fixed effect, and child fixed effect regressions.

In our study, the hours of television watched by the child is reported by the mother. This raises a strong possibility that hours of television watched is measured with some noise. A potential complication in identifying β_1 in equation (1) arises from the measurement error problem. Under the assumption of classical measurement errors in a regressor, the use of only within-child or within-family variation in the fixed effect estimators exacerbates the

measurement error bias relative to the OLS estimates [Griliches 1979]. This because the de-meaning, both within-child and within-family, removes part of the variation in the data, thus leaving a disproportionate amount of noise. Furthermore, measurement errors induce a correlation between hours of television watched and the error term in equation (1). We relied on a solution proposed by Lewbel [1997] to eliminate the bias resulting from measurement error in right-hand-side variables. The solution is closely related to instruments frequently used in GMM estimations where the characteristics of the data are exploited to obtain instruments – Lewbel's method exploits the skewness in the data by devising instruments based on higher order moments of the data.[15] We used the *third order centered moment of the television variable* to instrument the television variable, which, by construction, is strongly correlated with hours of television watched but extremely unlikely to be correlated with the test scores. There is the issue of "weak instrument" whereby a low correlation between the instrument and hours of television watched will cause a larger bias in the instrumental variable estimate of β_1 than the OLS estimate [Bound, Jaeger and Baker 1995]. To check that the instrument is not a weak instrument, we have carried out the weak instrument test as proposed by Stock and Yogo [2002].

Finally, our primary specification (1) identifies the "contemporaneous" effect of watching television on child outcomes as measured by the coefficient β_1. However, there are two alternative possibilities that may be tested. First, the contemporaneous effect may not be the same at different stages of the child's life. So, we run separate regressions for children (less than 10 years of age), preteens (between 10 and 13 years), older teenagers (age between 13 and 18 years), and all teenagers (age between 10 and 18 years). Secondly, television may have "non-contemporaneous" effects that work at a lag. So, we included past television viewing behavior to specification (1).

[15] Millimet and Osang [2005] also used the approach for endogeneities arising from reasons other than measurement errors.

3. DATA

We use data from the 1979 National Longitudinal Survey of Youth (NLSY79) and the NLSY79 Child Survey. The NLSY79 began in 1979 with a sample of 12,686 respondents (6,283 female respondents) born between 1957 and 1964. It provides a wide variety of longitudinal information such as family income, education, cognitive skills, hours worked, family structure, and region of residence. The biological children of the NLSY79 female respondents have been interviewed every two years in the NLSY79 Child Survey, starting in 1986. We use data from 1990 to 2002 survey rounds.[16] The NLSY79 Child Survey provides information on a given child over time and also the child's biological siblings.

As our measures of cognitive skills we use mathematics and reading test scores from the Peabody Individual Achievement Test (PIAT) that are administered to all children aged above five years in each round of the NLSY79 Child Survey [Center for Human Resource Research (CHRR), 2002].[17] The PIAT math test measures a child's attainment in mathematics as taught in mainstream education. It consists of 84 multiple choice questions of increasing difficulty and measures skills ranging from recognizing numerals to advanced concepts in geometry and trigonometry. The PIAT reading test also contains 84 multiple choice questions assessing skills that include matching letters, naming names and reading single words aloud. We use the age-normed standard scores of both these tests as our dependent variables. The key explanatory variable, the average daily hours of television watched, is obtained from information provided by the mother of the child for each survey year. Table 3 presents variation in the key dependent and explanatory variables that we exploit in our fixed effects estimates. Sixty nine percent of the total variation in daily television hours is within family and 64 percent within child.

[16] TV viewing information is available since 1990 and data beyond the 2002 survey round was not available at the time of writing this paper.

[17] These tests were administered to children of age 5 years and above until 1992. But after that they were administered only for the age group 5-14 years. Therefore, albeit relatively few, we do have observations for teenagers above 14 years of age with valid test scores.

We also include a large set of variables that are likely to confound the relationship between test scores and hours of television watched. The set of child characteristics include sex, gender, birth-weight, and number of siblings. We control for mother's characteristics such as education, education of her parents, household income, race, and whether she is a first or second generation immigrant. These variables are important determinants of test scores and are also correlated with the television watching patterns of the family and the child. We include mothers Armed Forces Qualification Score (AFQT)[18] in the regressions. This score measures the mother's cognitive abilities that could be strongly correlated with the child's abilities. A lower ability child will have lower test scores and is also more likely to spend more time watching television.

