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Working Paper

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Australian School of Business Research Paper No. 2012 ECON 37

Can video games affect children's cognitive and non-cognitive skills?

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This version 13 August 2012

Abstract

The aim of this paper is to investigate whether there is a causal relationship between video game playing and children's cognitive and non-cognitive skills. According to the literature, video games have a potential to improve children's cognitive abilities. Video games may also positively affect such non-cognitive skills as the ability to sustain attention and pro-social behavior. On the other hand, there are concerns that video games can teach children to behave aggressively. The Child Development Supplement to the Panel Study of Income Dynamics is used for the analysis. The key advantages of this data set are its panel nature, which allows addressing the endogeneity of video game playing, and the time diary component, which provides a reliable measure of children's video game time. I find that video game playing has a positive statistically significant effect on some of the cognitive skills. More specifically, an increase in video game time is found to improve children's ability to solve problems. There is no statistically significant effect of video game playing on children's reading skills, once other variables are held fixed. The findings of this study support the hypothesis that video game playing may improve certain non-cognitive skills. Moreover, there is no evidence that video game playing increases aggressiveness in children.

JEL: D13; J13; J24

*I am grateful to Denise Doiron, Hong Il Yoo, Charlene Kalenkoski, Susumu Imai, Fiona Carmichael, James Murchison, and the participants of the U21 Doctoral Research Conference in Business at the University of Connecticut, the Empirical Microeconomics seminar at the University of New South Wales, and the Econometric Society Australasian Meeting in 2012 for their useful comments and advice. All opinions and any mistakes are my own.

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Keywords: cognitive and non-cognitive skills; human capital; video game playing; time use; children

1 Introduction

The aim of this paper is to determine how video game playing affects cognitive and non-cognitive skill development in childhood. To answer this question, I estimate a set of production functions of selected cognitive and non-cognitive skills. Children's time spent playing video games is included as one of the inputs in these functions. The main challenge in estimating the effect of video game playing on children's cognitive and non-cognitive skills is accounting for the unobserved innate abilities and family environment, which may be correlated with children's video game playing. I address this issue by using the child fixed effects model that eliminates any unobserved child-specific time-invariant factors.

According to the literature, an individual's cognitive and non-cognitive skills are related to a number of outcomes. There is evidence that cognitive skills contribute to an individual's educational achievement and success in the labor market, as measured by wages, employment, work experience, and occupational choice (Heckman et al., 2006; Fletcher, 2012; Currie and Thomas, 2001). Non-cognitive skills are shown to be as important as cognitive skills in determining these outcomes (Heckman et al., 2006). In addition, the same cognitive and non-cognitive skills are related to teenage pregnancy, marital status, smoking, use of marijuana, participation in illegal activities, and engaging in activities that lead to incarceration (Heckman et al., 2006). Therefore, it is important to understand how these skills could be improved. I focus on children in this analysis, as childhood is the period when most of the development of cognitive and non-cognitive skills takes place. The human brain mostly develops in early years, but important changes continue into adolescence, when the neural connections that are used are strengthened and those that are not used are cut off (Department of Children, Schools, and Families, 2008).

In this analysis, I focus on the relationship between video games and cognitive and non-cognitive skills for the following reasons. First, video game playing is a popular activity among children. The majority of US children have access either to a video game console or a computer at home (Roberts and Foehr, 2008). In 2007, as estimated in this paper, almost 90 percent of 10-18 year old children in the U.S. played video games[1] at least once or twice a month and 43 percent played video games everyday or almost everyday.

[1] Video games include games played on hand held devices, video game systems (consoles), computers, and the Internet.

Second, video game playing has a potential to enhance (certain) cognitive skills. Video game players are required to develop strategies, plan actions, and test hypotheses in order to win a game (Buckingham, 2007). Therefore, skills such as problem solving, abstract reasoning, pattern recognition, and spatial logic are most likely to be affected by video games (Johnson, 2005). Additionally, video games incorporate a number of principles that facilitate learning (Gee, 2003). Third, video games could potentially affect non-cognitive skills of children. On the one hand, it has been proposed that video game playing may positively affect children's ability to sustain attention and social skills (Buckingham, 2007). On the other hand, there is a concern that video game playing may negatively affect children's behavior, because many video games involve violence (Anderson and Bushman, 2001).

There is empirical evidence that television watching matters to the development of children's cognitive skills. For example, Gentzkow and Shapiro (2008) and Huang and Lee (2010) conclude that (moderate) television watching improves children's reading skills. Huang and Lee also find evidence of a negative effect of television watching on children's math skills. Although television watching and video game playing are somewhat similar, there are also differences between these media activities. Video games are more cognitively challenging than television programs. Video game playing is also more interactive than television watching (Buckingham, 2007), and learning by acting is central to child cognitive and non-cognitive development (Department of Children, Schools, and Families, 2008). Therefore, the findings on the effects of television cannot be generalized to the effects of video games. To my knowledge, this study is the first to focus on the effects of video game playing on children's cognitive and non-cognitive skills.

The results of this paper provide support for the hypothesis that video game playing affects children's problem solving skills positively. The effects of video game playing on reading ability and short-term memory are found to be statistically insignificant once other activity time is held constant. According to the findings of this analysis, video game playing may also improve some of the non-cognitive skills. More specifically, the time spent playing video games is found to reduce externalizing behavior problems in children. Moreover, there is no evidence that video game playing increases aggressiveness among children.

2 Literature review

In the economics literature, there are several studies that look at the effects of media use, including video game playing, on cognitive and/or non-cognitive skills. However, the effects of video game playing in these studies are either confounded with the effects of other media or only measure the effects of console game playing and do not inform of the effects of computer game playing. The findings of these studies suggest that media use may have positive effects of children's cognitive skills. The evidence on the effects of media use on non-cognitive skills is inconclusive.

Fiorini (2010) finds that computer use at young ages (4-5 years), including computer game playing, has positive effects on cognitive and non-cognitive skills. At older ages (6-7 years), however, none of the skills are found to be significantly affected by computer use. The results of Fiorini's analysis also suggest that the time spent playing video games on a console has a negative effect on young children's verbal skills and a positive effect on their non-verbal intelligence. The effects of console game playing on children's non-cognitive skills such as restlessness, social skills, and emotional problems are statistically insignificant. In a related paper, Fiorini and Keane (2011) study the effects of children's time allocation to different activities, including media use, on their cognitive and non-cognitive skills. Media use includes television watching, computer use, video game playing, and listening to music in their analysis. Media time is found to be important input in the cognitive skill production function and not to affect children's non-cognitive skills.

Ward (2010) investigates whether there is a relationship between the time spent on video game playing or computer use and violent behavior among adolescents. Although Ward finds a positive correlation between the time spent on video game playing or computer activities and the probability of being involved in a fight, this correlation becomes weaker and less statistically significant as more demographic characteristics are added to the model. In the model with a full set of available covariates, the positive association between fighting and the time spent on video game playing or computer use persists only for long hours of play or computer use (4 hours per day or more) (Ward, 2010). These findings imply that it is important to account for the endogeneity of video game playing.

Studies in the non-economics literature find both positive and negative effects of video game playing on children's cognitive and non-cognitive skills. On the one hand, there is experimental evidence that violent video game playing may have detrimental effects on children's non-cognitive skills (Anderson and Bushman, 2001; Bensley and Van Eenwyk, 2001). In these experimental studies, children are first assigned to play either a violent or non-violent video game and then observed during a free play. It is usually found that children who have played a violent video game behave more aggressively than children who have played a non-violent game. It is not clear, however, whether the increased aggressiveness observed immediately after playing a violent video game would persist for a longer period time. Additionally, the findings of these studies are limited to young children (Bensley and Van Eenwyk, 2001). On the other hand, there is evidence of positive effects of video game playing on children's cognitive skills. Experimental studies show that video game playing enhances such cognitive skills as hand-eye coordination, reaction time, spatial reasoning, and spatial attention (Evans Schmidt and Vandewater, 2008). Durkin and Barber (2002) found that students who had spent moderate time playing computer games in grade 10 had a higher grade point average in grade 11 than students who did not play computer games at all or played these games excessively. According to Jackson et al. (2012), video game playing is positively correlated with children's creativity. It is uncertain, however, whether the effects found in the latter two studies are causal, as the unobserved child heterogeneity is not taken into account.

3 Underlying economic model

In this section, I describe the underlying economic model. In this model, the parents of a child make all decisions. Parents have paternalistic preferences, as in Pollak (1988), that is, they care about their children's utility, and get utility directly from the cognitive and non-cognitive skills of their children ($s_{c,t}$ and $s_{n,t}$, respectively), as well their own consumption $c_{p,t}$ (t denotes time period). Parent's utility is also increasing in the number of children N_t, but at a decreasing rate, which is captured by the parameter $\lambda < 1$. The utility of children depends on their skills, time spent playing video games $t_{vg,t}$, and time spent doing other activities $T_t = (t_{1,t}, \ldots, t_{J,t})$. Children may also get utility or disutility from goods $G_{c,t}$ and $G_{n,t}$ that are used to produce cognitive and non-cognitive skills, respectively; in other words, this model is characterized by joint production. Parents face a budget constraint, children's time constraint, and technological constraints given by the production functions of cognitive and non-cognitive skills. Thus, parents solve the following utility maximization problem:

$$\max \quad u_p(c_{p,t}, s_{c,t}, s_{n,t}) + N_t^{\lambda}[u_c(s_{c,t}, s_{n,t}, t_{vg,t}, T_t, G_{c,t}, G_{n,t})] \tag{1}$$

$$s.t. \quad c_{p,t} + N_t(p_{c,t}G_{c,t} + p_{n,t}G_{n,t}) = M_t, \tag{2}$$

$$t_{vg,t} + t_{1,t} + \ldots + t_{J,t} \leq \overline{T}, \tag{3}$$

$$s_{c,t} = f_c(t_{vg}, T, G_c, \mu_c) + e_{c,t}, \tag{4}$$

$$s_{n,t} = f_n(t_{vg}, T, G_n, \mu_n) + e_{n,t}, \tag{5}$$

where $t_{vg} = (t_{vg,1}, \ldots, t_{vg,t-1}, t_{vg,t})$, $T = (T_1, \ldots, T_{t-1}, T_t)$, $G_c = (G_{c,1}, \ldots, G_{c,t-1}, G_{c,t})$, and $G_n = (G_{n,1}, \ldots, G_{n,t-1}, G_{n,t})$. Good input prices are denoted as $p_{c,t}$ and $p_{n,t}$, and M_t is household income (all are normalized with respect to the price of parent's consumption). Children's time spent on different activities in period t can sum up to a higher number than the total available time in that period, because children can do two or more activities at the same time. Nonetheless, there still is a threshold $\overline{T}$, which children's total time cannot exceed, as children can only do limited amount of multitasking.

