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The Impact of Computer Games on Cognitive Development in Adolescents

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Abstract
Computer games have become an integral part of everyday life for most adolescents, although the impact on cognitive skills is still controversial and nearly no data are available from Central Asia. This study examined the association of regular gaming with four cognitive functions (processing speed, working memory, inhibitory control and cognitive flexibility) in adolescent boys aged 13–14 years old. Sixty eighth-grade boys from a Bishkek lyceum were divided into gamers (n = 31) and non-gamers (n = 29) and assessed with four PsyToolkit tasks - Digit Symbol Substitution Test, a 2-Back task, the Stroop task and a task-switching paradigm. Sleep, school grades and physical activity were documented as controls on a short questionnaire. Independent-samples t-tests showed no significant group differences on any measure, with effect sizes ranging from d = -.03 to .21, significantly below the sensitivity of the design. Weekly hours spent gaming were not predictive of performance. The results are congruent with the sceptical side of the gaming-and-cognition literature and provide a first Kyrgyz data point to it.

Keywords: computer games, cognitive development, adolescents, executive functions, processing speed, working memory, inhibitory control, Kyrgyzstan

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Introduction

Computer gaming have gone from a fringe hobby to a daily habit for teens. The spread of phones, consoles and home computers has allowed young people to play virtually anywhere. Surveys in numerous countries have shown that everyday gaming among adolescents is somewhere between 60 and 90 per cent and boys often game more hours than girls [1, p. 66]. So many kids spend so much time gaming. The obvious question is: can gaming damage their brains?

Research has not answered this question. One type of work reports real cognitive improvements. Green and Bavelier found that action-game players are better at detecting and pursuing visual targets than non-players [2, p. 535]. In a later meta-analysis, dozens of studies were examined and indicated moderate increases in attention and processing speed in players of action-games [3, p. 92]. A major US neuroimaging experiment revealed that children who played three or more hours a day performed better on some memory and impulse-control tasks than children who did not play at all [4, p. 4]. On their own, these studies show that gaming might sharpen some skills.

A second line of work is more conservative. Controlling for general IQ, the difference between gamers and non-gamers almost vanished in Unsworth et al. [5, p. 766]. Tatlidil and Gobet took it a step further: sala When adjusting for publication bias, the average advantage of game training across multiple studies was close to zero [6, p. 122]. Working with more than 120,000 teenagers, Przybylski and Weinstein found that moderate screen use was associated with slightly better well-being than no use, while severe use was associated with worse outcomes – a curved rather than straight-line trend [7, p. 211]. Taken together these studies point to early promising outcomes that may disappear when the design is adjusted.

Three theories structure the argument. Piaget put the period from eleven on in the formal operational stage, when abstract reasoning and rule-based thinking develop [8, p. 1]. According to Vygotsky higher mental functions are developed by cultural tools. In this point of view a complex game is a modern instrument, which could mediate thinking [9, p. 39]. Other neurodevelopmental research indicates that the adolescent brain is very responsive to reward with the control system still evolving, making games with fast feedback exciting and possibly challenging for this age group [10, p. 116].

This body of study is lacking in regional and developmental diversity. Most research are done on university students or young people from North America and Western Europe. To the author's knowledge, few tests several executive functions within the same early-adolescent sample and none in Kyrgyzstan. Local teachers and parents have to make conclusions from quite different contexts when deciding how to handle screen time and gaming at home and in school.

The present study fills this gap by examining a small, tightly controlled sample of adolescent boys from Kyrgyzstan. The aim is to study the influence of computer games on the cognitive development of adolescents. Four objectives follow from this aim. The first is to compare gamers and non-gamers on four cognitive functions. The second is to test whether more hours of play relate to better or worse scores within the gamer group. The third is to check whether any group difference survives controls for sleep, school grades, and physical activity. The fourth is to turn the findings into practical advice for schools and families.

Research Methodology

Design. The study used a cross-sectional, between-subjects design. Two groups of boys, regular and non-regular players of computer games were compared on four cognitive tests. Three lifestyle variables were measured and utilized as statistical controls (sleep, school grades and physical activity). This way, any difference between groups would be tougher to explain away by these characteristics.