We have included the following variables that proxy for parental control of television viewing and monitoring: whether the child lives with a single mother, hours per week the mother works, mother's own television viewing behavior,[19] and whether parents monitor the child's television viewing behavior.[20] These variables essentially control for differences in content of television viewing. Of course, family income and parental background (education, etc.) also control for content, but they do so indirectly. The importance of including parental control stems from the conjecture that parents with less control over children's television watching may also have less control over their academics. Besides, watching 'good' television for an hour could have a different impact compared to watching 'bad' television for the same amount of time.

To capture any difference in television watching and child outcomes across different geographic locations we have included dummy variables for four regions (Northeast, North Central, South, and West), central cities, suburbs, and rural areas. To capture

[18.] The AFQT is a general measure of trainability on a scale of 1 to 99. Normed scores (adjusted for age differences) are reported in the survey. The test includes as components arithmetic reasoning, word knowledge, paragraph comprehension, and numerical operations.

[19.] In 1981 when they were between 16 and 24 years of age, the mothers were asked about their own television viewing. We include it along with their age in 1981.

[20.] The specific question about monitoring television viewing behavior is "Do Parents Discuss TV Programs with Child?"

macroeconomic effects we have included regional unemployment rates. Descriptive statistics of all the dependent and explanatory variables are presented in Table 4.

4. RESULTS

4.1. Cross-section and fixed effect estimates

For each test score, we estimate four different versions of equation (1) described in Section 2. The results for the reading test score are reported in Table 5 and the mathematics test score in Table 6. In the first column of each table, we present the results from a cross-section regression that includes only child characteristics, geographical location and its characteristics, and year dummies (Cross-sec 1). In the next column we add mother's characteristics (Cross-sec 2). In the last two columns we add mother/family fixed effects (Family-FE) and child fixed effect (Child-FE), respectively.

The cross-section regression that includes only child specific characteristics (Cross-sec 1) shows that an hour increase in daily television viewing leads to 0.84 points *decrease* in the reading test score and it is statistically different from zero (Table 5). This result is consistent with the findings of other researchers and is often used to infer that watching television adversely affects children's cognitive achievements. However, once we add observed family characteristics (Cross-sec 2 in Table 5), the effect reduces to a 0.102 point decline. We conclude that child, family and neighborhood characteristics play an important role in explaining the negative correlation between hours of television viewing and reading test scores found in Cross-sec 1.

We still cannot draw a causal inference based on Cross-sec 2 estimates because they do not address the fact that there could be unobserved child and parent characteristics that determine both television viewing and the reading test score. It is also possible that the true effect of television viewing on the reading test scores is actually positive but children who watch more television have lower ability – or their parents are less motivated in investing in

their children's cognitive development – which gives rise to a negative correlation between hours of television viewed and test scores. We have estimated fixed effect regressions to address this issue.

Both family-fixed effect and child-fixed effect regression results for the reading test scores are reported in Table 5 (Family-FE and Child-FE). Based on the Child-FE regression – which is our preferred estimate because it eliminates the effects of both child and family-specific unobserved time-invariant characteristics – we find that an increase in television watched by one hour leads to only 0.047 points *decrease* in the reading test scores and this effect is statistically indistinguishable from zero. We, therefore, conclude that that there is no causal effect of hours of television watched on the reading test score.

Our findings for the mathematics test score are very similar (Table 6). Although Cross-sec 1 indicates a negative correlation between hours of television watched and the mathematics test score, based on the Child-FE estimates we conclude that there is no statistically significant causal effect of hours of television watched on the mathematics test score.

The content of the television programs is an important issue in the analysis of the effects of television on children. Some researchers have argued that educational television programs such as *Sesame Street* and *Mister Rogers' Neighborhood* have significant positive impacts on children's learning [Huston and Wright, 1998]. Ideally we would like to have information on the actual content. Lacking this data, we attempted to control for differences in program content across children by including variables that are likely to be correlated with the types of program a child watches. Examples of such variables include mother's education, family income, parent-child interaction as measured by the variable whether parents discuss television programs with their children, etc. Given the wide range of variables that control for differences in content across children, our estimated coefficients measure the effect of television with 'typical' content.

4.2. Non-linearity

In Table 7 we present coefficients of a non-linear specification of hours of television watched (equation (2) of section 2). Based on Cross-sec 1 estimates, we find large and statistically significant non-linear effects: compared to children who watch less than 2 hours of television (the omitted category) reading test scores of children who watch 2-4 hours of television are 1.83 points *lower*, and for children who watch more than 6 hours of television, reading test scores are 6.13 points (42 percent of one standard deviation) lower. In our preferred Child-FE estimates, however, we find that the magnitudes of the coefficients of the television variables are very small and they are statistically indistinguishable from zero. Almost the exact same pattern follows for the mathematics test score. To summarize, the results from the nonlinear specification (equation (2)) is qualitatively similar to those from the linear specification (equation (1)) in that there is no statistically significant causal relationship between average daily hours of television watched and cognitive test scores.