The focus of this analysis is to estimate equations (4) and (5), that is, the production functions of children's cognitive and non-cognitive skills. A child's stock of the skill $s_{j,t}$ depends on his/her innate ability μ_j, the history of time inputs t_{vg} and T, and the history of other inputs G_j, $j = c, n$ (Todd and Wolpin, 2003, 2007; Cunha and Heckman, 2007, 2008). In the production function of cognitive skills, other inputs refer to nutrition and educational resources. In the production function of non-cognitive skills, other inputs are less tangible and include parental warmth, attitudes towards discipline, and involvement in child activities. Random shocks to children's cognitive and non-cognitive development are denoted by $e_{c,t}$ and $e_{n,t}$, respectively.

4 Identification strategy

In this analysis, the estimation of equations (4) and (5) is infeasible due to the lack of data on the past inputs in the production functions of cognitive and non-cognitive skills. Therefore, the estimated model includes current period inputs only. Nevertheless, the presented estimates are likely to capture not only the effects of the contemporaneous inputs, but also the effects of the past inputs, as the investments in child development may be correlated over time. I further assume that functions f_c and f_n are linear. Thus, the following specifications of children's cognitive and non-cognitive skill production functions are estimated:

$$s_{c,t} = \beta_0 + \beta_{vg} t_{vg,t} + T_t' \beta_T + G_{c,t}' \beta_G + \mu_c + e_{c,t}, \tag{6}$$

$$s_{n,t} = \gamma_0 + \gamma_{vg} t_{vg,t} + T_t' \gamma_T + G_{n,t}' \gamma_G + \mu_n + e_{n,t}. \tag{7}$$

The aim of this study is to obtain consistent estimates of the parameters β_{vg} and γ_{vg}, which measure the causal effects of video game playing on children's cognitive and non-cognitive skills, respectively. The key threat to internal validity is a possible correlation between the inputs in the skill production functions and the unobserved ability endowments μ_c and μ_n. For example, children who are interested in video games may have higher innate cognitive abilities or lower innate non-cognitive abilities, that is, be more prone to behavior problems. The correlation between children's video game time and innate abilities is also implied by the model described in the previous section. Solving this model would give the reduced form demand functions for $t_{vg,t}$, T_t, $G_{c,t}$, and $G_{n,t}$ that depend not only on the prices and income, but also on the ability endowments μ_c and μ_n. Thus, the ordinary least squares estimates of β_{vg} and γ_{vg} are likely to be biased and inconsistent. Identification of these parameters requires an estimator that allows for the correlation between the variables $t_{vg,t}$, T_t, $G_{c,t}$, and $G_{n,t}$ and the unobserved child heterogeneity μ_c and μ_n.

For this reason, equations (6) and (7) are estimated using the child fixed effects (FE) model. More specifically, I use the within-child estimator, which eliminates any time-invariant child-specific unobservables, including the ability endowments μ_c and μ_n. The identification of the parameters in the child FE model comes from the within-child variation in children's video game time and other variables over time. Thus, panel data is needed for the estimation of this model. In other words, cognitive and non-cognitive skills and inputs in these skills need to be observed in at least two time periods for the same child. The identifying assumptions of the child FE model are as follows (Todd and Wolpin, 2007):

1. The effects of the unobserved ability endowments μ_c and μ_n are time-invariant.
2. The inputs in the skill production functions are not affected by the current and past skills: $E(e_{j,k}|t_{vg,l}, T_l, G_{j,l}) = 0$, $\forall k, l = 1, \ldots, T,\ j = c, n$ (strict exogeneity).
3. If any of the inputs are unobserved, their effects are time-invariant or uncorrelated with the included inputs.

The first assumption may not necessarily hold. For example, the effects of the unobserved ability endowments may be decreasing as a child grows. For this reason, I also estimate the value added model, in which the effects of a child's innate abilities are allowed to decrease with age. The strict exogeneity assumption would be violated if a child's video game time depended on his/her skills either in the current or past periods. As a check for this possibility, I estimate a model that includes the future period video game time as a regressor. A statistically significant coefficient on the future period video game time would indicate a violation of the strict exogeneity assumption. To check robustness of the results to the violation of the third assumption, I include additional controls, which may be considered as proxies for some of the unobserved inputs, to the model.

Note that the interpretation of the coefficients on the video game time variable (β_{vg} and γ_{vg}) depends on how the time inputs $t_{vg,t}$ and T_t are measured. Children often engage in more than one activity at the same time. One of these activities is usually primary and other activities are secondary. If children's secondary activities were ignored when measuring their time spent doing different activities, the time inputs $t_{vg,t}$ and T_t would add up to a fixed number, for example, 168 hours per week for all children. Therefore, one activity would have to be omitted from equations (6) and (7) to avoid perfect collinearity. In other words, it would be only possible to estimate the effects of video game playing relative to other activities.

On the other hand, if children's secondary activities were taken into account when measuring their time spent doing different activities, the sum of $t_{vg,t}$ and T_t would vary across children. As a result, all time inputs could be included in equations (6) and (7). It would be possible to estimate the effects of video game time holding other time inputs (and other variables) constant, that is the"absolute" effects of video game playing[2]. The absolute effects of video game playing are more informative, because they are not confounded with the effects of the other activities, as the relative effects are. Therefore, I focus on the estimation of the absolute effects in this analysis. Once the absolute effects of all time inputs are obtained, it is possible to estimate the relative effects of video game time by taking differences between the coefficient on the video game time variable and the coefficients on the other activity time variables. It is also possible to compare these effects to the relative effects obtained using the primary activity data only.

[2]Note that the identification of the absolute effects of a particular activity comes from the time spent engaging in this activity while doing something else. If all children always focused on this activity exclusively it would not be possible to identify its absolute effects. For example, it is not possible to identify the absolute effects of sleeping, as children perform no other activities while they sleep.

5 Data and variables

5.1 Data

I use the Child Development Supplement (CDS) to the Panel Study of Income Dynamics (PSID) for the estimations of the production functions of cognitive and non-cognitive skills. The PSID is a panel survey of US families, which have been followed since 1968. The aim of this study is to collect data on changes in family income, wealth, welfare participation, employment, and housing. The original PSID sample consisted of a nationally representative subsample of around 3,000 households and an over-sample of around 2,000 low-income households. In 1997, an immigrant refresher sample was added to reflect the changes in immigration into the US since 1968. The re-interview rates of the PSID are high (96-98%). Consequently, the (weighted) sample remains nationally representative (The Institute for Social Research, 2010a).

The purpose of the PSID-CDS is to collect data on children's health, cognitive development, and behavior problems and factors affecting these outcomes, including the family environment, neighborhood characteristics, and school environment (The Institute for Social Research, 2010b). In 1997, all PSID families with children under 13 were included in the CDS. If there were more than two children under 13 years of age in the family, two children were randomly selected into the sample. In total, 2,394 families were interviewed (88% of the selected families) and data on 3,563 children were collected. These children and their families were re-interviewed in 2002 (2,907 children) when children were 5-17 years old and in 2007 (1,506 children) when children were 10-18 years old. The sharp decrease in the sample size in 2007 is due to a large number of children reaching 19 years of age, which made them no longer eligible for the CDS[3]. The PSID-CDS collects data from the child, the primary caregiver of the child, and other people related to the child[4]. The primary care giver of a child is the person in the family who has the primary responsibility for caring for the child. It is usually the mother of a child, but could also be the father, a grandparent, a sibling, and another relative.

The PSID-CDS has a number of advantages over other alternative data sources. First, it has a time diary component, which provides a relatively reliable measure of video game time. To my knowledge, the only other survey on children that has a time diary component is the Longitudinal Survey of Australian Children (LSAC) used by Fiorini

[3]These individuals became part of another supplement to the PSID (Transition to Adulthood). Once children form their own households they become part of the core PSID survey.

[4]These people include the other caregiver of the child (usually the father, but could be a grandmother or another family member), the interviewer, the absent father, and the teachers.

and Keane (2011). The LSAC time diaries are less informative, however, as parents completing the diaries can only choose between 26 categories of activities, rather than recording the actual activity as in the PSID-CDS. This would make using these data for my analysis problematic, as computer game time is recorded in the same category as other computer activities. In addition, the LSAC time diary is divided into 15 minute slots, so children's time use is not measured as precisely as in the PSID-CDS diaries, which record the actual amount of time spent on each activity.

Second, the PSID-CDS has measures of other time and good inputs in the production functions of cognitive and non-cognitive skills, which allows disentangling the effect of video game time from the effects of other time inputs. Most of the studies looking at the effects of children's time use on cognitive and non-cognitive skills include only one or a few time inputs in the regressions of these skills. As a result, the effect of the variable of interest is confounded with the effects of all the omitted time inputs, as explained by Fiorini and Keane (2011). Third, the PSID-CDS time diaries record up to two activities for each time slot. As noted in Section 4, this feature of the data allows identifying the absolute effects of video game playing on children's cognitive and non-cognitive skills, that is, the effects of video game time holding other activity time fixed. This is not possible if only primary activities are recorded.

5.2 Variables

Children's cognitive skills are measured by the standardized scores of achievement tests. These tests were administered to the survey children during the interviews. I investigate the effects of video game time on children's performance in three tests. The Letter-Word Identification test assesses a child's reading recognition ability. This test requires children to identify pictures, name letters, and read words, but does not require them to necessarily understand the meaning of these words. Holding other activity time, including reading time, fixed, I expect video game playing to have no effect on children's performance in the Letter-Word Identification test. Although video games may require children to read and understand the instructions of a game, the child does not have to know how to read words correctly.

The Applied Problems test assesses a child's ability to solve practical math problems[5]. This test evaluates how well children can apply their math knowledge in real life situations rather than testing their math knowledge per se. To solve these problems successfully, a

[5]The Letter-Word Identification and Applied Problems tests are part of the Woodcock-Johnson Revised Tests of Achievement (WJ-R).

child has to determine the steps to be followed, identify relevant and eliminate irrelevant information, and perform relatively simple calculations. These problems are somewhat similar to the tasks given to children in video games (Buckingham, 2007). Therefore, my hypothesis is that video game time has a positive effect on the Applied Problems test score.

