Research Report

Video Game Play

Any Association With Preteens' Cognitive Ability Test Performance?

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Abstract: This exploratory study examined the video gaming experience of 160 urban public-school preteen-age students as well as the association between video game play and students' performance on a standardized cognitive ability test (CogAT), which includes verbal, quantitative, and nonverbal/spatial batteries. Overall, neither duration of play nor video game genres played had significant correlations with the CogAT measures. Similarly, when using an "extreme-groups" approach to examine relations with playing a subset of games previously linked with certain enhancements in cognitive skill (i.e., action video games), no significant effects were observed. These results are thus inconsistent with theories that predict diminished cognitive performance in children who play a great deal of video games, but they are also inconsistent with previous work suggesting possible enhancements in those who play certain types of games. The potential contribution of this null finding and an alternative explanation are discussed.

Keywords: video game play, cognitive ability, upper elementary school children

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Given the extensive amount of time many (or even most) children spend playing video games (Perrin, 2018), there has been significant interest in the potential relationship between video game play and a wide variety of behaviors (e.g., prosocial behaviors, aggression, motor skill, educational attainment, basic visual abilities, etc.). Within the domain of cognitive psychology, some theoretical perspectives have predicted a negative relation between video game play and cognitive performance, particularly in children, where cognitive abilities are still developing (Gentile et al., 2012). For instance, the "displacement" hypothesis suggests that playing video games may displace activities that would cause greater development of cognitive skills (e.g., academic work). Support for this hypothesis is reported in studies that found negative relationships between video game play time and particular cognitive skills (e.g., Gentile et al., 2012) as well as in the form of observed negative relations between video game play time and academic performance (e.g., Cummings & Vandewater, 2007; Gentile et al., 2004). While the majority of this work has been purely correlational in nature, similar outcomes have also been found in intervention studies. For instance, Weis and Cerankosky (2010) randomly assigned children who did not have a video game system to either receive a system immediately or receive a system after 4 months. At the conclusion of the 4-month period, children who received the system immediately had lower scores in reading and writing as compared to the children who had not yet received a system.

While the displacement hypothesis puts the main mechanism of action as time-substitution, and thus the type of game engaged with is not a primary concern (as long as the experiences in the game(s) are less valuable than those experiences that are being displaced for the development of the skills in question), other theoretical perspectives meanwhile more tightly link the experiences inherent in some types of games and cognitive outcomes. For instance, it has been argued that some (but not all) types of games place extreme demands (Bowman, 2018) on cognitive skills and thus those individuals who play such games should show higher cognitive task performance than those who do not play such games (typically researchers in this field make a causal argument, but the same relation would still be predicted from purely selection effects/correlational means as well). In examining these ideas empirically, researchers have frequently contrasted individuals who are avid players of "action video games" (i.e., that place heavy demands on perception and cognition; most commonly first- and third-person shooter games) with individuals who do little gaming (e.g., Dale et al., 2019; Feng et al., 2007; Green & Bavelier, 2003, 2012). The results of such extreme-groups studies (primarily conducted on college-age students) over the past 20 years have revealed a reliable medium-to-large effect (Hedge's g = 0.55) on cognitive performance (Bediou et al., 2018).

Critically though, there are reasons to believe that the magnitude of the action-video game effect depends on the age of the participants. While work in this domain is somewhat sparse (perhaps because most action games are not rated for play by individuals under 18), the little work that exists suggests that while similar trends in which action video game players outperform nonplayers are seen in adolescents and teens, an attenuated (or perhaps, even nonexistent) effect may be seen in younger children. Such a speculation is supported in the empirical work by Dye and Bavelier (2010), in which action video game players in the 11–13 and 14–17-year-old cohorts outperformed nonplayers in visual search, multiple-object tracking, and in recovery from the attentional blink in a manner consistent with the college-aged sample (18–22-year-olds). The effects in the youngest age group, 7–10-year-olds, were more equivocal.

A reduced relationship between gaming and grade point average (GPA) in very young children was also seen in the systemic review and meta-analysis conducted by Adelantado-Renau and colleagues (2019). While they did not separate the studies by game genre, they did consider 58 cross-sectional studies that focused on the relationship between gaming and GPA in children and adolescents (ages 4–18). They found that while the duration of video game playing was negatively associated with adolescents' (ages 12–18) GPA, this association was not found for the younger group of children (ages 4–11). Taken together, these results suggest the possibility of a lessened effect of video game playing on cognitive skills and academic performance in the younger student population.

