The Impact of Video Games on Attention Span and Working Memory Retention in Underprivileged Adolescents: Preliminary Findings

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Abstract

Background: Video games, especially action games, has become increasingly prevalent among adolescents, with studies indicating potential cognitive benefits, particularly on attention and working memory. However, the effects of video gaming on underprivileged teenagers remain underexplored, despite the unique cognitive challenges they face due to their level of exposure, level of cognitive abilities, and socioeconomic factors.

Objective: The present study aimed to evaluate the effects of action video games on attention span and visual working memory retention among underprivileged adolescents. By comparing cognitive performance between those exposed to action games and those in a control group, as well as a sub-group analysis into the difference between older (16-18) and younger groups (13-15), we sought to determine if gaming could enhance cognitive functions in this population, and whether age has any significant factor to play in memory and attention scores.

Methods: A sample of 100 adolescents aged 13-18 from the Panaah Communities Center in Maharashtra, India, was divided into control (n=50) and experimental (n=50) groups. The experimental group engaged in a 20-minute action game before completing two assessments: the Continuous Performance Test (CPT) to measure attention and the Visual Pattern Test (VPT) for visual working memory. Each day, the experimental and control groups sat for different tests to ensure reliable results. Statistical analyses were conducted to compare group performances and assess age-related differences. T-test Assuming Unequal Variance and the Mann-Whitney U Test were utilized to measure statistical significance. Cohen's d was applied to all variables to ensure real-life applicability through effect size.

Results: The experimental group scored higher than the control group in both attention (CPT: M = 79.028, SD = 32.0; p = 0.034) and working memory (VPT: M = 77.019, SD = 51.5; p = 0.026), suggesting that video game exposure had a positive effect on cognitive functioning. Further analysis revealed minimal age-related differences in cognitive outcomes. High variability in responses, especially among those in the experimental group, highlighted the influence of individual baseline characteristics inherently present in the population.

Conclusions: The findings indicate that action video games can enhance attention and visual working memory in underprivileged adolescents, though individual differences must be considered. These results emphasize the potential for video games as supplementary cognitive training tools in the classroom, especially for those who have cognitive deficits or trouble learning in normal, peer-group settings.

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Literature Review

Due to technological advancements and gaming accessibility in today's generation of teenagers, the mean age of a gaming addict is 24 years of age (Hoffman and Miller). About 97% of adolescents aged 12-17 play some sort of online game, whether that be through websites, computers or consoles (Lenhart et al.). 8% of minors worldwide are addicted to gaming (Hoffman and Miller). It is no surprise, therefore, that there is a growing interest in the effect that video games have on the cognitive processes and abilities of adolescents, specifically attention and working memory, the two main components of cognitive functioning (Center for Excellence in Teaching and Learning). 57% of teenagers regularly choose action games over other games due to the fast-paced nature, visually stimulating surroundings, and high-stakes that action video games offer young gamers (Shah). This study investigates the extent to which action games improves attention span and visual working memory retention in underprivileged adolescents, a population usually overlooked in cognitive research.

Attention is the ability to focus on a specific stimuli and block out other environmental distractions (Posner and Peterson), while working memory is the process of retaining information and memory for a short period of time for quick retrieval (Cowan). Both attention and working memory are crucial for everyday cognitive processes such as learning, problem-solving and reasoning, forming the neural basis of higher-order thinking (Center for Excellence in Teaching and Learning).

Visual Working Memory (VWM) is a specific type of working memory and is an important part of cognitive processing (Asp et al.). Visual short-term memory (VSTM) is crucial in processing and retaining visual information (such as object color and spatial location (Luck)). Visual long-term memory (VLTM) is the cognitive process of storing visual information for extended periods of time (Friedman et al.). These cognitive functions use two main neural pathways; ventral and dorsal (Zhan et al.). The ventral pathway leads up to the temporal lobe of the brain, and is responsible for identifying objects in a given sequence (such as recognizing that an object is an eraser) (Righi and Vettel). The dorsal pathway is part of the occipital lobe, where it analyzes the spatial relationships and placements of objects (recognizing that the eraser is pink, and the third object in the sequence) (Rehman and Khalili).