The Memory for Digit Span test assesses a child's short term memory. There are two tasks in this test[6]. In the first task, the interviewer reads a sequence of numbers and the child is asked repeat it. In the second task, the child is given a sequence of numbers and is asked to repeat it in the reverse order. It is unclear what effect video game playing may have on children's memory. On the one hand, video games require children to remember information. For example, if a child makes a mistake and has to start the game (or part of it) again, the child needs to remember what he/she learned previously to get to the same point of the game or further. On the other hand, children are not specifically required to remember numbers. Therefore, I expect video game time either to affect the score of the Memory for Digit Span test positively or have no effect.

Children's non-cognitive skills are measured by the behavior problem index (BPI), which is constructed using the primary care giver's answers to the questions about a child's behavior and personality. The BPI is often used in the literature as a measure of children's non-cognitive skills (Cunha and Heckman, 2008; Fiorini, 2010; Fiorini and Keane, 2011). The primary care giver is asked whether the given statements are "Not true", "Sometimes true" or "Often true" of the child's behavior. I recode these variables so that they take the value 0 if the primary care giver answers "Not true" and the value 1 otherwise. A BPI for each child is calculated by adding up these binary variables. Therefore, a *higher* BPI is an indication of more behavior problems or *lower* non-cognitive skills.

I use two BPI sub-scales for the analysis. These sub-scales are constructed following the user guide for CDS-II (The Institute for Social Research, 2010a)[7]. The full list of behaviors included in the two BPI sub-scales is provided in Appendix A. The externalizing behavior problem sub-scale includes disturbed and antisocial behaviors, such as "cheating or telling lies", "arguing too much", "bullying or being cruel or mean to others", "being disobedient", "not seeming to feel sorry after misbehaving", "being restless or overly active", and "breaking things on purpose or deliberately destroying things". Given contradicting predictions of the literature, it is not clear how video game playing my affect children's externalizing behavior problems. To specifically test the hypothesis that video

[6] The Memory for Digit Span test is a component of The Wechsler Intelligence Scale for Children (WISC-III).

[7] I exclude two questions that are only relevant to school age children and include two BPI items that are not included in any of the sub-scales according to the user guide for CDS-II.

game playing causes children to behave aggressively, I construct another sub-scale that includes aggressive behaviors only ("bullying or being cruel or mean to others", "not seeming to feel sorry after misbehaves", and "breaking things on purpose or deliberately destroying things").

The internalizing behavior problem sub-scale includes emotional and withdrawn behavior problems, such as "feeling or complaining that no one loves me", "being too fearful or anxious", "having trouble getting along with other children", "feeling worthless or inferior", "being unhappy, sad or depressed", and "worrying too much". The literature suggests that video games may positively affect pro-social behavior in children, but does not discuss what effects video game playing may have on the other internalizing behaviors. Thus, my hypothesis is that video game playing has either no or decreasing effect on children's internalizing behavior problems.

The measures of both cognitive and non-cognitive skills are standardized with respect to the weighted sample mean and standard deviation (by wave). Thus, the weighted means of these skills are equal to zero and their standard deviations are equal to one in each year of the data. As a result, these variables measure how well a child performs relative to an average US child in a given year and age group. For example, if a child has a positive standardized cognitive test score in wave I, that means that he/she performed better than average among 3-12 year old U.S. children in 1997. A positive score in wave II (III) is interpreted as better than average performance in the year 2002 (2007) among 5-17 (10-18) year old US children.

The variable of interest in this analysis is a child's video game time t_{vg}, which captures the time a child spends playing video games on a console, a hand-held device, a computer, or the Internet. Other activities are also included in the model and grouped as follows:

1. television watching;
2. computer use for recreational activities, communication with others, or services, excluding computer game playing;
3. educational activities, including time at school/daycare center, private tutoring, studying, and homework;
4. reading;
5. playing other (non-electronic) games, for example, pretend, dress-up, card, board, social, and educational games, playing with toys/dolls, and other indoors and outdoors play;
6. sports and other active leisure, such as fishing, camping, walking, hiking, jogging, and other outdoor activities;

7. creative activities, for example, photography and other hobbies, crafts, painting, writing, playing an instrument, or singing;
8. attending sport events, going to movies, and visiting museum or zoo;
9. participating in the activities of charity, religious, youth, and other organizations;
10. socializing and communicating with other people (face-to-face or via phone);
11. other passive leisure, including listening to music, traveling, and relaxing;
12. work, household duties, obtaining goods or services, and caring for other children or adults;
13. basic needs of the child, including sleeping and eating; and
14. missing time.

A child's time spent on a particular activity is measured in hours per week. The PSID-CDS respondents were asked to complete two 24 hour diaries, one on a randomly selected weekday and another on a randomly selected weekend day. The data from both diaries is combined according to this formula:

$$t_j = 5 * t_{j,wd} + 2 * t_{j,we}, \tag{8}$$

where $t_{j,wd}$ is the time spent on an activity j on the randomly assigned weekday and $t_{j,we}$ is the time spent on an activity j on the randomly assigned weekend day. A child can be doing more than one activity at a time. One of these activities is usually primary and the other one is secondary. Both primary and secondary activity data is used to measure a child's time spent on each activity.

As to the other inputs, the following variables are included in the cognitive skill production functions: the number of books a child has, the frequency of museum visits[8], equivalized family food expenditure[9], and a binary variable indicating whether or not a child has breakfast. The first two inputs are usually included in the cognitive skill production functions, either directly, as in Cunha and Heckman (2008), or as part of an index describing family environment, as in Todd and Wolpin (2007). The last two variables are related to nutrition and, therefore, may also affect a child's cognitive development. The non-cognitive skill production functions, in addition to the time inputs, include the number of activities the primary care giver and the child do together[10], parenting style variables, a binary variable indicating whether or not a child changed schools since the

[8]Note that time diaries may not provide a reliable measure of a child's museum visits, as it is not a common activity among children. For this reason, I include the frequency of museum visits in the regressions along the time spent attending events and visiting places.

[9]For more information on how this variable is constructed please see Appendix B.

[10]These activities include recreational and educational activities, as well as household chores.

beginning of school, and a binary variable indicating whether or not the family moved since the last PSID interview. The parenting style variables measure how often the primary care giver expresses positive feelings towards the child and shows interest in a child and how the primary care giver would discipline the child if he/she misbehaved. These variables are listed in Table 2. Fiorini and Keane (2011) find that similar parenting style variables significantly affect children's non-cognitive skills. Additionally, a child's age (more specifically, a child's age in years and age in days) and the year fixed effects are included in all estimations. The age effects can be identified separately from the time effects, because the children were surveyed not exactly every five years.

5.3 Descriptive statistics

The analysis sample includes children who are 3-18 year old[11]. An initial sample contains 6,330 observations with completed primary care giver and child questionnaires. An observation is excluded from the initial sample if any of the above described variables are missing (1,321 observations), missing time inputs account for more than 25% of the total weekly time (13 observations), or the total primary activity time does not sum up to 168 hours per week (11 observations). Children observed once only are also excluded from the sample (1,188 observations), as they do not contribute to the identification of parameters in the child fixed effects model. The final analysis sample consists of 3,797 observations on 1,733 children. Around 81% of the sample children are observed two times and the rest are observed three times.

In each wave, the weighted means of the cognitive and non-cognitive measures are all zero and their standard deviations are equal to one due to the standardization[12]. Table 1 presents the weighted means of children's time use variables. On average, children spent 3 hours and almost 30 minutes per week playing video games. Children's average video game time increased over time from close to 2 hours per week in 1997 to just above 4 hours per week in 2007. This increase is likely to be due to the sample children getting older as well as to the increasing time trend in video game playing.

There is heterogeneity in the time spent playing video games. Boys play more video games than girls. Black children play more console games, but less computer games than children of other races. The relationship between video game playing and age is nonlinear. Age is positively correlated with video game time among younger children (3-13 years

[11]In wave III, a few children are slightly over 18 years old.

[12]The means and standard deviations of the standardized skill measures are slightly different from zero and one, respectively, as these variables are standardized using the weighted means and standard deviations in the initial sample.

of age) and negatively correlated with video game time among older children. Family income is negatively correlated with console game playing, but positively correlated with computer game playing. Children from single parent families play more video games than children who live with both parents. Children whose primary care givers have 12 years of education play more video games than children of less and more educated parents. More video games are played on weekends (on average, 46 minutes per day) than on weekdays (on average, 23 minutes per day). In the pooled sample, more time is spent playing console games (on average, 2 hours and 22 minutes per week) than computer games (on average, 1 hour and 4 minutes per week), but computer game time increased over time more than console game time. Most of the time, video game playing is a primary activity, that is, children usually play video games either without engaging in other activities or video game playing is their primary focus.

Table 1: Weighted means of time use variables, hours per week

	1997	2002	2007	All years
Basic needs	91.35	85.23	81.17	85.88
Educational act.	28.26	33.96	37.28	33.23
Socializing	22.98	20.75	20.94	21.42
TV	15.63	17.11	16.02	16.42
Other passive act.	9.78	12.57	15.34	12.51
Other games	14.91	6.06	2.37	7.57
Duties	5.43	6.90	7.25	6.58
Active leisure	5.36	3.97	5.13	4.66
Video games	2.26	3.73	4.18	3.44
Computer	0.11	1.75	4.99	2.14
Creative act.	2.25	1.62	1.80	1.85
Organizations	1.67	1.86	1.65	1.75
Reading	1.69	1.70	1.27	1.59
Events	0.64	0.93	1.27	0.94
Missing	1.19	0.68	0.80	0.85
Total	203.52	198.84	201.49	200.83
Observations	1,208	1,670	919	3,797

Looking at the other activities, the largest fraction of children's time is allocated to sleeping and other basic needs and educational activities. Children spend a substantial part of their time socializing and communicating with others either face-to-face or via phone. Comparing to the other media, video games is not as popular activity as television watching, but it is more popular than computer use for other purposes than games. Over time, children's exposure to television did not change much, whereas video game and computer time increased substantially[13]. Thus, it does not appear that the new media

[13]Roberts and Foehr (2008) find a similar trend using another source of data.

displaced the old media, rather the total media time increased. In the pooled sample, children's time spent playing non-electronic games exceeds their time spent playing video games. Non-electronic games, however, became less popular among children over time. In wave III, children's video game time exceeds other game time by almost 2 hours. On average, slightly more of children's time is spent on sports and active leisure than on video games, but video game playing is more popular than creative activities or reading. The average total time is around 200 hours per week, which indicates that children spend around 32 hours per week engaging in more than one activity at the same time.