Given the mixed results and scarcity of studies that focus on preteens' use of video game play and especially action video games, further investigations and study replications are much needed. The secondary dataset reported in this study allowed us to examine the relations between video game play habits and cognitive performance, including verbal, quantitative, and nonverbal/spatial cognition in a preteen population. Unlike the studies reported thus far, our study utilized a standardized cognitive ability test owing to its robustness instead of using teacher-assigned language and math grades or student-reported GPA. While cognitive ability is not synonymous with academic performance, numerous studies have indicated that cognitive ability measures have high predictive power of academic performance (Leeson, et al., 2008; Rohde & Thompson, 2007). Thus, the results obtained from our cognitive ability test are comparable to those studies focusing on academic performance such as GPA.

Study Questions

Given the different theoretical perspectives in the field to date (e.g., some that might predict a negative relation between video game play and standardized measures of spatial skills, others that would predict a positive relation between at least some types of video game play and these skills), our study sought to characterize both the overall relationship between reported duration of video game play and performance on a standardized cognitive ability test (CogAT) as well as to examine whether these relations differ if individuals are grouped into "action" and "nonaction" playing categories.

Method

This study offered a secondary analysis of a dataset that was collected in 2015 for a federally funded study that focused on upper elementary children's use of Geographic Information Systems (GIS) technologies to problem-solve historical and contemporary social studies challenges (Jadallah et al., 2017). Children's video gaming behavior survey was collected as a background measure for that study but was not analyzed or reported elsewhere.

Participants

We recruited 174 students (88 boys, 86 girls; age M = 11 years + 8 months; SD = 4.43 months) from seven fifth-grade classes in three elementary schools in a Midwestern urban public school district in the US. The study was IRB approved and included a group made up of 52% White, 32% Black, 13% two or more races, 2% Asian, and 1% Hispanic students. About 70% of the students received free or reduced-price lunch. The free or reduced-price lunch is used as an index of low socioeconomic status (SES). Working with this diverse demographic was important because a great deal of the psychology literature to date has been disproportionately made of higher-SES individuals (Henrich et al., 2010). Due to missing data, the final sample included 160 students: 78 boys and 82 girls.

Instruments

Two instruments were used for data collection: Cognitive Ability Test 7 (CogAT; Lohman, 2011) and a video game questionnaire. CogAT is a standardized evaluation tool (Lohman & Gambrell, 2012). It consists of three batteries

Table 1. Videogame genre with examples played by fifth-grade students and percentage of students who played each genre

Genre	Examples	Percent
1. Action first-/third-person shooters (AVG)	*Call of Duty Black Ops 2, Eve Dust 514, Halo 4*	13.4%
2. Action RPG/adventure	*Grand Theft Auto 5 (GTA 5)*	16.5%
3. Sports/driving	*2K16, WWE 15, Forza Horizon 2, 2K15 NBA*	17.7%
4. Real-time strategy/MOBA	No game listed for this genre	0%
5. Fighting	*Mortal Kombat, Super Smash Bros*	3.7%
6. Nonaction turn-based role playing/fantasy	*Pokémon Alpha Sapphire, Minecraft PC with Mods*	11.0%
7. Turn based strategy/life simulation/puzzle	*Sims Free Play, SimCity Societies, Monster High*	3.7%
8. Music games	*Just Dance 2015*	0.6%
9. Educational games	*Cupcakeria games at Cool Math, Animal Jam*	2.4%
10. Other	*Movie Star Planet, Roblox, Clash of Clans*	24.41%

Note. AVG = action video game; RPG = role-playing game; MOBA = multiplayer online battle arena.

that measure general reasoning abilities (verbal, quantitative, and nonverbal). Nonverbal CogAT is relatively equivalent to tasks that have been used in previous action video gaming research (e.g., see Bediou et al., 2018) to measure certain aspects of individuals' cognitive performance.

The second instrument was created by the research team and resembles the questionnaire used in previous studies by Green and Bavelier (2003). Students were asked to indicate the duration of playing video games per day and per week, to list up to six video games they played, and the game they played most (see Appendix in Jadallah, 2022). To establish the instrument reliability, we used Pearson's correlation coefficient to evaluate the consistency between the students' survey responses that were administered 2 months apart. The reliability of the question about playtime duration delivered a correlation coefficient of .66 and .64.