Prolonged exposure to action games can result in adolescents developing a state of hyperarousal, with symptoms such as heightened emotions, increased alertness, and angry outbursts, symptoms commonly associated with post traumatic stress disorder (PTSD). While hyperarousal can be linked to enhanced focus and reduced reaction times, it can also result in loss of impulse management and anxiety (Santos et al.).

However, video games do not have an overall negative effect on cognitive functions. In fact, in a study supported by the National Institute on Drug Abuse, the results showed that children who play video games for up to three hours daily perform better on cognitive tasks than the controlled group (NIH). This finding challenges popular belief that video games have purely detrimental effects on mental health and cognition in adolescents. However, much of the existing research has focused on general adolescent populations, leaving a gap in our understanding of how video games may impact adolescents from underprivileged backgrounds, who may have different baseline cognitive abilities and environmental stressors.

In the context of underprivileged adolescents, the cognitive processes are a lot more complicated. In fact, Hackman et al. concluded that childhood socioeconomic status (SES) “influences neural development”, and families with low SES typically entail worse health, and reduced cognitive and emotional development due to issues such as stress, low quality resources, less access to educational resources and more (Hackman et al.). These findings make the study even more relevant, as their lack of resources for cognitive training can help us understand if short term, one-time cognitive tests and exposure can create a noticeable short-term impact, encouraging further studies to administer more long-term solutions.

Current study and Aim

The aim of this study is to investigate the impact that video games have on cognition, specifically attention span and working memory, in underprivileged adolescents. By administering, the investigation will establish a relationship between video games and cognitive enhancements. Based on prior research (e.g., [cite 2-3 studies]), our hypothesis is that attention and working memory scores will be associated with video game exposure/experience.

Methodology

Participants

The sample consists of 100 students from Panaah Communities Center for Vocational Skills (PCCVS), Maharashtra India. The participants were divided into two groups. The control group (n=50) did not play any video games, and the experimental group (n=50) played video game while
Both groups had the same gender ratio (25 boys, 25 girls), and the age range was 13-18 years of age. Due to the stimuli involved with the experimental group, an available guardian for the children was contacted. All students from PCCVS were encouraged to join if they met the age criteria.
Students were categorized as ‘older teens’ or ‘younger teens’ based on their age ranges. If a student was above 16 years of age, in the context of the experiment, they were considered an ‘older teen’ . Anyone below 16 was labeled as a ‘younger teen ’ or ‘O’ and ‘Y’.

Variable	Young teens	Older teens	Statistics
Age range	13-15 years (n=51)	16-18 years (n=49)	*(Younger Teens)* M: 14.529 SD: 0.504 *(Older teens)* M: 16.490 SD: 0.505
Group	Control (n=25) Experimental (n=25)	Control (n=25) Experimental (n=25)	n=100

Guardian Contact and Signature Forms	Required for all participants

Ethical considerations

All adolescents participating in the study were given consent forms at Panaah Community Centre-Ganj Peth that required signatures from their legal guardians or supervisors. The form detailed the purpose of the study, their rights, ensured confidentiality and how the data collected will be used. Participants were given an opportunity to opt-out of the study at any time they wanted, and were also given freedom to withdraw from specific tests without negative consequences. Finally, the organization's manager was present at all times to monitor the teens' subtle body language that might indicate unease with the analysis, in which case they were withdrawn.

Tools used

The tools used to measure and collect data were the following:
All experimental participants were given an iPad with the video game (Galaxy Arcade Shooting Game) loaded, and were timed with 15 minutes of exposure.
The CPT and VPT tests were administered on the tablet, but results and answers were recorded and scored with paper and pencil.