Table 2 provides the weighted means of the other inputs in the cognitive and non-cognitive skill production functions. Most of the children have 20 or more books and visit museum at least once or twice a year. Almost 90% of the children usually have breakfast, either at home or at school. On average, families spend around $60 per person (equivalent adult) on food per week. Although the proportion of children having breakfast decreased, the family food expenditure increased over time. The number of activities that a child and his/her primary care giver do together is standardized by wave; therefore, the mean is approximately zero in each wave. Parental warmth variables show that most parents express positive feelings towards their children by telling the child that they love him/her or that they appreciate something the child did. A majority of parents talk to their children about things that interest them at least a few times a week. It is slightly less common for parents to participate in the favorite activities of children, especially as children get older. Nonetheless, some of the children never or rarely receive any parental warmth from their parents, as measured by these variables. The descriptive statistics of the variables describing parents' attitude towards discipline show that most parents would talk to the child if he/she misbehaved. Only a small proportion of parents would ignore the child's misbehavior. Spanking, giving chores, or taking away an allowance are not common ways to discipline children. A larger proportion of parents would send the child to his/her room or put the child in time out if he/she misbehaved. Although only a small proportion of the children changed schools during the school year, around 20% of children moved between the PSID waves.

Table 3 reports the weighted and unweighted means of the demographic characteristics for the analysis sample. The sample is equally distributed by gender. The average age is close to 11.5 years. Around 50% of the observations are of white children and 39% of the observations are of black children. The average annual family income (adjusted for family size and composition) is around 26 thousand (in 1996 dollars). The fraction of the observations with both parents living in the household is less than two thirds. Around a fifth of the observations have a primary care giver who has at least 16 years of

Table 2: Weighted means of other variables

	1997	2002	2007	All years
Books = 10 to 19[a]	0.08	0.12	0.17	0.12
Books = 20 or more	0.84	0.76	0.66	0.75
Museum = sometimes[b]	0.40	0.36	0.34	0.37
Museum = frequently	0.28	0.18	0.16	0.20
Breakfast	0.95	0.88	0.85	0.89
Food expenditures, 1997$ pp/wk	57.24	61.65	64.40	61.14
No of activities w/PCG (standardized)	0.06	0.06	0.01	0.04
PCG told child that he/she loved him/her ...[c]				
once/wk	0.03	0.06	0.06	0.05
a few times/wk	0.12	0.18	0.17	0.16
everyday	0.83	0.71	0.71	0.74
PCG told child that he/she appreciated smth child did ...[c]				
once/wk	0.08	0.20	0.23	0.17
a few times/wk	0.43	0.48	0.44	0.45
everyday	0.46	0.25	0.21	0.30
PCG spent time with child doing his/her favorite activities ...[c]				
once/wk	0.19	0.27	0.29	0.25
a few times/wk	0.40	0.39	0.30	0.37
everyday	0.31	0.13	0.09	0.17
PCG talked with child about things that interest him/her ...[c]				
once/wk	0.09	0.15	0.15	0.13
a few times/wk	0.34	0.44	0.45	0.42
everyday	0.54	0.33	0.26	0.37
If child misbehaved, PCG would ...				
spank child	0.19	0.12	0.09	0.13
talk with child	0.82	0.78	0.79	0.79
give him/her chores	0.12	0.10	0.15	0.12
ignore it	0.12	0.11	0.09	0.10
send to his/her room	0.36	0.46	0.43	0.43
take away allowance	0.06	0.07	0.10	0.08
put child in time out	0.40	0.20	0.10	0.23
Changed school	0.04	0.05	0.03	0.04
Moved	0.15	0.21	0.27	0.21
Observations	1,208	1,670	919	3,797

Notes: [a] The omitted category is none. [b] The omitted category is never. [c] The omitted category is 1-2 times in the past month or never.

Table 3: Means of demographic characteristics

	Unweighted	Weighted	Observations
Male	0.50	0.49	3,797
Age at child interview	11.41	11.73	3,797
Age at PCG interview	11.40	11.72	3,797
White	0.50	0.66	3,797
Black	0.39	0.14	3,797
Hispanic	0.07	0.13	3,797
Other race	0.04	0.06	3,797
Annual family inc, k 1996$ pp	25.59	28.68	3,599
Both parents in the HH	0.61	0.71	3,757
Education of PCG $\geq$ 16	0.21	0.26	3,591
SMSA	0.55	0.51	3,766

education, which should correspond to a college degree for most of the individuals. More than a half of the observations are from the standard metropolitan statistical areas. The differences between the weighted and unweighted statistics indicate that black children, children with a single parent, children from lower income families, and children with a less than college educated primary care giver are overrepresented in the analysis sample. These differences can be explained by the overrepresentation of the low income families in the PSID sample.

6 Results

6.1 Main results

First, I present the child fixed effects (FE) estimates of the absolute and relative effects of video game playing on children's cognitive skills (reading recognition, problem solving, and short-term memory) and non-cognitive skills (externalizing, internalizing, and aggressive behavior problems). Table 4 reports the estimates of the absolute effects of video game playing and other activities. Regressions of different skills are estimated separately. Standard errors are clustered at the family level to account for the presence of siblings/cousins in the data. As the cognitive and non-cognitive skill measures are standardized, the estimates in Table 4 measure by how many standard deviation units a particular skill changes as a child's time spent on a certain activity increases by an hour per week. The time effects control for any changes over time common to all children, and the within-child estimator eliminates any time-invariant child-specific factors. Note that a higher behavior problem score indicates lower non-cognitive skills. Therefore, negative coefficients in columns 4-6 indicate beneficial effects on non-cognitive skills.

The fit of the child FE models is measured by the within R-squared, obtained from the within-child regressions, and the overall R-squared, obtained from the dummy variable regressions, in which the child fixed effects are included as regressors. The within R-squared statistics show that there are differences in model fit between cognitive and non-cognitive skill regressions. The cognitive skill regressions explain a substantial fraction of the within-child variation in the test scores, especially the variation in the reading recognition and problem solving skills. Most of this variation is explained by the age and time effects. To the contrary, the observed inputs in non-cognitive skill production function explain only a small proportion of the within-child variation in behavior problems[14]. On the other hand, the overall R-squared statistics are quite high in all of the regressions, indicating that together observed variables and child fixed effects explain a substantial variation in children's non-cognitive and cognitive skills.

Columns 1-3 of Table 4 report the estimated effects of video game time on the cognitive skills. I find support for the hypothesis that video game time has a positive effect on children's problem solving ability. A one hour increase in video game time per week is estimated to increase the Applied Problems test score by 0.004 (or 0.4%) of a standard deviation. Although this effect appears to be quantitatively small, it is significantly different from zero[15]. The hypothesis that video game playing does not have any effect on children's reading recognition ability cannot be rejected. Video game playing neither benefits nor harms children's ability to correctly identify letters and words, holding other activity time, including reading time, fixed. Although I have expected that there may be a positive effect of video game playing on children's short-term memory, there is no support for this hypothesis in the data. Video game playing does not seem to improve children's ability to memorize numbers. The results presented in columns 4-6 of Table 4 show that video game playing positively affects some of the non-cognitive skills. A one hour per week increase in video game time is estimated to decrease the externalizing behavior problem sub-scale by 0.006 of standard deviation. Moreover, there is no support for the hypothesis that video game playing increases aggressiveness in children. Positive video game time effects on the aggressive behavior sub-scale can be rejected with a 95% confidence. The hypothesis that video game playing has no effect on children's emotional problems cannot be rejected.

As to the other activities, children's reading recognition ability is positively affected by their computer use, educational activities, participating in cultural or sports events, and

[14]Fiorini and Keane (2011) also note that observed variables explain only a small fraction of the variation in child non-cognitive skills.

[15]I discuss how the effect of video game time compares to the effects of other variables analyzed in the literature in Section 7.

Table 4: Absolute effects of time use variables on cognitive and non-cognitive skills, child FE estimates

	Reading recogn	Problem solving	Short-term memory	External beh probl	Internal beh probl	Aggressive behavior
Video games	0.001	0.004**	−0.001	−0.006**	−0.003	−0.007**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Television	0.000^a	0.002*	0.000^a	−0.002	−0.002	−0.002
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Computer	0.006***	0.004**	0.004	−0.002	0.001	0.002
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Educational act.	0.002*	0.004***	0.002	0.001	0.002	0.000^a
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Reading	0.004	0.003	0.002	−0.010*	−0.006	−0.003
	(0.003)	(0.003)	(0.005)	(0.005)	(0.006)	(0.007)
Other games	−0.002*	−0.001	−0.000^a	0.005**	0.005**	0.002
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)
Active leisure	0.001	0.004**	0.002	−0.002	−0.003	−0.002
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Creative act.	0.002	0.001	−0.001	0.002	0.003	0.000^a
	(0.003)	(0.003)	(0.004)	(0.005)	(0.005)	(0.005)
Events	0.005*	0.002	0.001	0.010*	0.004	0.008
	(0.003)	(0.003)	(0.005)	(0.006)	(0.005)	(0.007)
Organizations	−0.001	0.004	−0.006	0.000^a	0.002	−0.007
	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)
Socializing	−0.000^a	−0.000^a	0.001	0.001	0.000^a	0.000^a
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Passive act.	−0.000^a	0.001	0.002	−0.001	−0.001	0.000^a
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Duties	−0.001	0.001	−0.001	0.000^a	−0.001	0.001
	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)
Basic needs	−0.001	−0.001	−0.000^a	0.003*	0.003	0.001
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Missing	0.003	0.007**	0.008*	0.001	0.000^a	0.002
	(0.003)	(0.003)	(0.004)	(0.005)	(0.005)	(0.006)
Within R-squared	0.614	0.553	0.353	0.063	0.057	0.045
Overall R-squared	0.907	0.898	0.836	0.767	0.732	0.662
Observations	3,797	3,797	3,797	3,797	3,797	3,797

Notes: Standard errors (clustered at the family level) in parentheses. Regressions include the other variables described in Section 5.2, age, and time effects. *denotes statistical significance at the 10% level, **denotes statistical significance at the 5% level, and ***denotes statistical significance at the 1% level. ^{a} indicates that $|\hat{\beta}| < 0.001$.

negatively affected by non-electronic game playing. Computer use, educational activities, sports and other active leisure as well as television viewing have positive effects on the problem solving skills of children. None of the activities are found to affect children's short-term memory. Reading decreases externalizing behavior problems in children, whereas playing non-electronic games and attending events have negative effects on this measure of non-cognitive skills. The latter effect is driven by going to movies. The positive relationship between non-electronic games and externalizing behavior problems is mostly due the positive association of these games with children's hyperactivity. Playing non-electronic games is also found to contribute to internalizing behavior problems in children. None of the activities, besides video game playing, have statistically significant effects on children's aggressiveness.