Video Game Genre Coding

The games children played were categorized by three coders (one of the authors and two students from the author's laboratory) independently using established genres that were previously employed to analyze cognitive effects of adults' gaming behavior (Green et al., 2012) with minor additions. These genres include action video games (AVG), action role-playing games, sports games, real-time strategy games/multiplayer online battle arena (MOBA) games, fighting games, nonaction role-playing turn-based games, turn-based strategy/life simulation/puzzle, music games, educational games, and other. Coders were simply told to "place the games in the following genre categories based upon your knowledge of the games and what defines members of the genres." The interrater reliability was quite high (kappa coefficients among the three coders ranged from .80 to .85; see Table 1). Our data can be found at https://osf.io/5wvkx/.

Results

Basic Descriptive Statistics of Student Game Play

On average, students played about 2.5 hr per day; for a total of 13 hr per week.

A total of 153 games were listed by the students. The child-themed games under the genre called "other" captured the majority of the games (24.4%); this may indicate a need to utilize different genre categories for children of this age (see Discussion). The second most played genre was sports and driving games (Genre 3 at 17.7%), followed by action role-playing game/adventure (Genre 2 at 16.5%), and Action Video Game (AVG) (Genre 1 at 13.4%). The other genres were listed by fewer students (see Table 2).

Relations Between Videogame Playtime and CogAT Scores

The displacement hypothesis predicts that negative relations would be found between playtime and CogAT scores. In contrast to this, the results indicated generally low and negative partial correlations between playtime and CogAT scores when considering playtime as a continuous variable ($r = -.032, -.056, -.104$; see Table 3). When controlling for two other CogAT scores, none of the partial correlations between playtime and CogAT quantitative, verbal, or nonverbal score was significant. Similar null results were found in an extreme-groups comparison where participants were first separated into two groups based on playtime measures using the highest (heavy) and lowest (nonheavy) quartiles The heavy players ($n = 40$) played on average 278.9 min/day ($SD = 95.8$), which is nearly 4.5 hr/day. The nonheavy players ($n = 37$) played on average 72.7 min/day ($SD = 103.7$), which is nearly 1.2 hr/day.

Table 2. Descriptive statistics of gaming profile variables on post-tech survey

	Entire sample (N = 160)		Female (N = 82)		Male (N = 78)	
Playtime	*M*	*SD*	*M*	*SD*	*M*	*SD*
Minutes per week	779.02	811.68	526.00	663.36	1,053.84	869.04
Genre played	Freq.	Percent	Freq.	Percent	Freq.	Percent
1 = Action first-/third-person shooters	22	13.4%	5	6.1%	17	21.0%
2 = Action RPG/adventure	27	16.5%	10	12.2%	17	21.0%
3 = Sports/driving	29	17.7%	10	12.2%	19	23.5%
4 = Real-time strategy	0	0	0	0	0	0
5 = Fighting	6	3.7%	3	3.7%	3	3.7%
6 = Role playing/fantasy	18	11.0%	10	12.2%	8	9.9%
7 = Life simulation/puzzle	6	3.7%	4	4.9%	2	2.5%
8 = Music games	1	0.6%	1	1.2%	0	0
9 = Educational games	4	2.4%	4	4.9%	0	0
10 = Other	40	24.4%	29	35.4%	11	12.3%

Note. RPG = role-playing game.

Table 3. Partial[†] correlations between CogAT scores (SAS[††]) and playtime (N = 160)

	CogAT Verbal	CogAT Quantitative	CogAT Nonverbal
CogAT Verbal	1		
CogAT Quantitative	.379**	1	
CogAT Nonverbal	.399**	.430**	1
Play time (min/week)	−.056	−.104	−.032

Note. CogAT = cognitive ability test; SAS = standard age score. [†]Partial correlation between play time and each CogAT score is calculated by controlling for two other CogAT scores; partial correlation between each pair of CogAT scores is calculated by controlling for the third CogAT score. [††]SAS is a normalized standard score with a mean of 100 and standard deviation of 16; it enables comparisons of the level of cognitive development of a particular student with others in the same age group. *p < .05; **p < .01.

Table 4 presents the descriptive statistics of CogAT scores by extreme group. MANOVA results showed no significant differences between heavy players and nonheavy players on CogAT scores, Wilks' λ = .982, F(3, 73) = .45, p = .71, although heavy players scored numerically lower than nonheavy players on each domain (verbal, quantitative, and nonverbal).