4.3. Endogeneity: IV estimates

Table 8 presents the instrumental variable estimates of reading and mathematics test scores on hours of television watched where the third centered moment of daily television was used to instrument daily television [Lewbel 1997]. We report the coefficients of the television variable from 2SLS 1, 2SLS 2, Family-IVFE and Child-IVFE that are the instrumental variable counterparts of Cross-sec 1, Cross-sec 2, Family-FE and Child-FE, respectively, from Tables 5 and 6. The effect of television is significant in 2SLS 1 for both test scores and not in any of the other regressions. And, based on our Child-IVFE results, our conclusions remain the same: hours of television watched has no causal impact on reading and mathematics test scores.

4.4. Age groups and non-contemporaneous effects

Our primary specification (1) identifies the "contemporaneous" effect of watching television on child outcomes as measured by the coefficient β_1. It has two underlying

assumptions: first, the marginal effect is the same throughout childhood and teenage years and, secondly, only contemporaneous television watching matters. However, the literature emphasizing possible adverse effects of television on brain development [Wallace et. al. 1992; Greenough, Black and Wallace 1987] suggests that both these assumptions may be violated. In other words, the effect of television may be different during the childhood and the teenage years, and childhood television watching may have longer term developmental consequences [Nicholson and Adilov 2006].

So, in Table 9, we report fixed effect regressions by the following age groups: children of age 10 years or less, preteens between 10 and 13 years, older teenagers between 14 and 18 years, and all teenagers (i.e., between 10 and 18 years of age).[21] The coefficients are significant in only 2 out of 28 regressions: Child-FE for all teenagers in reading score regression (which becomes insignificant in the Child-IVFE regression) and Family-IVFE for the math score regression of preteens (which becomes insignificant in the Child-FE regressions with or without instrumental variable). However, even in the two cases when the coefficients are statistically significant their magnitudes are very small (less than 2 percent of standard deviation).

To check for non-contemporaneous effects, we run two separate specifications. In the first specification we simply add a one period lag television variable. Since we observe the children at two year intervals this variable measures television watching two years ago. In the second specification we add a two period lagged television variable, i.e., television hours four years ago. Note that this sample includes mostly preteens and teenagers and, in these regressions, we are able to capture the effects of watching television during childhood and preteen years. Table 10 reports the effects of the television variables. In only 3 of 16 cases television watching with a four year lag has significant positive effects on the test

[21] PIAT test scores are usually administered to children between age 5 and 14. However, till 1992, they were administered to all children. As a result, although we do have some teenagers above 14 years of age with valid test scores running a child fixed effect regression was not possible for the 14-18 years age group. Therefore, we report family fixed effect estimates for the 14-18 year age group.

scores. However, the magnitudes of these effects are very small, none exceeding 2 percent of a standard deviation. Besides, they become insignificant in the instrumental variable regressions. Therefore, we do not find evidence of non-contemporaneous effect of television on test scores.

4.5. Robustness

Since our primary focus has been sibling and child fixed effects, in our main analysis we restricted our sample to only families with more than one child. So, as a robustness check, we run separate cross-section and child fixed effect regressions on a broader sample that includes children without siblings. We obtain essentially identical results.

Some research shows that television may cause behavioral problems such as aggression, violent tendencies and anti-social behaviors and attitudes [Huesmann 1998, Huesmann et. al. 2003]. It is possible that the true effect of hours of television watched on cognitive test scores is positive and the often observed negative correlation is attributable to the behavioral problems of children caused by television viewing. To check this, we have run separate regressions where we included on the right hand side of equation (1) a Behavioral Problem Index (BPI).[22] This, however, does not produce results that are measurably different from those reported in Tables 5 and 6.

In our sample, girls have a lower average mathematics score and higher average reading test score compared to those of the boys. We estimated separate regressions for boys and girls to check if hours of television watching have any differential impact. The results are qualitatively similar for both boys and girls; we find no statistically significant relationship between hours of television watched and the test scores for either group. All these robustness check results are available on request.

[22] Mothers of children aged four and above were asked 28 questions about their children's behavioral problems in the previous three months. These questions capture six domains of behavioral problems: antisocial behavior, anxiousness/depression, headstrongness, hyperactivity, immaturity, dependency, and peer conflict/social withdrawal. The BPI is an index constructed from the answers to these questions. It is an overall assessment of the child's behavioral problems [Center for Human Resources Research (CHRR) 2002].