- A Continuous Performance Test (CPT; (Roebuck et al.).) was used to measure sustained attention. This test asks questions over a long period of time (15 minutes- mention time duration) to test the users' sustained attention span with different stimuli (verbal and nonverbal stimuli, noting the percentage outcome accuracy).
- Visual Pattern Test (VPT) is utilized to understand the extent of short term working memory. Specifically, this test gives participants a pattern of shapes that they recall and recreate from memory (McInerney).

The percentage of correct answers for both the CPT and VPT were used as outcome measures for each individual, further used for analysis.

Experimental Conditions

1. **Experimental Group** – Participants (n=50) completed the action video game intervention before taking the CPT and VPT.
2. **Control Group** – Participants (n=50) completed the CPT and VPT with no prior game exposure.

Data collection procedure

Data collection was conducted at PCCVS over a four-day period with a sample size of 100 participants (n=100). Each day, 50 participants were assigned and further subdivided into groups of 5 for logistical ease. Before starting, all members had to complete a form with their name (all members completed the form, and any identification was removed in data processing), age and gender .

On the first two days, the experimental group (n=50) engaged in the intervention. Each participant was provided with a designated tablet equipped with both an action video game and the CPT software (adapted from *Millisecond.com*). Participants first played the action video game for five minutes. After a one-minute break, they completed the CPT to assess attention span. This process was repeated for the remaining 45 participants within the experimental group. On the second day, the same experimental group participants returned, repeating the sequence, but this time engaging with the VPT on the tablets instead of the CPT.

The final two days were for the control group (n=50), which was also subdivided into groups of 5. On the third day, the control group participants completed the CPT on designated tablets without prior exposure to the action game. This process was repeated across all control group sub-cohorts. On the fourth day, control group participants returned and performed the VCT.

The percentages of each participant's scores in the VPT and CPT were calculated and recorded in an Excel spreadsheet.

Statistical Analysis

The study analyzed the effects of action video game exposure on the cognitive performance of underprivileged adolescents, examining sustained attention and visual working memory using the Continuous Performance Test (CPT) and the Visual Pattern Test (VPT). Data were stratified by experimental conditions (control and experimental groups) and age categories (older and younger teens) to create a nuanced analysis in cognitive outcomes. Descriptive statistics such as mean (M), median (MD), standard deviation (SD), and range were used to describe group performance distributions. Inferential statistics employed to assess the significance and reliability of the recorded differences.

Variable		Control *(n=50)*	Experimental *(n=50)*	Group Comparison Statistics	Effect Size (Cohen's d)
CPT*	M	77.232	79.028	*t(97)=1.848*	0.056
	MD	76.75	78.8	*p=0.034*	
	SD	32.5	32	*t Crit= 1.661*	
	Range	4.669	5.043		
VPT*	M	74.056	77.019	*T (93)= 1.961*	0.064
	MD	73.75	77.3	*p=0.026*	
	SD	40.2	51.5	*t Crit= 1.661*	
	Range	6.643	8.366		

Variable		Older teens *(n=50)*	Younger teens *(n=50)*	Group Comparison Statistics	Effect Size (Cohen's d)
CPT	M	78.610	77.669	*U*= 1318.0	-0.18
	MD	78.1	77.2	*p*=0.909	
	SD	5.275	4.554		
	Range	34	24.4		
VPT	M	75.142	75.917	*U*= 629.5	-0.06
	MD	74.8	75.5	*p*= 0.973	
	SD	7.089	8.227		
	Range	46.6	51.1		

Note. To compare cognitive performance between control and experimental groups, CPT scores with normal distribution were compared using independent samples *t*-tests assuming unequal variance, while VPT scores with non-normal distribution were compared using the non-parametric Mann-Whitney *U* test. Statistical significance was determined without corrections for multiple comparisons; M = Mean; MD = Median; SD = Standard deviation; ES = Effect size (Cohen's *d*); * = statistically significant difference at $p < .05$.