Given the estimates of the absolute effects, it is possible to estimate the effects of video game playing relative to the other activities. Tables 5 and 6 present the estimates of these effects. The relative effects of video game playing show how children's cognitive and non-cognitive skills would be affected if a child's video game time increased by one hour per week and another activity decreased by the same amount of time, that is, if video game playing replaced this activity. Columns 1, 3, and 5 use the estimates from Table 4 to calculate the relative effects of video game playing. More specifically, these relative effects are computed as differences between the absolute effect of video game time and the absolute effect of the corresponding activity time[16]. Columns 2, 4, and 6 report the relative effects of video game playing that are obtained using only the primary activity data for the measurement of the time inputs. As explained in Section 4, such approach requires omitting one activity from the cognitive and non-cognitive skill regressions, and thus allows estimating the relative effects of video game time only. The two sets of estimates of the relative effects of video game playing are not expected to be the same for two reasons. First, the first set of estimates is based on a more complete measure of children's time, which takes into account not only their primary activity time, but also their secondary activity time. Second, the identification of the absolute effects of the time input variables comes from the variation in the time spent multitasking, that is, doing more than one activity at a time. An activity may affect a child's cognitive and non-cognitive skills differently depending on whether the child is solely focusing on this activity or is multitasking. Nonetheless, the two sets of estimates are qualitatively similar in this case.

[16]Excluding one of the activities from the regression and including a child's total time (obtained by adding his/her time spent on all activities) to the regression would give the same set of estimates.

Table 5: Relative effects of video game playing on cognitive skills, child FE estimates

	Reading recognition		Problem solving		Short-term memory	
Relative to	(1)	(2)	(3)	(4)	(5)	(6)
Television	0.001	0.001	0.003	0.002	−0.002	−0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Computer	−0.005**	−0.007***	0.000^a	−0.003	−0.005*	−0.007**
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Educational act.	−0.001	−0.001	0.000^a	−0.000^a	−0.003*	−0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Reading	−0.002	−0.003	0.001	−0.002	−0.003	−0.002
	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)
Active leisure	0.001	0.000^a	0.000^a	−0.000^a	−0.004	−0.004
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Creative act.	−0.001	−0.006*	0.003	−0.000^a	−0.000^a	−0.006
	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)	(0.005)
Other games	0.004*	0.006***	0.005***	0.006**	−0.001	−0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Observations	3,797	3,797	3,797	3,797	3,797	3,797

Notes: Columns 1, 3, and 5 present the relative effects derived from the absolute effects. Columns 2, 4, and 6 present the relative effects obtained by using the primary activity data only. Standard errors (clustered at the family level) in parentheses. Regressions include the other inputs described in Section 5.2, age, and time effects. *denotes statistical significance at the 10% level, **denotes statistical significance at the 5% level, and ***denotes statistical significance at the 1% level. ^{a} indicates that $|\hat{\beta}| < 0.001$.

As discussed in the introduction, there may be differences in the effects on children's cognitive and non-cognitive skills between video game playing and other similar activities, such as television viewing and computer use. The results reported in Table 5 suggest that relative to television viewing, video game playing has positive effects on the reading and problem solving skills and a negative effect on short-term memory. None of these relative effects are statistically significant. Relative to computer use, the effects of video game playing on reading and short-term memory skills are negative, because computer use is found to affect these skills positively, whereas the effects of video game playing are not significantly different from zero, as shown in Table 4. The first finding is not surprising, as computer activities require children to read more than video game playing. Relative to computer use, the effect of video game playing on children's problem solving ability is close to zero, as both activities have similar positive significant effects on this ability. The estimates reported in Table 6 show that video game playing has positive, but mostly insignificant effects on children's non-cognitive skills, relative to television viewing and computer use. Thus, there is some evidence that video game playing is more beneficial to children's non-cognitive skills than the other media.

The results presented in Tables 5 and 6 also show that if children spent more time playing video games and less time on other (non-electronic) games, this would have positive effects on children's reading, problem solving, and non-cognitive skills. The latter finding is driven by some of the traditional games increasing such behavior problems as hyperactivity in children. Video game playing would have a negative effect on short-term memory if it displaced educational activities. On the other hand, this may positively affect children's non-cognitive skills. The latter result is driven by video game playing reducing behavior problems among children, and educational activities having no significant effects on children's behavior. Although neither video game playing nor educational activities have a significant absolute effect on children's internalizing behaviors, relative to educational activities, video game playing is found to reduce these behavior problems.

Table 7 reports the estimated effects of the other variables on children's cognitive skills. The number of books positively affects all three measures of cognitive skills. The effects of the number of museum visits on children's cognitive skills are of unexpected sign, but largely statistically insignificant, once the time spent attending events and visiting places, including museums, is held constant. The nutrition variables are also found not to significantly affect children's cognitive skills. Age has significant positive effects on children's performance in the cognitive achievement tests, as expected.

Table 8 presents the estimated effects of the other variables on children's non-cognitive skills. The non-cognitive skills are positively affected by some of the parental warmth

Table 6: Relative effects of video game playing on non-cognitive skills, child FE estimates

	External beh probl		Internal beh probl		Aggressive behavior	
Relative to	(1)	(2)	(3)	(4)	(5)	(6)
Television	-0.004^{*}	-0.004^{*}	-0.001	-0.001	-0.004	-0.004
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Computer	-0.004	-0.000^{a}	-0.004	-0.004	-0.008^{*}	-0.003
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)
Educational act.	-0.007^{***}	-0.007^{***}	-0.006^{**}	-0.005^{*}	-0.007^{**}	-0.007^{**}
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Reading	0.004	0.001	0.002	-0.002	-0.004	-0.004
	(0.005)	(0.006)	(0.006)	(0.007)	(0.007)	(0.008)
Active leisure	-0.004	-0.005	-0.001	-0.002	-0.005	-0.005
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
Creative act.	-0.008^{*}	-0.008	-0.006	-0.003	-0.007	-0.005
	(0.005)	(0.006)	(0.005)	(0.006)	(0.006)	(0.007)
Other games	-0.011^{***}	-0.011^{***}	-0.008^{**}	-0.006	-0.008^{**}	-0.009^{**}
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)
Observations	3,797	3,797	3,797	3,797	3,797	3,797

Notes: Columns 1, 3, and 5 present the relative effects derived from the absolute effects. Columns 2, 4, and 6 present the relative effects obtained by using the primary activity data only. Standard errors (clustered at the family level) in parentheses. 3,797 child-year observations. Regressions include the other inputs described in Section 5.2, age, and time effects. *denotes statistical significance at the 10% level, **denotes statistical significance at the 5% level, and ***denotes statistical significance at the 1% level. ^{a} indicates that $|\hat{\beta}| < 0.001$.

Table 7: Effects of other inputs on cognitive skills, child FE estimates

	Reading recognition		Problem solving		Short-term memory	
	Coeff	s.e.	Coeff	s.e.	Coeff	s.e.
Books = 10 to 19[a]	0.035	0.037	0.050	0.044	0.022	0.048
Books = 20 or more	0.014	0.036	0.067^{*}	0.039	0.105^{**}	0.044
Museum = sometimes[b]	-0.007	0.026	0.022	0.024	-0.010	0.032
Museum = frequently	0.001	0.031	-0.057^{*}	0.032	-0.046	0.040
Breakfast	-0.016	0.032	0.034	0.043	0.006	0.046
Food expend. 1997$ pp/wk	0.000^{c}	0.000^{c}	0.000^{c}	0.001	0.001	0.000^{c}
Observations	3,797		3,797		3,797	

Notes: Standard errors are clustered at the family level. Regressions control for the time inputs, age, and time effects. *denotes statistical significance at the 10% level, **denotes statistical significance at the 5% level, and ***denotes statistical significance at the 1% level. [a] The omitted category is none. [b] The omitted category is never. [c] $|\hat{\beta}| < 0.001$.

measures. Participating in the child's favorite activities or talking with the child about things that interest him/her reduces both disturbed and emotional behavior problems, especially if this is done regularly. On the other hand, expressing positive feelings (telling your child that you love him/her or appreciating something the child did) does not have any statistically significant effect on either externalizing or internalizing behavior problems. The variables describing parents' attitude towards discipline are jointly significant in all the non-cognitive skill regressions. It appears that the worst strategy is to avoid dealing with a child's misbehavior by ignoring it or sending the child to his/her room, as this may increase both externalizing and internalizing behavior problems. Changing schools has negative effects on a child's non-cognitive skills. Internalizing and aggressive behavior problems appear to decrease with age, but externalizing behavior problems are positively associated with age.

Table 8: Effects of other inputs on non-cognitive skills, child FE estimates

	External beh probl		Internal beh probl		Aggressive behavior	
	Coeff	s.e.	Coeff	s.e.	Coeff	s.e.
No of activities w/PCG	−0.017	0.023	0.010	0.022	−0.025	0.027
Warmth (love)=Once/wk[a]	−0.025	0.090	−0.004	0.096	−0.116	0.115
Warmth (love)=A few times/wk	−0.051	0.079	0.013	0.085	−0.088	0.103
Warmth (love)=Everyday	−0.109	0.083	−0.017	0.089	−0.134	0.106
Warmth (appr)=Once/wk[a]	0.017	0.068	0.065	0.074	−0.042	0.088
Warmth (appr)=A few times/wk	0.028	0.073	0.036	0.075	−0.054	0.092
Warmth (appr)=Everyday	0.036	0.081	0.050	0.084	−0.025	0.102
Warmth (part)=Once/wk[a]	−0.023	0.047	−0.003	0.050	−0.083	0.059
Warmth (part)=A few times/wk	−0.086*	0.051	−0.037	0.053	−0.111*	0.063
Warmth (part)=Everyday	−0.140**	0.065	−0.134*	0.069	−0.139*	0.079
Warmth (talk)=Once/wk[a]	−0.183***	0.071	−0.108	0.072	−0.093	0.099
Warmth (talk)=A few times/wk	−0.148**	0.068	−0.079	0.071	−0.191**	0.094
Warmth (talk)=Everyday	−0.208***	0.073	−0.159**	0.074	−0.212**	0.101
Would spank child	0.053	0.046	0.069	0.050	0.023	0.060
Would talk to child	0.026	0.035	0.071*	0.036	−0.003	0.044
Would give chores	0.034	0.052	−0.007	0.052	0.057	0.069
Would ignore	0.247***	0.065	0.191***	0.068	0.177**	0.078
Would send to his/her room	0.111***	0.034	0.064*	0.036	0.126***	0.041
Would take allowance	0.004	0.053	0.066	0.059	−0.049	0.073
Would put in time out	0.045	0.041	0.021	0.044	0.029	0.050
Changed school	0.147*	0.080	0.183**	0.078	0.056	0.096
Moved	0.014	0.038	0.039	0.044	−0.016	0.050
Observations	3,797		3,797		3,797	

Notes: Standard errors (clustered at the family level) in parentheses. Regressions control for the time inputs, age and time effects. *denotes statistical significance at the 10% level, **denotes statistical significance at the 5% level, and ***denotes statistical significance at the 1% level. [a] the omitted category is 1-2 times in the past month or never.