5. CONCLUDING REMARKS

In this paper we used longitudinal data to examine if there exists a causal relationship between hours of television watched by a child and measures of her cognitive development (reading and mathematics test scores). Although we find evidence that hours of television watched is negatively *correlated* with these measures, we do not find evidence in favor of the conventional wisdom that this effect is *causal*. Once we eliminate the effects of unobservable child and family characteristics, the negative effects of hours of television disappear for both test scores. We obtain qualitatively similar results when we estimate instrumental variable models to eliminate biases due to endogeneities arising from, say, measurement errors. Therefore, a policy emphasis on children's television watching to improve their cognitive achievements is not likely to yield any measurable success and may, instead, simply lead to misplaced priorities and misallocation of resources.

Our results do not necessarily shed lights on the question as to whether test scores will improve if the television time is replaced with reading, other studies, structured learning activities, etc. It is certainly true that those who are watching fewer hours of television have more time for studies. However, whether they actually do so is another issue; the extra time may simply be wasted in some other unproductive way. To examine how exactly time allocation affects child outcomes we need to have detail time use information such as a time diary.

It is quite possible that although hours of television *per se* does not affect child outcomes – which is what we found in this paper – a few specific television programs could have beneficial impacts on children's cognitive development. Most of the current and existing research is not focused in this direction. This paper emphasizes the need to have large and more extensive studies of the content analysis and rigorous experiments with larger and more representative pool of subjects. Once such program contents are identified and substantial causal effects are established, only then it may be prudent to think about

proactive policies targeted towards specific program types and not simply targeted towards turning the television off.

As the population is exposed to – and gets used to – a rapidly evolving 'new' media such as computers and the internet, video games, etc., a natural question to ask is whether television is a thing of the past. Interestingly, the new media may not necessarily substitute television. For instance, while usage of video game consoles have witnessed a meteoric rise over the last decade, Neilson report on the "State of the Console" do not find evidence of declining television viewing.[23] It is quite possible that newer media will lead to increasing overall media exposure as television continues to be a significant part of our lives, for a while that is.

[23] See http://www.nielsenmedia.com/nc/nmr_static/docs/Nielsen_Report_State_Console_03507.pdf.

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Table 1: U.S. Households with Television Sets and Cable

Percent of households with	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
television	10	67	87	94	96	97	98	98	98	98	98
multiple TV sets	-	4	12	22	35	43	50	57	65	71	76
wired cable	-	-	-	-	7	12	20	43	56	63	68
wired pay cable	-	-	-	-	-	-	-	26	29	28	32

Source: Nielsen Media Research (available at www.tvhistory.tv).

Table 2: Media Use Among U.S. Youths (Hours per Day), 1999

Medium	2-18 year-olds	2-7 year-olds	8-18 year-olds
Total media exposure	7:00	4:29	8:43
Television	3:16	2:16	3:46
Taped television shows	0:12	0:00	0:19
Videotapes	0:28	0:28	0:28
Movies	0:16	0:02	0:25
Video games	0:22	0:14	0:31
Print media	0:42	0:42	0:41
Radio	0:43	0:26	0:48
CDs and tapes	0:43	0:19	1:07
Computer	0:19	0:05	0:28

Source: The Henry J. Kaiser Family Foundation; 2003 [Updated 2003 Dec 10; cited 1999 Nov 15]. URL: http://www.kff.org/entmedia/1535-index.cfm.

Table 3: Variation of the Key Variables in the Sample

	Overall		Family level		Child level	
	mean	std dev	between group std dev	within group std dev	between group std dev	within group std dev
Standardized reading score	103.99	14.61	12.16	8.83	13.35	6.24
Standardized mathematics score	101.11	13.81	11.07	8.75	12.14	6.76
Average daily television viewing	3.87	2.54	1.94	1.76	2.01	1.63
Television viewing between 0-2 hours	0.25	0.43	0.32	0.30	0.34	0.28
Television viewing between 2-4 hours	0.40	0.49	0.30	0.40	0.33	0.37
Television viewing between 4-6 hours	0.19	0.39	0.25	0.32	0.27	0.30
Television viewing more than 6 hours	0.16	0.37	0.25	0.28	0.27	0.26

Table 4: Descriptive Statistics for Dependent and Explanatory Variables in the Sample