Extreme Groups and Separation by Action-Genre

To examine whether playtime and genre had a joint influence on CogAT scores, we grouped the 10 genres into two major categories – action and sports (Genres 1, 2, 3) – and the other genres into nonaction games. The first three genres were combined as they have some degree of overlap in terms of mechanics, cognitive load, and brain executive demands, although they are not perfectly overlapping (for further details, see Dale et al., 2020). Here we note that while sports/driving games were not, for instance, included as action video games in the recent meta-analysis by Bediou and colleagues (2018), such games have been included in some empirical papers. Additionally, as is explicitly noted in the most recent Bavelier lab questionnaire (https://www.unige.ch/fapse/brainlearning/vgq/), some genres that have not classically been included as "action games" (which in its strictest definitions has comprised just shooter games), now include action-like mechanics and can be folded into the label of action games (these include among others action–RPG, action–adventure, sports/driving).

Furthermore, while it can be argued that sports/driving games do not exert a high executive and cognitive demand on adults, this might not be the case for children and thus we chose to be more, rather than less, inclusive (noting that this decision does not meaningfully impact the pattern of results). We further compared three extreme groups (nonheavy players, heavy action players, and heavy nonaction players). MANOVA results again showed no significant difference among the three extreme groups on CogAT scores, Wilks' λ = .94, F(6, 144) = .71, p = .64. Finally, these results are consistent with a series of MANOVA tests that showed no significant differences in CogAT scores across genres, Wilks' λ = .78, F(24, 386) = 1.382, p = .11.

Table 4. Descriptive statistics of CogAT scores by genre and by extreme group

		CogAT verbal		CogAT quantitative		CogAT Nonverbal	
Genre	*N*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1 = Action first-/third-person shooters	22	56.67	21.103	51.76	18.745	51.00	23.009
2 = Action RPG/adventure	27	44.32	15.569	46.16	14.232	48.88	19.379
3 = Sports/driving	29	47.39	16.292	47.68	17.280	43.07	15.456
6 = Role playing/fantasy	18	48.41	16.035	47.94	14.648	53.76	12.214
7 = Life simulation/ puzzle	6	41.80	7.050	47.00	19.912	45.00	28.293
8 = Music games	1	28.00		39.00		46.00	
9 = Educational games	4	62.00	12.987	51.75	12.842	61.00	11.106
10 = Other	40	48.71	18.958	54.55	18.939	55.32	20.305
Extreme group							
Nonheavy players	37	50.35	17.399	52.32	17.862	53.03	19.240
Heavy players	40	47.47	17.961	47.85	16.384	50.00	21.956
Heavy nonaction players	21	49.71	18.078	47.24	15.414	53.00	24.050

Note. CogAT = cognitive ability test; RPG = role-playing game.

Discussion

This exploratory study examined the relationship between video game play and cognitive performance of an under-studied student population, namely, upper elementary diverse urban public-school children, by investigating the duration of play as well as utilizing extreme group analysis to explore the potential association between playing action video games and performance on cognitive measures. In this discussion, we first situate our findings within the existing literature; second, we offer alternative explanations to our results; third, we suggest future directions based on our study limitations; and finally, we offer an overall conclusion.

No Association

While our results indicate weak negative correlations between overall reported playtime and CogAT scores, both in the continuous and extreme groups comparisons, in none of these cases did the results reach the level of statistical significance. The results thus do not support the displacement hypothesis (Gentile et al., 2012) but are consistent with Adelantado-Renau and associates' (2019) results regarding 4–11-year-old children noting the lack of association. In their review Adelantado-Renau and colleagues (2019) point out, among other suggestions, that low-income families with a restricted budget might be limited in their capacity to buy books for their children to read or pay expenses to cover extracurricular activities; as a result, playing video games can be the most affordable out-of-school experience (i.e., game play is not necessarily displacing more "virtuous" activities in all cases). Along this same line of thinking, it is argued that depending on the content and nature of the game, some games require successful understanding of language that have the potential to increase engagement with text, which indirectly reduces the negative impact of time away from reading and other academically related activities (Ferguson, 2015; Van Schie & Wiegman, 1997).

Similarly, no significant results were observed when comparing participants who were categorized as playing more action games and children who did not play action games. While these results, particularly for the spatial skills component of the CogAT, are inconsistent with much of the adult literature (less so for the quantitative and verbal components), they are consistent with previous work that showed no action game associations in children aged 7–10 (Dye & Bavelier, 2010). Our results also seem to align with newer findings in relation to the variety of genres that children in our study played; the lack of association perhaps is explained in part by results obtained by Dale and Green (2017), who found that multigenre gamers showed lower performance on attention and cognitive measures compared to "pure" AVG players; few children in our study could be classified as pure players. As such, the null results for this particular age group might be partially explained by two factors canceling each other. The decline in academic performance due to time spent away from completing homework is possibly canceled out by the benefits gained from playing action (or a variety of) video games as indicated by the two-decade literature (Bediou et al., 2018). Another possibility is that children of this age may not be capable of truly playing most action games in a way that places significant load upon the relevant cognitive systems (i.e., that will require sufficiently precise motor abilities, higher-level understanding of game rules and patterns, etc.). Conceivably this suggestion can contribute positively to the debate regarding the impact of video game playing on young children's academic performance.