Next, I present the results of alternative identification strategies. For comparison purposes, the first row of Table 9 replicates the baseline results. Panel A report the estimates of random effects (RE) and ordinary least squares (OLS) models, respectively. The OLS and RE estimators are based on the assumption that children's innate abilities and any other unobserved characteristics are uncorrelated with children's video game time and the other inputs in the cognitive and non-cognitive skill production function functions. If this assumption were true, the child FE, RE, and OLS estimators should give qualitatively similar results. Overall, the estimates presented in Table 9 do not support the assumption that children's video game time is uncorrelated with the unobserved heterogeneity. The OLS and RE estimates of the effects of video game time on the reading and problem solving skills are larger than the child FE estimates of these effects, implying that the OLS and RE estimators are positively biased. Thus, it appears that video game playing is indeed positively correlated with children's innate cognitive abilities. In the externalizing and aggressive behavior problem regressions, the OLS and RE estimates are smaller in absolute magnitude than the child FE estimates. These differences indicate that the OLS and RE estimators of these effects are also positively biased. Thus, it seems that video game playing is negatively correlated with children's innate non-cognitive abilities, as expected. A Hausman test rejects the child RE model in favor of the child FE model for all the cognitive and non-cognitive skills at the five percent significance level.

In addition to the child FE model, the family FE and value added (VA) models can be used to address the endogeneity of video game playing. The estimates of these models are presented in panel B of Table 9. In the family FE model, the identification of coefficients comes from the differences in video game time between siblings (or cousins) in the same family. Thus, the family FE model eliminates any variables that are common to children from the same family. To facilitate the comparison of the child FE and family FE estimates, the child FE regressions are re-estimated using the same (sibling) sample. Both estimation methods produce qualitatively similar results, which suggests that either family fixed effects capture most of the unobserved child heterogeneity, or that family environment matters to child development, or both. The family FE estimates are, however, less precise. For this reason, the child FE model is preferred to the family FE model in this analysis. The last row of Table 9 reports the estimates of the value added (VA) model. In this model, the lagged value of the dependent variable is included as a regressor. The key identifying assumption of the value added model is that the effects of the innate abilities and other time-invariant variables decline over time at a rate given by the coefficient on the lagged dependent variable. Although based on different assumptions, the child FE and VA models produce qualitatively similar results. However, the estimates of the latter model are less precise. Overall, the results are robust to using alternative estimation methods to deal with the endogeneity of video game playing.

Table 9: Other model estimates of video game time effects on cognitive and non-cognitive skills

	(1) Reading recogn	(2) Problem solving	(3) Short-term memory	(4) External beh probl	(5) Internal beh probl	(6) Aggressive behavior
Child FE	0.001	0.004**	−0.001	−0.006**	−0.003	−0.007**
(baseline)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
A.						
Child RE	0.004**	0.006***	−0.001	−0.004*	−0.002	−0.004*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
OLS	0.006***	0.007***	-0.000^{a}	−0.001	-0.000^{a}	−0.003
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
B.						
Family FE	0.007	0.009*	0.003	−0.007	−0.006	−0.014*
	(0.004)	(0.005)	(0.005)	(0.008)	(0.007)	(0.008)
Child FE	0.006***	0.010***	0.005	−0.010**	−0.003	−0.013**
(same sample)	(0.002)	(0.003)	(0.003)	(0.004)	(0.005)	(0.006)
VA	0.001	0.003	-0.000^{a}	−0.005*	−0.003	−0.003
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)

Notes: Standard errors (clustered at the family level) in parentheses. Sample size: in the child FE, RE, and OLS models, 3,797 observations; in the family FE model, 1,672 observations; in the VA model, 2001 observations. Regressions include other activity time, the other variables described in Section 5.2, age, and time effects. The OLS and VA models control for gender and race. The family FE model controls for gender. *denotes statistical significance at the 10% level, **denotes statistical significance at the 5% level, and ***denotes statistical significance at the 1% level. ^{a} indicates that $|\hat{\beta}| < 0.001$.

6.2 Sensitivity analysis

In this subsection, I first attempt to address the threats to internal validity. The child FE model assumes zero correlation between the within-child variation in the explanatory variables and the error terms, which may contain omitted inputs, measurement errors, and random shocks to child cognitive and non-cognitive development. In reality, the variation in these unobserved variables could potentially be correlated with the variation in children's video game time and other inputs, violating the strict exogeneity assumption and making the coefficient estimates biased and inconsistent. One way to address this issue would be to use the instrumental variable (IV) method. Finding valid instruments for all the inputs is, however, hardly feasible.

Therefore, I employ two other strategies to investigate if the strict exogeneity assumption is reasonable in this analysis. As a first check, additional control variables, which are presumably correlated with some of the unobserved factors, are included in the cognitive and non-cognitive skill regressions. If the strict exogeneity assumption is violated in the baseline model, the addition of these variables should alter the estimated effects of video game playing. The first group of controls consists of the variables that have been used in other studies on children's cognitive and non-cognitive skills such as the number of magazines the family gets, whether or not the family receives a daily newspaper, and interviewer observations of the child's home environment and the interaction between the primary care giver and the child[17]. These variables are not included in the baseline model, because the data are missing for a large number of observations. The second group of controls consists of the variables that could be considered as shocks to child cognitive and non-cognitive skill development, such as changes in the family's financial security, neighborhood safety, the primary care giver's emotional well-being, and a child's health. The last group of control variables includes family characteristics, such as family income; age, education, and employment status of the primary care giver; and the number of children and adults in the family. Additionally, variables that were only added to the cognitive skill regressions are added to the non-cognitive skill regressions, and vice versa. The full list of these additional variables is provided in Appendix C. To account for the sample selection due to missing values, the baseline model is re-estimated using this smaller sample. The estimates presented in panel A of Table 10 show that the results remain robust to the inclusion of the above mentioned additional variables. The estimated effect of video game time on children's problem solving ability remains positive and statistically significant. There is still support for the hypothesis that video game playing decreases externalizing behavior problems in children.

As a second check for how reasonable the strict exogeneity assumption is in this analysis, I include a child's future period video game time as a regressor to the cognitive and non-cognitive skill regressions (Fiorini, 2010). Future period video game time should not affect current period skills directly. If the coefficient on this variable were found to be significant, this would imply that children's cognitive and non-cognitive skills in the past period affect their current period video game time, which in turn would violate the strict exogeneity assumption. As shown in panel B of Table 10, the coefficient on the future period video game time variable is not statistically different from zero in any of the regressions. These findings further support the strict exogeneity assumption.

[17]These variables are used to compute the Home Observation Measurement of Environment - Short Form (HOME-SF) index, used in Todd and Wolpin (2007).

Table 10: Sensitivity checks, child FE estimates of the effects of video game playing on cognitive and non-cognitive skills

	(1) Reading recogn	(2) Problem solving	(3) Short-term memory	(4) External beh probl	(5) Internal beh probl	(6) Aggressive behavior	Sample size
Baseline	0.001	0.004**	−0.001	−0.006**	−0.003	−0.007**	3,797
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	
A.							
Adding other controls	0.001	0.006**	−0.004	−0.010***	−0.004	−0.010**	1,850
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)	
New baseline	0.002	0.006**	−0.003	−0.011***	−0.004	−0.010**	1,850
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	
B.							
$t_{vg,t+1}$	−0.001	−0.002	−0.005	−0.001	0.008	−0.009	870
	(0.003)	(0.003)	(0.004)	(0.006)	(0.007)	(0.007)	
$t_{vg,t}$	0.001	0.003	0.000^{a}	−0.032***	−0.015	−0.027***	
	(0.004)	(0.004)	(0.006)	(0.007)	(0.009)	(0.009)	
C.							
Excluding outliers	-0.000^{a}	0.005**	−0.001	−0.005	−0.003	−0.006	3,292
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)	
Excluding atypical days	0.002	0.006**	−0.003	−0.009***	−0.007**	−0.009**	2,619
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	
Excluding non-consecutive obs	0.001	0.004**	−0.001	−0.006***	−0.004	−0.008**	3,671
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	
D.							
$t_{vg,t}$	−0.003	0.005*	−0.001	−0.007*	−0.008**	−0.007	3,797
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	
$t^2_{vg,t}$	0.000^{**a}	-0.000^{a}	-0.000^{a}	0.000^{a}	0.000^{*a}	0.000^{a}	
	(0.000^{b})	(0.000^{b})	(0.000^{b})	(0.000^{b})	(0.000^{b})	(0.000^{b})	
Different standardization	0.001	0.003*	−0.001	−0.006**	−0.004	−0.007**	3,797
	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)	
Applying weights	0.001	0.004***	0.000^{a}	−0.013***	−0.006*	−0.009*	3,797
	(0.001)	(0.002)	(0.003)	(0.003)	(0.004)	(0.005)	

Notes: Standard errors (clustered at the family level) in parentheses. Regressions include other activity time, the other variables described in Section 5.2, age, and time effects. *denotes statistical significance at the 10% level, **denotes statistical significance at the 5% level, and ***denotes statistical significance at the 1% level. ^{a} indicates that $|\hat{\beta}| < 0.001$ and ^{b} indicates that $se(\hat{\beta}) < 0.001$.