Variable Label	N	Mean	Std	Min	Max
Year	12782	1996	4	1990	2002
Standardized PIAT reading score	12782	103.99	14.61	65.00	135.00
Standardized PIAT mathematics score	12782	101.11	13.81	65.00	135.00
Average daily television viewing	12782	3.87	2.54	0.00	12.86
Television viewing between 0-2 hours	12782	0.25	0.43	0.00	1.00
Television viewing between 2-4 hours	12782	0.40	0.49	0.00	1.00
Television viewing between 4-6 hours	12782	0.19	0.39	0.00	1.00
Television viewing more than 6 hours	12782	0.16	0.37	0.00	1.00
Child age (in months)	12782	120.99	28.40	60.00	178.00
Parent discusses television with the child	12782	0.82	0.39	0.00	1.00
Number of siblings	12782	2.64	1.15	0.00	9.00
Child female	12782	0.50	0.50	0.00	1.00
The child had a low birth weight	12782	0.07	0.26	0.00	1.00
Single mother	12782	0.30	0.46	0.00	1.00
Family income ($10,000)	12782	4.51	4.32	0.00	63.88
Hours/week worked by mother	12782	25.66	20.40	0.00	100.00
Highest grade completed by mother	12782	12.76	2.92	0.00	95.00
Mother's AFQT score	12782	37.60	27.29	1.00	99.00
Highest grade completed by mother's parents	12782	11.28	3.38	0.00	20.00
Mother's race is white	12782	0.50	0.50	0.00	1.00
Mother's race is black	12782	0.29	0.45	0.00	1.00
Mother's race is Hispanic	12782	0.17	0.38	0.00	1.00
Mother is first generation immigrant	12782	0.05	0.21	0.00	1.00
Mother is second generation immigrant	12782	0.02	0.15	0.00	1.00
Number of TV hours by mother (1981)	12782	2.38	2.42	0.00	13.71
Mother's age in 1981	12782	19.47	2.18	16.00	24.00
Rural	12782	0.17	0.38	0.00	1.00
City residence other than central city or suburb	12782	0.34	0.47	0.00	1.00
Central city residence	12782	0.18	0.38	0.00	1.00
Suburbs	12782	0.32	0.46	0.00	1.00
Regional unemployment rate	12782	5.51	1.20	3.63	8.23
Residence in the north-central region	12782	0.14	0.34	0.00	1.00
Residence in the northeast region	12782	0.27	0.45	0.00	1.00
Residence in the southern region	12782	0.39	0.49	0.00	1.00
Residence in the western region	12782	0.20	0.40	0.00	1.00
Year dummy: 1990	12782	0.08	0.28	0.00	1.00
Year dummy: 1992	12782	0.14	0.35	0.00	1.00
Year dummy: 1994	12782	0.18	0.39	0.00	1.00
Year dummy: 1996	12782	0.18	0.38	0.00	1.00
Year dummy: 1998	12782	0.17	0.38	0.00	1.00
Year dummy: 2000	12782	0.13	0.33	0.00	1.00
Year dummy: 2002	12782	0.11	0.31	0.00	1.00

Table 5: OLS and Fixed Effect Estimates of Equation (1) for the Reading Test Scores

	Cross-sec 1	Cross-sec 2	Family-FE	Child-FE
Average daily television viewing	-0.840	-0.102	-0.003	-0.047
	(0.065)***	(0.062)*	(0.050)	(0.042)
Child female	2.380	2.516	2.438	
	(0.408)***	(0.374)***	(0.438)***	
The child had a low birth weight	-4.085	-2.144	0.085	
	(0.789)***	(0.713)***	(0.959)	
Central city residence	-0.072	-0.681	-0.956	-0.257
	(0.579)	(0.544)	(0.508)*	(0.426)
City residence other than central city or suburb	-2.516	-1.519	-1.537	-1.428
	(0.655)***	(0.619)**	(0.691)**	(0.555)**
Suburbs	0.497	-0.703	-0.962	-0.633
	(0.533)	(0.497)	(0.499)*	(0.422)
Regional unemployment rate	-0.500	-0.296	0.116	0.057
	(0.444)	(0.420)	(0.104)	(0.085)
Residence in the northeast region	-3.238	-2.513		
	(0.717)***	(0.664)***		
Residence in the southern region	-3.426	-1.191		
	(0.628)***	(0.585)**		
Residence in the western region	-4.755	-3.587		
	(0.741)***	(0.702)***		
Year dummy: 1992	1.844	0.938		
	(0.884)**	(0.841)		
Year dummy: 1994	0.954	0.060		
	(0.431)**	(0.416)		
Year dummy: 1996	2.071	0.477		
	(0.456)***	(0.438)		
Year dummy: 1998	1.738	-0.168		
	(0.727)**	(0.688)		
Year dummy: 2000	2.604	-0.143		
	(0.922)***	(0.880)		
Year dummy: 2002	3.860	1.262		
	(0.591)***	(0.580)**		
Parent discusses television with the child		1.130	0.036	-0.104
		(0.399)***	(0.337)	(0.270)
Number of siblings		-1.132	-0.354	-0.058
		(0.171)***	(0.277)	(0.221)
Single mother		-0.255	0.172	0.360
		(0.431)	(0.440)	(0.356)
Family income ($10,000)		0.285	0.102	0.081
		(0.042)***	(0.039)***	(0.036)**
Hours/week worked by mother		-0.013	-0.009	-0.009
		(0.008)	(0.007)	(0.006)
Mothers AFQT score		0.153		
		(0.011)***		
Mother's highest grade completed		0.143		
		(0.109)		
Mother's parent's highest grade completed		0.208		
		(0.073)***		
Mother black		-0.693		
		(0.575)		
Mother Hispanic		1.828		
		(0.660)***		
Mother is first generation American		2.011		
		(1.103)*		
Mother is second generation American		2.085		
		(1.320)		
Number of TV hours by mother (1981)		-0.206		
		(0.083)**		
Mother's age in 1981		-0.203		
		(0.091)**		
Constant	110.744	102.624	103.658	104.403
	(2.674)***	(3.293)***	(1.183)***	(0.928)***
Observations	12782	12782	12782	12782
Groups			2306	4086
MSE	200.600	173.200	77.190	38.900