Alternative Explanations

Three other factors may be at play in explaining the overall weak-to-null results. The first involves playtime reporting. Work by Parry and colleagues (2021) indicated that self-report measures of quantity or duration of media use, primarily by adults, only moderately correlate with logged measures and rarely reflect an accurate count of logged use by either over- or underestimating duration and volume of use. Bearing in mind that number-sense is still a developing concept for preteen children (Dehaene, 2011) the accuracy of children's reporting of gameplay duration might be unreliable. While such self-report measures have been used successfully in previous work to outline relations between game play and cognitive performance (either positive or negative), and thus were found appropriate for this exploratory study, additional caution may be needed in future studies when working with very young children who may be less accurate and/or struggle with indicating their full game play behaviors accurately.

The second major factor is related to instruments used to measure the impact of video games. Intelligence tests and cognitive ability batteries tend to be paper-based and differ from the more widely used screen-based visuospatial attention and perception tasks that typically assess speed and accuracy. It is possible that some positive impacts associated with video game play are unique to screen-based assessments where stimuli are often quickly flashed (noting that the excitement hypothesis would also predict more negative relations with games for less exciting paper-based assessments). In future studies, it might be important to use screen-based and paper-based measures to establish how well they are associated in measuring the impact of video game play.

The third factor is related to video game genres. One issue to consider is how best to categorize games in the pursuit of cognitive psychology-based research questions, which is far from settled. For instance, here we included sports games with action role playing, action, and real-time strategy games, but excluded games like Minecraft and Roblox that are known to be highly spatial. Because games like Minecraft and Roblox do not fit neatly into existing genres, it makes their consideration difficult. However, future dedicated work examining these types of games (or on a new classification scheme based specifically on spatial demand) may be warranted. Indeed, many of the types of games children report playing most did not fit neatly into an existing genre (i.e., were classified as "other"). This likely reflects a combination of issues, some unique to children of the age range considered here (i.e., that children of this age play game types that are less frequently played by adults, which were the primary consideration in the scale/categorization scheme utilized by previous investigators), and some that are more universal (i.e., that many mobile/tablet/mini-games, which include a great deal of the "other games" reported being played by the children in this study, do not fit nicely into genre categories that were originally developed based on games designed for PC or consoles). Because the most rigorous possible hypotheses regarding the impact of video games and cognitive performance (or associations between video game play and cognitive performance) are at the level of mechanics, the current results thus highlight our need as a field to continue to evolve our understanding of how to best map from the games that are played to the mechanics that are inherent in those games (i.e., where "genre" has been, and continues to be, used as a way to do that mapping, but where the evolution of the game space and/or the consideration of new populations of game players – like children – may necessitate new approaches).

Limitations and Future Directions

As a single time-point correlational study, our results cannot speak to causal relations. This is particularly notable given that, as is true of all such correlational designs and especially because of the secondary nature of our analysis, there are possible confounds that can only be easily addressed via other research designs or additional data. For instance, a good portion of the games listed as being played by children in our study are rated by the Entertainment Software Rating Board (ESRB) as being highly inappropriate for this age group. As such, children who report regularly playing these games may differ from children who do not report playing these games in a host of factors other than simply game play (e.g., life experience, economic conditions, family structure, family size, child order, adult supervision each can potentially all co-vary with the amount and type of video games played by children). As such, designs that can more directly address causation are needed (ideally intervention, but in the case of potential harm, this might include various longitudinal designs). In these, more accurate measures of gameplay, although considerably more difficult to obtain/code, would provide invaluable data as well. Finally, future work would benefit from using a variety of instruments that can make more precise predictions regarding children's short- and long-term performance on academic and nonacademic tests. The null findings reported in the current study also await further replications.

Conclusion

Findings from this study suggest that playing video games by upper-elementary preteen age children has no bearing on their cognitive skills. We suggest that time spent away from doing homework is balanced by the benefits children gain from playing video games.

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Open Data
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