Participants. Sixty eighth-grade guys participated. They were all thirteen or fourteen years old and studied at the Kurmanbek Baatyr Children's Lyceum, a division of the Sapat International Educational Institution in Bishkek. The sample was exclusively male due to the structure of the school, which also removed the well-known gender gap in gaming as a source of noise. Based on a screening question on weekly playing, 31 boys were classified as gamers (five or more hours per week, with an average approaching fourteen hours) and 29 as non-gamers (less than one hour per week). Each subject was given a code from S-1 to S-60. The list associating codes with names was kept offline by the author and was never incorporated into the analysis file. Hence the data remained anonymous.

Instruments. Cognitive performance was assessed with four well-established tasks available in PsyToolkit, a free web-based platform for executing experiments and questionnaires [11, p. 1097]. We designed each exercise to assess one of the four functions under consideration. The Digit Symbol Substitution Test assesses processing speed, in which the subject replicates symbols coupled with digits as soon as possible for a specified period of time. The 2-Back task assesses working memory updating. A letter is given and the participant answers whenever the current letter matches the letter two steps back. The Stroop task evaluates inhibitory control, where the participant states the ink color of a word while ignoring the colour spelled by the word, and the slowing on mismatched trials is the interference score [12, p. 165]. The task-switching paradigm assesses cognitive flexibility. Here the subject switches between two sorting rules. The additional time required on switch trials is the switch cost [13, p. 137]. Information on age, gaming patterns, hours of sleep on school nights, grade-point average, and weekly days of physical activity was obtained using a short questionnaire based on a draft produced with the supervisor.

Procedure. Data were collected in the school during the spring semester. Prior to any testing being started, permission was acquired from the administration and consent papers were given home to the parents. First each boy completed the paper questionnaire, which took about fifteen minutes. Then he performed the four cognitive activities on a lab computer, in a single session lasting about half an hour. The chores were always in the same order. Answers to the questionnaires and test scores were kept under the same anonymous code so that the records of each boy could be linked, without disclosing his identity.

Data analysis. Prior to the main analysis, reaction-time data were cleaned by excluding trials faster than 150 milliseconds or slower than 2,000 milliseconds, as these are frequently indicative of guessing or gaps of attention. No individual lost more than fifteen per cent of trials. Independent-samples t-tests were employed for comparisons of group means. The Mann–Whitney U test was utilized as a check where distributions were skewed. Effect sizes were given as Cohen’s d, reading against the traditional benchmarks of 0.2, 0.5, and 0.8 for small, medium, and large effects [14, p. 25]. In the gamer group, correlation between Pearson and Spearman was performed to assess the relationship between weekly hours and scores and a squared term was added to test for the curved pattern predicted by the Goldilocks hypothesis. Finally, multiple regression tested if the gaming status still explained any variance after considering sleep, grades and physical activity. All analyses were conducted in SPSS.

Results

Group characteristics. The two groups were well matched on every background variable, so later comparisons are not confounded by age, sleep, school performance or exercise level. The gamers averaged almost fourteen hours a week of play time while the non-gamers averaged less than an hour, so the lines were rather clear. Table 1 provides you the whole story.

Table 1. Background characteristics and cognitive scores by group (M ± SD)

Variable	Gamers (n = 31)	Non-gamers (n = 29)
Age, years	13.39 ± 0.50	13.38 ± 0.49
Sleep, h/night	6.50 ± 0.87	6.74 ± 0.74
GPA, 5-point scale	3.36 ± 0.54	3.23 ± 0.53
Physical activity, days/week	2.04 ± 1.01	2.09 ± 1.15
DSST, correct responses	69.39 ± 10.85	67.41 ± 14.33
2-Back, hits − false alarms	28.48 ± 6.69	27.17 ± 8.27
Stroop interference, ms	80.42 ± 27.30	74.93 ± 23.34
Switch cost, ms	73.15 ± 26.46	73.85 ± 25.40

On three of the four cognitive tests the gamers had a small numerical lead, although the disparities were tiny compared with the spread within each group. Also note the direction: for the Stroop task a bigger interference score is worse, so the gamers' higher result of 80.42 ms is a small disadvantage rather than an edge.

Group comparisons. None of the four differences was statistically significant. t-statistics, p-values and effect sizes are shown in Table 2. All effects were minor by Cohen's criterion (d = -0.03 to 0.21) and all p-values were far above 0.40.