Notes: (a) Robust Standard Errors in parenthesis. (b) Standard Errors adjusted for intra-group correlations. Observations within each family constitute a group in the Family-FE and observations of each child constitute a group in the other regression. (c) *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively.

Table 6: OLS and Fixed Effect Estimates of Equation (1) for the Mathematics Test Scores

	Cross-sec 1	Cross-sec 2	Family-FE	Child-FE
Average daily television viewing	-0.847	-0.057	0.042	0.009
	(0.060)***	(0.055)	(0.050)	(0.045)
Child female	-0.881	-0.690	-1.258	
	(0.367)**	(0.325)**	(0.406)***	
The child had a low birth weight	-4.092	-2.088	-0.994	
	(0.748)***	(0.663)***	(0.992)	
Central city residence	-0.357	-0.554	0.110	0.486
	(0.522)	(0.478)	(0.468)	(0.441)
City residence other than central city or suburb	-2.249	-0.314	0.357	0.163
	(0.589)***	(0.543)	(0.604)	(0.563)
Suburbs	1.050	0.042	-0.109	-0.049
	(0.472)**	(0.433)	(0.455)	(0.434)
Regional unemployment rate	-0.749	-0.522	-0.025	0.045
	(0.417)*	(0.391)	(0.098)	(0.088)
Residence in the northeast region	-1.450	-1.065		
	(0.664)**	(0.593)*		
Residence in the southern region	-3.267	-0.682		
	(0.583)***	(0.525)		
Residence in the western region	-3.773	-2.241		
	(0.680)***	(0.632)***		
Year dummy: 1992	2.454	1.409		
	(0.839)***	(0.786)*		
Year dummy: 1994	1.529	0.483		
	(0.414)***	(0.392)		
Year dummy: 1996	2.746	0.971		
	(0.435)***	(0.418)**		
Year dummy: 1998	1.796	-0.367		
	(0.678)***	(0.647)		
Year dummy: 2000	3.676	0.392		
	(0.875)***	(0.824)		
Year dummy: 2002	5.495	2.494		
	(0.556)***	(0.532)***		
Parent discusses television with the child		1.086	0.176	0.028
		(0.362)***	(0.319)	(0.282)
Number of siblings		-0.754	-0.018	0.211
		(0.147)***	(0.256)	(0.216)
Single mother		-0.137	0.088	0.115
		(0.381)	(0.408)	(0.359)
Family income ($10,000)		0.272	0.046	-0.003
		(0.043)***	(0.042)	(0.038)
Hours/week worked by mother		-0.006	-0.008	-0.005
		(0.007)	(0.007)	(0.006)
Mothers AFQT score		0.142		
		(0.010)***		
Mother's highest grade completed		0.223		
		(0.099)**		
Mother's parent's highest grade completed		0.248		
		(0.065)***		
Mother black		-3.142		
		(0.500)***		
Mother Hispanic		-0.945		
		(0.575)		
Mother is first generation American		2.085		
		(0.920)**		
Mother is second generation American		0.842		
		(1.042)		
Number of TV hours by mother (1981)		-0.103		
		(0.071)		
Mother's age in 1981		-0.203		
		(0.078)***		
Constant	109.362	99.449	101.586	100.177
	(2.512)***	(2.984)***	(1.077)***	(0.932)***
Observations	12782	12782	12782	12782
Groups			2306	4086
MSE	176.720	146.740	76.420	45.640

Notes: (a) Robust Standard Errors in parenthesis. (b) Standard Errors adjusted for intra-group correlations. Observations within each family constitute a group in the Family-FE and observations of each child constitute a group in the other regression. (c) *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively.