Continuous Performance Test (CPT)

In the CPT, which measures sustained attention, participants in the experimental group (M = 79.028, SD = 32.0) showed a somewhat higher average score than those in the control group (M = 77.232, SD = 32.5). This reflects sustained attention. This trend was supported by the median scores, with the experimental group reaching a median (MD) of 78.8 compared to 76.75 in the control group.

Though the differences in the M and MD values between the control and experimental group are not significant, the two-sample independent t-test assuming unequal variance showed that there is a statistically significant difference between the groups, (t(97)= 1.848), (p=0.034). These values indicate that video game exposure had a measurable effect on sustained attention. The effect size, calculated using Cohen's D (d = 0.056), suggests a small but present impact the results could have. This aligns with the previous findings discussed above, that state that short-term, immersive action games can enhance cognitive attention to a certain extent.

The standard deviations were comparable across groups (control SD = 32.5, experimental SD = 32), suggesting a similar degree of variability in attention scores within each condition.

However, the experimental group displayed a slightly greater range of scores (5.043) compared to the control group (4.669), implying that while the intervention had an overall positive effect, individual responses to gaming exposure varied based on specific circumstances. This increased range might reflect differential engagement levels or baseline cognitive differences that influenced how much video games improved each individual participants' CPT score.

Visual Pattern Test (VPT)

The VPT assesses visual working memory. Here, the experimental group showed a higher mean score (M = 77.019) than the control group (M = 74.056), with medians following a similar pattern (experimental MD = 77.3, control MD = 73.75). The experimental group's standard deviation was higher (SD = 51.5) than that of the control group (SD = 40.2). This shows a higher variability in performance among those exposed to video games, similar to the CPT performance.

A two-sample t-test assuming unequal variances compared VPT scores between groups and showed statistical significance ($t(93) = 1.961$), ($p = 0.026$), concluding that action game exposure can enhance working memory retention. With Cohen's d as 0.064, the effect size was small, suggesting that while the impact of gaming on VPT performance was statistically detectable, the impact it can have in practical settings can be explored further.

The differences in the experimental group's scores, along with a wider range (experimental range = 8.366, control range = 6.643), underscores the variability of impact that each individual faced with their VPT results, indicating differences in cognitive capacity differences and grasp on the task at hand. The pattern of increased dispersion within the experimental group aligns with prior studies suggesting that cognitive responses to gaming may be heterogeneous, especially among adolescents.

Age-Based Stratification: Older Teens vs. Younger Teens

Further sub-group analysis by age showed that older teens scored marginally higher on the CPT (M = 78.610, MD = 78.1) compared to younger teens (M = 77.669, MD = 77.2), even though the difference was not statistically significant, ($U = 1318.0$), ($p = 0.909$).

Similarly, on the VPT, older teens exhibited a mean score of 75.142 with a narrower range (46.6) in comparison to younger teens, who had a mean score of 75.917 and a range of 51.1. This lack of significant difference in CPT and VPT scores between age groups, with p-values above the threshold for significance ($p > 0.05$), suggests that age did not significantly impact the effect of gaming on attention and working memory within the study's age range of 13-18 years.

Discussion

The current study aimed to understand the influence of brief exposure to action video games on sustained attention and visual working memory in underprivileged adolescents, using the Continuous Performance Test (CPT) and Visual Pattern Test (VPT) as primary cognitive measures. Statistical analysis of these tests reveals findings that align with previous research suggesting that video game exposure can positively impact specific cognitive functions. However, the data also highlight individual variability, especially amongst those in the experimental group, suggesting that the cognitive benefits of gaming exposure may be influenced by unique baseline abilities and engagement levels.