Table 2. Independent-samples t-tests and effect sizes

Measure	t	p	Cohen's d
DSST correct	0.60	.548	0.16
2-Back hits − false alarms	0.68	.501	0.17
Stroop interference	0.83	.412	0.21
Switch cost	−0.12	.906	−0.03

These statistics put in perspective using a power check. There were around thirty boys each group, and the design was only sensitive to effects of d=0.74 or greater. Actually the differences identified were three to four times less, so the honest reading here is that there is no large effect, not that there could never be an effect of any size.

In the gamers group. More play didn't lead to better scores. " Weekly hours were weakly correlated with each cognitive measure ($r = -0.08$ to 0.25) and none were significant (all $p > .15$). Nothing changed when we included a squared term to test the curved Goldilocks pattern – those terms weren't significant either (all ps > .25). When sleep, GPA, and physical activity were incorporated in a regression with gaming status, the lifestyle variables explained whatever little incremental variance was found, with no contribution from gaming status (all ps > .35).

Absolute performance against international norms. Without Kyrgyz norms for these tasks, the raw scores are worth reading in their own right, not just as a group comparison. The sample averaged 68.4 accurate responses on the DSST. This is within the range of 55 and 80 reported for Western thirteen-year-olds. The hit rate on the 2-Back of 55–57 per cent was lower than the 75–80 per cent reported by Pelegrina and colleagues for the same age in a large European sample [15, p. 1547]. Nevertheless, false alarms still were low at about 5.5, indicating a cautious, speed-first strategy rather than a real weakness of memory. Both the Stroop interference (77.8 ms) and the switch cost (73.5 ms) were lower than the typical ranges for adolescents (80–120 ms and 80–140 ms, respectively), approaching adult performance. So, in a nutshell, this group had good inhibitory control and flexibility, only working memory was a little bit soft.

Discussion

The main finding is straightforward: in these boys, regular gaming was not detectably associated with processing speed, working memory, inhibitory control or cognitive flexibility. This places the study on the skeptical side of the argument. It sits comfortably alongside Unsworth et al.'s gamer advantage vanishing when IQ was adjusted [5 , p. 766] and the corrected meta-analysis of Sala, Tatlidil and Gobet where the average training benefit shrinks towards zero [6 , p. 122]. This is not in agreement with the more positive image drawn by Green and Bavelier [2, p. 535] or the recent neuroimaging results of Chaarani and colleagues [4, p. 4].

What difference? There are four explanations that seem worth considering. The first one is statistical power. With thirty boys in each group, the study could only detect rather big effects, thus a real but modest benefit could easily have gone undetected. The second is age. The boys may just be too young at thirteen or fourteen for the gaming benefits to build up; studies indicating advantages are frequently with older or longer-exposed gamers. The third is genre. The sample played a variety of titles and only a portion of it was the fast-paced action games most commonly linked with cognitive advances, so any genre-specific effect would be diluted. The fourth is location. Almost all favorable findings are from Western samples and whether they even translate to a Kyrgyz school is an unresolved subject.

One thing in the data warrants a second look. Lifestyle variables, including sleep and grades, explained more of the variation in test scores than did gaming status. It's a quiet but helpful reminder that for everyday cognitive performance in this age range, how a teenager sleeps and studies may be more important than whether he games.

The findings have some practical messages. So what's the bottom line for teachers? It's not alarm, it's knowledge. These facts do not justify a blanket ban on gaming, but they do support getting kids to pay attention to sleep and to have solid study habits. The broader literature backs moderation, a shared understanding of what their sons are playing, and a screen-free hour before bedtime as sensible actions for parents to take. For the boys themselves, a good rule of thumb is to monitor how much time they are playing and not let games eat into sleep or other activities.

The study has major limitations. Since it is cross-sectional, it cannot demonstrate cause and effect. The sample is limited, from one school and all male which limits how far the results travel. . Playtime was self-reported, which is easy but dirty. And the design didn't segregate genres or screen for problem gaming, both of which could matter.

These bounds suggest future work directly. A larger Kyrgyz study – two or three hundred participants from multiple schools, including girls – would have the power this one lacked. Following the same kids over two or three years would allow researchers to see change rather than a one-off snapshot. You may separate players by genre and add a quick screen to identify issue gaming. This is the kind of undertaking that would make a good PhD thesis or multi-institutional collaboration.