Table 7: OLS and Fixed Effect Coefficients of Hours of Television Watched on Various Child Test Scores, based on Equation (2)

	Reading test scores				Math test scores			
	Cross-sec 1	**Cross-sec 2**	**Family-FE**	**Child-FE**	**Cross-sec 1**	**Cross-sec 2**	**Family-FE**	**Child-FE**
Television viewing between 2-4 hours	-1.830	0.293	0.405	0.233	-2.184	0.051	0.355	0.263
	(0.392)***	(0.364)	(0.304)	(0.252)	(0.377)***	(0.330)	(0.305)	(0.274)
Television viewing between 4-6 hours	-4.807	-0.344	-0.001	-0.119	-5.011	-0.292	0.519	0.345
	(0.486)***	(0.459)	(0.393)	(0.319)	(0.447)***	(0.415)	(0.389)	(0.343)
Television viewing more than 6 hours	-6.130	-0.377	0.031	-0.265	-6.358	-0.173	0.339	0.155
	(0.507)***	(0.493)	(0.415)	(0.336)	(0.473)***	(0.440)	(0.415)	(0.360)
Child time invariant characteristics	*yes*	*yes*	*yes*		*yes*	*yes*	*yes*	
Child time varying characteristics	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Family time invariant characteristics		*yes*				*yes*		
Family time varying characteristics		*yes*	*yes*	*yes*		*yes*	*yes*	*yes*
Regional variables, year dummies	*yes*	*yes*			*yes*	*yes*		
Observations	12782	12782	12782	12782	12782	12782	12782	12782
Groups			2306	4086			2306	4086
MSE	200.390	173.210	77.180	38.890	176.380	146.760	76.420	45.640
F-statistic	58.150	2.040	1.140	1.890	60.660	0.550	0.170	0.170
p-value	0.000	0.130	0.318	0.152	0.000	0.579	0.841	0.845

Notes: (a) Robust Standard Errors in parenthesis. (b) Standard Errors adjusted for intra-group correlations. Observations within each family constitute a group in the Family-FE and observations of each child constitute a group in the other regression. (c) *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively. (d) The F-test is for testing if the coefficients of the television variables are statistically different. (e) Detailed results of all these regressions are available on request.

Table 8: Instrumental Variable OLS and Fixed Effect Coefficients of Hours of Television Watched on Test scores, based on Equation (1)

	Reading test scores				Math test scores			
	2SLS 1	**2SLS 2**	**Family-IVFE**	**Child-IVFE**	**2SLS 1**	**2SLS 2**	**Family-IVFE**	**Child-IVFE**
Average daily television viewing	-0.590	-0.111	0.026	-0.014	-0.554	-0.039	0.040	0.013
	(0.076)***	(0.075)	(0.064)	(0.053)	(0.070)***	(0.068)	(0.064)	(0.058)
Child time invariant characteristics	*yes*	*yes*	*yes*		*yes*	*yes*	*yes*	
Child time varying characteristics	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Family time invariant characteristics		*yes*				*yes*		
Family time varying characteristics		*yes*	*yes*	*yes*		*yes*	*yes*	*yes*
Regional variables, year dummies	*yes*	*yes*			*yes*	*yes*		
Observations	12782	12782	12782	12782	12782	12782	12782	12782
Groups			2306	4086			2306	4086

Notes: (a) 2SLS 1, 2SLS 2, IV-Family-FE and IV-Child-FE are the instrumental variable counterparts of Cross-sec 1, Cross-sec 2, Family-FE and Child-FE, respectively, of Tables 3 and 4. (b) Robust Standard Errors in parenthesis. (c) Standard Errors adjusted for intra-group correlations. Observations within each family constitute a group in the Family-FE and observations of each child constitute a group in the other regression. (d) *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively. (e) Following Lewbel [1997], the instrument is the third centered moment of average daily television viewing. The instrument passes the Stock and Yogo [2002] weak instrument test. (f) Detailed results of all these regressions are available on request.