Next, I show that the baseline results are robust to changes in sample composition and model specification. Panel C of Table 10 reports the results of the child FE model estimated using different analysis samples. First, I exclude the outliers of cognitive and non-cognitive skills and video game time. An observation is considered to be an outlier if one or more of the cognitive or non-cognitive skill measures is lower than the 1st percentile or higher than the 99th percentile of the corresponding distribution. If the time spent playing video games exceeds the 99th percentile of the video game time distribution, an observation is also considered to be an outlier. Second, I exclude the observations for which either weekday or weekend diary was completed on a day that was very atypical for the child (or this variable is missing). Finally, I restrict the sample to the children observed in at least two consecutive waves, that is, I exclude the children that are observed in wave I and III, but not in wave II. Overall, the exclusion of the above mentioned observations does not affect the key findings of the analysis. The effect of video game playing on the problem solving ability is consistently positive and statistically significant at the five percent level. The estimated effects of video game time remain negative and mostly statistically significant in the externalizing and aggressive behavior problem regressions.

The results of the remaining robustness checks are presented in panel D of Table 10. The first row of this panel reports the estimates of a model specification that includes a square of video game. These estimates show that there is little support for non-linear effects of video game time in either cognitive or non-cognitive skill regressions. Recall that in the baseline model, children's cognitive and non-cognitive skills are standardized by wave. I check how the results are affected if the overall sample means and standard deviations are used for the standardization. Standardized this way, the measures of the cognitive and non-cognitive skills show how well a child is doing compared to an average child in an average year. Therefore, the interpretation of the coefficients is different to that in the baseline model. Nevertheless, the results, presented in the second row of panel D, are very similar to the baseline estimates. Finally, I re-estimate the cognitive and non-cognitive regressions applying sampling weights. The last row of panel D shows that the estimated effects of video game time on children's cognitive skills are not affected by weighting, but the coefficient estimates in the non-cognitive skill regressions are larger in absolute magnitude. The differences between the non-weighted and weighted estimates suggest that there may be heterogeneity in the effects of video game playing, as explained by Deaton (1997, p.72). I investigate this issue further in the next subsection.

6.3 Heterogeneity in the effects of video game time

This subsection discusses how the effects of video game playing vary by child and family characteristics. The effects of video game time may be heterogeneous for three reasons. First, the effects of video game playing may vary with children's ability endowments, which in turn may be correlated with observed child and family characteristics. For example, children who have higher endowments of cognitive skills may benefit more from cognitively challenging video games than children with lower endowments of these skills, or vice versa. Second, there may be complementarity or substitutability between video game playing and other inputs in the skill production function. In this case, the effects of video game playing would vary by the level of other inputs in a child's development, which in turn may be correlated with family characteristics. Finally, children with different characteristics may play different types of games or be less or more likely to be supervised by their parents while playing. I investigate whether there is heterogeneity in the effects of video game playing by the following child and family characteristics: gender, race, socio-economic status, rural-urban location, and family structure. I split the sample by these characteristics and estimate separate models for each of the subsamples. As to the time varying characteristics, I only use the observations for which the values of these characteristics do not change in at least two survey years[18]. The sample sizes are smaller for this reason. Additionally, some of the family characteristics have missing values. Table 11 reports the estimates of the cognitive skill regressions. Table 12 reports the estimates of the non-cognitive skill regressions.

Comparing the effects of video game playing by gender, girls appear to benefit more from video game playing. The positive effect of video game time on the problem solving ability is larger in the girls' subsample. Moreover, video game playing is found to improve girls' short-term memory and reduce their emotional behavior problems, whereas the corresponding effects for boys are statistically insignificant. Most of the effects in the white and black children subsamples are imprecisely identified[19]. Nonetheless, the point estimates suggest that white children benefit more from video game playing, especially in terms of the non-cognitive skills. The effects of video game playing appear to vary by whether or not a child lives in a standard metropolitan statistical area. The positive effect on the problem solving ability is slightly stronger for children living in large metropolitan areas. On the other hand, the positive effects on non-cognitive skills are larger in absolute magnitude for children living in non-metropolitan areas, although this

[18]For example, if a child is observed two times in the baseline sample, and his/her family income changed from being below median to above median across waves, the observations of this child cannot be used in the heterogeneity analysis.

[19]The estimates for other races are not reported as the sample sizes are very small.

Table 11: Heterogeneity in the effects of video game playing on cognitive skills, child FE estimates

	Reading recognition		Problem solving		Short-term memory		Sample size
	Coeff	s.e.	Coeff	s.e.	Coeff	s.e.	
Gender							
Female	0.005	0.004	0.011**	0.005	0.008*	0.004	1,900
Male	0.003	0.002	0.004	0.002	−0.003	0.003	1,897
Race[a]							
White	−0.003	0.002	0.004	0.003	−0.001	0.003	1,897
Black	0.002	0.002	0.000[b]	0.002	−0.003	0.003	1,470
Standard metropolitan statistical area (SMSA)							
No	−0.001	0.003	0.004	0.003	0.000[b]	0.004	1,595
Yes	0.002	0.002	0.006**	0.003	−0.002	0.003	1,977
Family income							
$\leq$ median	0.002	0.003	0.003	0.003	−0.003	0.003	1,500
$>$ median	−0.002	0.002	0.001	0.003	−0.003	0.005	1,393
Education of PCG, years							
$\leq$ 12	0.004*	0.002	0.007**	0.003	0.000[b]	0.003	1,721
$>$ 12	−0.001	0.003	0.001	0.003	−0.004	0.004	1,668
Both parents live with child							
No	0.001	0.003	−0.002	0.003	−0.009***	0.003	1,282
Yes	−0.001	0.002	0.009***	0.003	0.006*	0.003	2,075

Notes: Standard errors are clustered at the family level. Regressions include other activity time, the other variables described in Section 5.2, age, and year fixed effects. *denotes statistical significance at the 10% level, **denotes statistical significance at the 5% level, and ***denotes statistical significance at the 1% level. [a] The sizes of Hispanic and other race subsamples are too small to draw any inferences. [b] indicates that $|\hat{\beta}| < 0.001$

is not true for aggressiveness. These differences in the effects of video game playing by child characteristics may be related to the differences in the types of games that children play and/or how much supervision they get.

The positive effects of video game playing on the problem solving ability and the non-cognitive skills (except for aggressiveness) are slightly larger in absolute magnitude in the lower income subsample. The results also show that the positive effect of video game time on the problem solving skills is driven by children with less educated primary care givers. For this subsample of children, video game playing also is found to positively affect their reading recognition skills. These results are consistent with those of Gentzkow and Shapiro (2008) who find larger positive effects of television viewing on math and reading skills for children of less educated mothers compared to children of more educated mothers. Overall, it seems that lower socio-economic status families, as measured by income and education, benefit more from video game playing in terms of the reading and problem solving skills and externalizing behavior problems. The data also show that the investments in the other inputs in the production functions of these skills are largely lower in lower socio-economic status families. Taken together, these findings suggest that video game playing may be a substitute for the other inputs, as the marginal product of video game time appears to decrease as the other inputs increase. A more flexible model including the interactions of video game time with the other inputs could be estimated to test this hypothesis. As to family structure, it seems that the benefits of video game playing are larger for children who have both parents living in the household, especially in terms of the cognitive skills. This result may indicate that parent involvement and supervision is important, as single parents may have less time and possibilities to supervise children while they play video games.

Table 12: Heterogeneity in the effects of video game playing on non-cognitive skills, child FE estimates

	External beh probl		Internal beh probl		Aggressive behavior		Sample size
	Coeff	s.e.	Coeff	s.e.	Coeff	s.e.	
Gender							
Female	−0.007	0.006	−0.011*	0.006	−0.006	0.007	1,900
Male	−0.005*	0.003	−0.002	0.003	−0.006	0.004	1,897
Race[a]							
White	−0.007*	0.004	−0.003	0.004	−0.010**	0.005	1,897
Black	−0.003	0.004	−0.001	0.003	−0.002	0.005	1470
SMSA							
No	−0.011***	0.004	−0.009**	0.004	−0.006	0.006	1,595
Yes	−0.006**	0.003	−0.004	0.004	−0.008**	0.004	1,977
Family income							
≤ median	−0.008**	0.004	−0.004	0.004	−0.006	0.006	1,500
> median	−0.004	0.004	−0.002	0.005	−0.009	0.005	1,393
Education of PCG, years							
≤ 12	−0.008**	0.003	−0.002	0.004	−0.007	0.005	1,721
> 12	−0.006	0.004	−0.004	0.004	−0.005	0.005	1,668
Both parents live with child							
No	−0.007*	0.004	−0.005	0.004	−0.007	0.006	1,282
Yes	−0.010***	0.003	−0.011***	0.004	−0.010***	0.004	2,075

Notes: Standard errors (clustered at the family level) in parentheses. Regressions control for other activity time, the other variables described in Section 5.2, age, and year fixed effects. *denotes statistical significance at the 10% level, **denotes statistical significance at the 5% level, and ***denotes statistical significance at the 1% level. [a] The sizes of Hispanic and other race subsamples are too small to draw any inferences.

The effects of video game playing may also vary by the type of a video game. The CDS time diaries separately record the time a child spent playing video games on a console or a hand held device and the time a child spent playing games on a computer or the Internet. The games that are more cognitively challenging, such as strategy or simulation games, are more likely to be played on a computer than on a console. In addition, computer games seem to have more complex control systems[20]. Therefore, I expect children's computer game time to have a larger positive effect on their problem solving skills. In addition, it seems that a computer is preferred to a console as a platform for playing "shooter" games, which involve violence. Provided that violent video games cause real-life aggression, I expect computer games to contribute to externalizing behavior problems, especially aggressive behaviors, more than console games. Table 13 reports the estimates of a model specification in which the total video game time is disaggregated into console and computer game time. It is possible to estimate the effects of these two variables separately, as the correlation between console game time and computer game time is very low. The results support the hypothesis that computer game playing has a larger positive effect on children's problem solving skills. The difference between the effects of computer and console game time is significantly different from zero at the one percent significance level in this regression. The hypothesis that computer game playing contributes to behavior problems more than console game playing is, however, not supported. To the contrary, the effects of computer game playing on externalizing behavior problems and aggressiveness are negative and larger than the corresponding effects of console game playing, although the differences between these effects are not significantly different from zero. Additionally, it appears that computer game playing positively affects children's reading recognition ability, although console game time does not have any effect on this skill.