Continuous Performance Test (CPT)

The results from the CPT showed a statistically significant difference between the experimental and control groups, with the experimental group achieving a slightly higher average score (M = 79.028, SD = 32.0) compared to the control group (M = 77.232, SD = 32.5). Although the mean and median scores between groups differ to a small extent, the significance level (p = 0.034) suggests that action game exposure has a measurable effect on sustained attention. Cohen's d, while small (0.056), indicates a small yet significant improvement in attention span among participants who played action games.

The comparable standard deviations between the two groups indicate that the variability in attention scores was similar across both conditions, meaning that while gaming had an impact, the degree of effect was consistent across most participants in each group. However, the experimental group exhibited a slightly wider score range (5.043) compared to the control group (4.669), indicating more variability in individual responses to the gaming intervention.

This could imply that while some participants' attention scores increased, others may have experienced a lesser magnitude of cognitive enhancement, potentially due to personal factors such as baseline attentional capacity, familiarity with gaming, or overall engagement with the task.This trend aligns with previous findings, which have documented that short-term, immersive gaming interventions can enhance attention and long-term focus to a certain extent but may not impact all individuals uniformly.

Visual Pattern Test (VPT)

In the VPT, participants in the experimental group again demonstrated higher scores (M = 77.019, MD = 77.3) compared to the control group (M = 74.056, MD = 73.75). The two-sample t-test revealed statistical significance (p = 0.026), supporting the hypothesis that gaming exposure enhances visual working memory retention. Although the effect size was small (Cohen's d = 0.064), this finding provides evidence of a cognitive benefit, due to the visuospatial demands that action video games had on the players, which could improve their ability to retain and manipulate visual information over short, measured durations.

However, the higher standard deviation in the experimental group (SD = 51.5) compared to the control group (SD = 40.2) shows high variability in responses among those exposed to video games. This dispersion in VPT scores suggests that video game exposure may enhance visual working memory differently depending on individual characteristics, as seen in the CPT. The wider score range in the experimental group (8.366) relative to the control (6.643) can suggest baseline cognitive or environmental differences affecting each participant's capacity for VWM retention.

Age-Based Sub-group Analysis: Older Teens vs. Younger Teens

Further age-based analysis revealed slight differences in cognitive outcomes between older and younger teens, though not statistically significant, older teens demonstrated marginally higher mean (M = 78.610) and median (MD = 78.1) CPT scores compared to younger teens (M = 77.669, MD = 77.2). However, the p-value is non-significant (p = 0.909). A similar trend was observed in the VPT, where older teens scored a mean of 75.142 and showed a smaller range (46.6) compared to younger teens (mean = 75.917, range = 51.1). These results indicate that age did not significantly impact the effects of gaming on attention and working memory within the age range of 13-18 years in this study.

The absence of significant age-related differences suggests that gaming's effects on cognitive measures like attention and working memory may apply broadly across this adolescent range. While other factors such as cognitive maturity or life experience could theoretically influence responses to cognitive tasks, the current data indicate that short-term video game exposure might exert similar cognitive effects regardless of specific age subgroups within adolescence.

Overall Implications and Future Directions

The findings from this study underscore the potential for action video games to enhance attention and visual working memory in underprivileged adolescents, though variability based on individual differences must be accounted for. The small effect sizes observed in both the CPT and VPT suggest that while gaming has a statistically detectable impact on cognitive functioning, the practical significance of these results may be limited without further, long-term intervention. The variability in responses, especially in the experimental group, show the importance of considering individual baseline characteristics

The results of this study will give way to new insights into neuroeducation techniques to support cognitive development in under-privileged communities. The cognitive effects observed here suggest that video games could be a viable supplementary tool for cognitive training, particularly in resource-limited settings, but further work is needed to explore whether prolonged gaming exposure or diverse game types might yield more pronounced cognitive improvements. Additionally, considering factors such as baseline attentional capacity and previous exposure to gaming could help clarify the contexts in which video games may be most beneficial for cognitive enhancement in adolescents.

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