Table 9: Fixed Effect regressions of Hours of Television Watched on Child Test Scores (by Age Groups)

		Effect of average daily television viewing		Number of observations	Number of groups
Reading test score					
Children (age ≤ 10 years)	Family-FE	-0.018	(0.085)	5286	1714
	Family-IVFE	-0.122	(0.113)	5286	1714
	Child-FE	-0.011	(0.083)	5286	2581
	Child-IVFE	-0.088	(0.109)	5286	2581
Preteens (10 < age ≤13 years)	Family-FE	-0.151	(0.125)	2148	883
	Family-IVFE	-0.018	(0.154)	2148	883
	Child-FE	-0.078	(0.103)	2148	1074
	Child-IVFE	-0.007	(0.133)	2148	1074
Older teenagers (age > 13 years)	Family-FE	0.163	(0.238)	1276	563
	Family-IVFE	-0.023	(0.287)	1276	563
All teens (age > 10 years)	Family-FE	-0.044	(0.085)	4933	1544
	Family-IVFE	-0.020	(0.105)	4933	1544
	Child-FE	-0.142	(0.067)**	4933	2308
	Child-IVFE	-0.135	(0.086)	4933	2308
Math test score					
Children (age ≤ 10 years)	Family-FE	0.010	(0.092)	5286	1714
	Family-IVFE	0.041	(0.120)	5286	1714
	Child-FE	0.078	(0.093)	5286	2581
	Child-IVFE	0.072	(0.121)	5286	2581
Preteens (10 < age ≤13 years)	Family-FE	0.100	(0.135)	2148	883
	Family-IVFE	0.278	(0.160)*	2148	883
	Child-FE	0.119	(0.120)	2148	1074
	Child-IVFE	0.209	(0.152)	2148	1074
Older teenagers (age > 13 years)	Family-FE	-0.082	(0.192)	1276	563
	Family-IVFE	-0.243	(0.241)	1276	563
All teens (age > 10 years)	Family-FE	0.066	(0.079)	4933	1544
	Family-IVFE	0.054	(0.101)	4933	1544
	Child-FE	0.063	(0.070)	4933	2308
	Child-IVFE	0.050	(0.094)	4933	2308

Notes: (a) Family fixed effect regressions include child time invariant, child time varying and family time varying characteristics. Child fixed effect regressions include child time varying and family time varying characteristics. (b) Robust Standard Errors in parenthesis. (c) *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively. (d) Following Lewbel [1997], the instrument is the third centered moment of average daily television viewing. The instrument passes the Stock and Yogo [2002] weak instrument test. (e) Detailed results of all these regressions are available on request.

Table 10: Family and Child Fixed Effect Coefficients of Television Watched on Various Child Test Scores (lag effects)

		Average daily television viewing		Average television 2 years ago		Average television 4 years ago		Number of observations	Groups
Reading test score									
[1]	Family-FE	0.005	(0.108)	0.004	(0.063)			3673	1215
	Family-IVFE	0.035	(0.129)	-0.032	(0.110)			3673	1215
	Child-FE	-0.121	(0.087)	-0.031	(0.054)			3673	1717
	Child-IVFE	-0.102	(0.113)	-0.051	(0.102)			3673	1717
[2]	Family-FE	0.019	(0.109)	0.047	(0.073)	0.095	(0.064)	3673	1215
	Family-IVFE	0.060	(0.131)	0.035	(0.128)	0.118	(0.118)	3673	1215
	Child-FE	-0.093	(0.089)	0.036	(0.065)	0.099	(0.056)*	3673	1717
	Child-IVFE	-0.063	(0.117)	0.050	(0.134)	0.116	(0.108)	3673	1717
Mathematics test score									
[1]	Family-FE	0.088	(0.106)	-0.043	(0.058)			3673	1215
	Family-IVFE	0.001	(0.127)	-0.066	(0.109)			3673	1215
	Child-FE	0.036	(0.090)	-0.072	(0.059)			3673	1717
	Child-IVFE	0.011	(0.120)	0.044	(0.109)			3673	1717
[2]	Family-FE	0.114	(0.106)	0.032	(0.064)	0.164	(0.064)**	3673	1215
	Family-IVFE	0.006	(0.129)	-0.051	(0.126)	0.027	(0.117)	3673	1215
	Child-FE	0.076	(0.090)	0.023	(0.067)	0.140	(0.054)***	3673	1717
	Child-IVFE	0.056	(0.125)	0.161	(0.143)	0.134	(0.115)	3673	1717

Notes: (a) In regression [1] we add a one period lag television variable. Since we observe the children at two year intervals this variable measures television watching two years ago. In regression [2] we add a two period lagged television variable. (b) Family fixed effect regressions include child time invariant, child time varying and family time varying characteristics. Child fixed effect regressions include child time varying and family time varying characteristics. (c) Robust Standard Errors in parenthesis. (d) *, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively. (e) Following Lewbel [1997], the instruments for all four television variables (contemporaneous and lagged television watching) are their respective third centered moments. (f) Detailed results of all these regressions are available on request.