Table 13: Computer games versus console games, child FE estimates

	Reading recogn	Problem solving	Short-term memory	External beh probl	Internal beh probl	Aggressive behavior
Computer games	0.005*	0.013***	0.001	−0.009*	−0.005	−0.009
	(0.003)	(0.004)	(0.004)	(0.005)	(0.006)	(0.007)
Console games	0.000^a	0.002	−0.002	−0.005**	−0.003	−0.006*
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Observations	3,797	3,797	3,797	3,797	3,797	3,797

Notes: Standard errors (clustered at the family level) in parentheses. Regressions include other activity time, the other variables described in Section 5.2, age, and time effects. *denotes statistical significance at the 10% level, **denotes statistical significance at the 5% level, and ***denotes statistical significance at the 1% level. ^{a} indicates that $|\hat{\beta}| < 0.001$

[20]I am grateful to James Murchison and Robert Bird for these insights.

7 Discussion

In this section, I compare the results of this analysis to the findings of the other studies in the literature. Fiorini (2010) only looks at the effects of console game playing on children's cognitive and non-cognitive skills. Therefore, I use the estimated effects of console game playing, presented in Table 13, to compare my results to those of Fiorini. Contrary to Fiorini, I do not find any evidence of a negative effect of console game playing on children's verbal skills, but this is not surprising given the differences between the two studies. The Letter-Word Identification test used in this analysis and the Peabody Picture Vocabulary Test used by Fiorini measure different verbal skills. The first test measures a child's ability to recognize words, but does not require the child to know the meaning of a word, whereas the latter test assesses whether a child knows the meaning of a word. Moreover, my specification of the cognitive skill production function controls for all the other time inputs, including reading time, whereas Fiorini controls only for the other media (television and computer) time, and reading time is allowed to vary in his model. Therefore, the interpretation of the coefficient on the video game time variable is different in the two studies. I do find that relative to reading video game playing has a negative effect on children's reading recognition skills, which suggests that my results may not be inconsistent with those of Fiorini. As to children's non-verbal cognitive skills, the results of the two studies are similar. My findings show that console game playing contributes to the development of children's problem solving skills, although this effect is imprecisely estimated. Fiorini finds a positive effect of video game playing on children's pattern recognition skills in one specifications of his model. The task of pattern recognition can be considered as an assessment of children's problem solving ability.

To put the findings of this study in perspective, I compare the estimated effect of video game playing on the problem solving ability to the effects of other variables on similar skills. Dahl and Lochner (2012) find that a $1,000 increase in the family's annual income increases a child's mathematics test score by 5.8% of a standard deviation. Given that the Applied Problems test score used in this analysis measures math related abilities, the effect of an additional video game hour per week roughly compares to the effect of a $70 increase in annual family income. Bernal and Keane (2011) find that a year of child care (or time away from the mother) decreases the cognitive skill test score of young children by 0.114 of a standard deviation[21]. Combining my findings with those of Bernal and Keane (2011) suggests that the effect of a one hour per week increase in video game time

[21] Although Bernal and Keane (2011) do not distinguish between different types of cognitive skill tests in the baseline specification, their additional estimations show that the effect of child care on math score is similar to the baseline estimate.

compares to the effect of a two week per year decrease in a child's time in child care. Thus, the effect of video game playing on child cognitive skills appears to be not trivial.

The results of this analysis are consistent with the conclusions of Ward (2010) who finds that controlling for observed heterogeneity eliminates the positive correlation between video game playing (or computer use) and fighting. In the OLS and child RE regressions that control for the observed variables only, there is no evidence that video game playing contributes to child externalizing or aggressive behavior problems. Moreover, once the unobserved heterogeneity is taken into account, the effects of video game time on these behavior problems become negative and statistically significant.

It may appear that my results contradict the findings of the experimental studies that generally find positive effects of exposure to violent video games on aggression among young children (Anderson and Bushman, 2001; Bensley and Van Eenwyk, 2001). These findings do not, however, preclude a possibility that non-violent video games may reduce behavior problems in children. For example, some games may teach children to concentrate better or cooperate with other people, which would reduce their externalizing behavior problem index (Buckingham, 2007). Moreover, the experimental studies only show that children's aggressiveness increases immediately after playing a violent video game and do not provide any evidence on the long term effects of violent video game playing. In the psychology literature, there are theories that predict that violent video games could in fact reduce aggression (Bensley and Van Eenwyk, 2001). According to the catharsis theory, video games can provide a safe outlet for children's aggressive thoughts and feelings thereby reducing real-life aggressive behavior in children. According to the drive-reduction theory, emotionally disturbed children may bring their emotions into balance by play violent video games.

The findings of this analysis do not provide support for the arguments of the proponents of the policies imposing restrictions on the sale of violent video games to children. The supporters of these policies claim that video game playing teaches children to behave aggressively (Associated Press, 2010). In this study, video game playing is found, in fact, to reduce aggressiveness in children. Nonetheless, this study looked at the effect of video games in general and did not investigate the effects of violent video games. Therefore, I cannot provide recommendations for the policies related to violent game sales. I plan to extend this study by investigating whether different types of video games affect children's cognitive and non-cognitive skills differently[22].

[22]The PSID-CDS time diaries collect data on the title of the video game played by a child, but access to this data is restricted and can only be obtained by researches who hold a full-time permanent faculty position.

8 Conclusions

To conclude, this paper contributes to the literature on child cognitive and non-cognitive development by investigating the role of video game playing in the production of children's cognitive and non-cognitive skills. The results of this analysis show that there is a plausibly causal relationship between video game playing and children's ability to solve problems. This finding is as expected, as many video games are, in fact, problem solving tasks. To win the game, children are required to use the knowledge they already have, find the relevant new information among all the information given to them, and determine the steps that need to be followed to reach the goal. Similar skills are required from children to succeed in the problem solving test. On the other hand, video game playing is found to have no statistically significant effects on children's reading recognition ability or short-term memory, once other activity time is held constant. The results of this analysis also show that video game playing may reduce children's externalizing behavior problems. Moreover, there is no evidence that video game playing increases aggressiveness in children. Finally, I do not find any statistically significant effects of video game playing on children's emotional problems.

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A Behaviors included in the externalizing and internalizing behavior problem sub-scales

Behaviors included in the externalizing behavior problems sub-scale:

- (He/She) has sudden changes in mood or feeling;
- (He/She) cheats or tells lies;
- (He/She) argues too much;
- (He/She) has difficulty concentrating, cannot pay attention for long;
- (He/She) bullies or is cruel or mean to others;
- (He/She) is disobedient;
- (He/She) does not seem to feel sorry after (he/she) misbehaves;
- (He/She) has trouble getting along with other children;
- (He/She) is impulsive, or acts without thinking;
- (He/She) is restless or overly active, cannot sit still;
- (He/She) is stubborn, sullen, or irritable;
- (He/She) has a very strong temper and loses it easily;
- (He/She) breaks things on purpose or deliberately destroys things;
- (He/She) demands a lot of attention;
- (He/She) hangs around with kids who get into trouble.

Behaviors included in the internalizing behavior problems sub-scale:

- (He/She) feels or complains that no one loves (him/her);
- (He/She) is rather high strung and nervous;
- (He/She) is too fearful or anxious;
- (He/She) is easily confused, seems to be in a fog;
- (He/She) has trouble getting along with other children;
- (He/She) feels worthless or inferior;
- (He/She) is not liked by other children;
- (He/She) has difficulty getting (his/her) mind off certain thoughts;
- (He/She) is unhappy, sad or depressed;
- (He/She) is withdrawn, does not get involved with others;
- (He/She) cries too much;

- (He/She) is too dependent on others;
- (He/She) feels others are out to get (him/her);
- (He/She) worries too much;
- (He/She) is secretive, keeps things to (himself/ herself);
- (He/She) clings to adults.

B Family food expenditure measure

To construct a measure of family's food expenditure per person, I divide a family's expenditure on food by the number of equivalent adults in the family unit. The number of equivalent adults is calculated by weighting the members of a family unit as follows: the first adult in the family is assigned the weight 1, the second adult is assigned the weight 0.5, and the children are assigned the weight 0.3[23]. This weighting scheme assumes that the additional food cost for the second adult in a family is equal to 50% of the food cost for the first adult and that the additional food cost for each child is 30% of that amount. I use the data from the core PSID surveys for the construction of this variable. A family's expenditures on three types of food - consumed at home, delivered to home, and eaten out - are reported in these surveys. I add expenditures on all types of food to obtain the total family food expenditure. The amount of food stamps is included in a family's expenditure on food consumed at home for those families that receive food stamps. Food expenditure is measured in 1997 dollars per week.

[23]To calculate equivalized food expenditure of a family, I followed a methodology used to construct equivalized income of a household (http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Equivalised_disposable_income). I deviate from this methodology by assigning the weight 0.3 to all children under 18 years of age, rather than assigning the weight 0.5 for the children 14 years of age or older and the weight 0.3 for the younger children.

C Additional controls

The following variables are added to the cognitive and non-cognitive skill equations: the number of magazines the family receives; whether or not the family gets a daily newspaper; interviewer observations about the interaction between the primary care giver and the child (whether or not the primary care giver spontaneously spoke with the child, responded to the child's questions, showed physical affection towards the child, slapped or spanked the child, physically restricted the child, conveyed positive feelings about the child, spontaneously praised the child, was warm and affectionate when interacting with the child); interviewer rating of the primary care giver based on hostility, pride, and warmth towards the child; interviewer rating of home environment (how monotonous, cluttered, clean, and safe the house is); whether the primary care giver reported ever spanking the child; how often the family gets together with friends or relatives; family income (adjusted for family size and composition, in 1996 dollars); the number of adults in the family; the number of children in the family; whether a child has another care giver; whether a child's both biological or adoptive parents live together with the child; age, education, and employment status of the primary care giver; whether or not the family lives in a standard metropolitan statistical area (SMSA); whether or not a child has any chronic conditions; a child's number of doctor visits in the past 12 months (for illness or injury); whether or not a child has any physical or mental disability; primary care giver assessed health status of a child; a child's BMI; whether or not a child is overweight or obese; whether or not a child is negatively affected by anyone in the household's alcohol consumption; the primary care giver's self-esteem, self-efficacy, and distress scales; whether or not the family had any financial hardships in the past 12 months; and neighborhood rating.

Additionally, the following controls are included to the cognitive skill regressions: the number of the primary care giver's activities with the child; parental warmth and discipline measures; whether a child changed schools, and whether the family moved. These variables are added to the non-cognitive skill equations: a child's number of books and museum visits, the family's food expenditure, and whether or not a child usually has breakfast.