Conclusion

This study explored the relationship between regular computer gaming and four cognitive functions in sixty eighth grade Kyrgyz males and found no statistically significant relationship. The differences between gamers and non-gamers were modest and statistically unconvincing and more hours of play didn't transfer into higher or poorer scores. In absolute terms boys had excellent inhibitory control and flexibility but a softer profile on working memory. This work provides a first school-based data point on gaming and cognition from Kyrgyzstan, demonstrates how difficult it is to capture typical gaming effects in a study of this size, and indicates that sleep and school habits deserve at least as much attention as gaming when adults think about adolescents' thinking skills.

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Компьютердик оюндардын өспүрүмдөрдүн когнитивдик өнүгүүсүнө тийгизген таасири

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Аннотация
Компьютердик оюндар бүгүнкү күндө өспүрүмдөрдүн басымдуу бөлүгүнүн күнүмдүк жашоосунун бир бөлүгү, бирок алардын ой жүгүртүүгө тийгизген таасири талаштуу бойдон калууда, ал эми Борбордук Азиядан маалымат дээрлик жок. Изилдөөдө үзгүлтүксүз оюн ойноо 13–14 жаштагы эркек балдардын төрт когнитивдик функциясы — маалыматты иштетүү ылдамдыгы, иштеп жаткан эс, тормоз контроль жана когнитивдик ийкемдүүлүк — менен байланышабы деген суроо текшерилди. Бишкектеги лицейдин алтымыш сегизинчи класс окуучусу оюнчуларга (n = 31) жана оюн ойнобогондорго (n = 29) бөлүнүп, PsyToolkit платформасынын төрт тапшырмасы менен текшерилди: цифраларды символдор менен алмаштыруу тести, 2-Back тапшырмасы, Струп тести жана тапшырмаларды которуштуруу парадигмасы. Кыска анкета уйку, окуу жетишкендиги жана дене активдүүлүгүн көзөмөл өзгөрмөлөрү катары каттады. t-критерий эч бир көрсөткүч боюнча топтордун ортосунда олуттуу айырмачылыкты тапкан жок; эффект өлчөмдөрү d = -0,03төн 0,21ге чейин болуп, дизайндын сезгичтик чегинен бир топ төмөн. Оюнчулардын ичинде оюн сааттарынын саны натыйжаны болжолдогон жок. Алынган маалыматтар адабияттагы скептикалык багытка дал келип, ага биринчи кыргыз чекитин кошот.

Ачкыч сөздөр: компьютердик оюндар, когнитивдик өнүгүү, өспүрүмдөр, аткаруучу функциялар, маалыматты иштетүү ылдамдыгы, иштеп жаткан эс, тормоз контроль, Кыргызстан

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Влияние компьютерных игр на когнитивное развитие подростков

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Аннотация
Сегодня компьютерные игры являются частью повседневной жизни большинства подростков. Однако исследования, проведенные в Центральной Азии, показывают, что их влияние на мышление остается спорным. В исследовании было проанализировано, связана ли регулярная игра с четырьмя когнитивными функциями у мальчиков в возрасте от тринадцати до четырнадцати лет: скоростью обработки информации, рабочей памятью, тормозным контролем и когнитивной гибкостью. Шестьдесят учеников восьмого класса Бишкекского лицея были разделены на группы, состоящие из играющих (n = 31) и неиграющих (n = 29). Они также прошли тестирование четырьмя заданиями PsyToolkit: тестом замены цифр символами, заданием 2-Back, тестом Струпа и парадигмой переключения задач. Короткая анкета определила контрольные переменные в виде сна, успеваемости и физической активности. Ни по одному показателю t-критерий не обнаружил значимых различий между группами; размеры эффектов составили d = -0,03 до 0,21, что значительно ниже порога чувствительности дизайна. Число часов игры в группе не предсказывало результат. Данные, полученные, не только согласуются со скептическим направлением литературы, но и добавляют первую кыргызскую точку.

Ключевые слова: компьютерные игры, когнитивное развитие, подростки, исполнительные функции, скорость обработки информации, рабочая память, тормозный контроль, Кыргызстан