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A Study of Video Game Influences on Memory and Attention

Duggi Sridevi[1]*, Dr. Rashmi Saxena[2]

[1] Research Scholar, University of Technology, Jaipur, Rajasthan, India

Email: sridevi.duggi@gmail.com

[2] Professor, Department of Psychology, University of Technology, Jaipur, Rajasthan, India

Abstract- This study delves at the ways in which video games impact memory and attention, specifically looking at how gaming can impact cognitive abilities that are crucial for everyday tasks and learning. We can't imagine life without ICTs, or information and communication technologies. Video games and other technological advancements have gained immense popularity among both younger and older generations. Both the video game business and research into how gaming affects people's lives have grown substantially in recent years. This study takes a look at research on the potential benefits of video games for cognitive development, specifically looking at memory & attention training, and particularly at a new approach to teaching VWM using video games. The effects of various video game genres on these cognitive domains and their potential practical implications are investigated in this study by reviewing and analysing current studies.

Keywords- Video game, Memory, Attention, Visual Working Memory

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INTRODUCTION

The rapid growth of video gaming as a popular form of entertainment has led to increasing interest in understanding its effects on cognitive functions, particularly memory and attention. Video games are no longer viewed solely as a recreational activity; they are now recognized as complex, interactive environments that engage multiple cognitive processes simultaneously. As such, researchers are exploring how playing video games may influence key cognitive abilities like memory retention, recall, and attention control.

Memory and attention are essential for learning, problem-solving, and adapting to new environments. Attention allows us to focus on relevant stimuli while ignoring distractions, and memory helps us store and retrieve information for future use. Video games, especially those that require quick thinking, decision-making, and strategy, create a dynamic context in which these cognitive functions are constantly engaged. Action and strategy games, in particular, have been found to enhance certain types of attention, such as sustained and selective attention, while also improving aspects of working memory.

However, questions remain about the extent and nature of these effects. While some studies suggest that gaming can lead to significant cognitive improvements, others caution that the overstimulation of certain attention networks may come at a cost, potentially affecting memory retention and the ability to focus on tasks requiring prolonged concentration. This duality highlights the need for a deeper investigation into the specific conditions under which video games influence memory and attention.

In this research, we look at how video games can teach people to improve their Visual Working Memory (VWM). This method is backed by two primary bodies of research. To start, a lot of research has focused on how different people's visual attention systems interact with their unique variations in visual word recognition (VWM). Secondly, there is a growing corpus of evidence from the previous several decades indicating that playing video games improves a variety of cognitive capacities, including attentional and perceptual abilities. The purpose of this literature review is to summarise the findings from studies that have investigated the potential of video games to aid in the maturation of intellectual capacities. The effects of training with video games on attention and memory are the primary topic of this article.
At UCR's Brain Game Centre, Deveau et al. (2015) created a video game with a space theme and a 3D environment. Considering that two pertinent areas of study have achieved major strides in the field of brain training:

- Investigating unintended advantages of mass-produced video games
- Converting typical mental exercises into educational opportunities

Researchers said the best results come from combining memory systems, brain plasticity, & modern game design. The game's usefulness in exercising working memory has been enhanced by incorporating design ideas from Perceptual Learning (PL) and Computer Science. Incorporating n-back duties into the game dynamics is how they accomplished this. An n-level cognitive challenge and other gaming difficulties, including impediments, are used to make levels harder as the player progresses through them. Players are expected to be more invested in the game due to their ability to manage their surroundings, even though the game is becoming increasingly challenging and focussing on more components than the traditional n-back. The game also takes inspiration from PL, which aims to train players using their multiple senses (sight, hearing, and touch), coordinate the use of these elements, and shape the player's attention and reinforcement for optimal learning.

Researchers Ballesteros et al. (2014) measured the effects on a variety of cognitive abilities related to ageing & participants' subjective well-being after twenty-one-hour training sessions using games selected from the online cognitive training platform Lumosity. Forty elderly people in good health agreed to take part in the research. Each participant was randomly assigned to one of two groups: the experimental group and the control group. A battery of neuropsychological assessments was administered to all subjects both prior to and following the intervention. Over the course of ten to twelve weeks, the experimental group participated in 21-hour training sessions using ten different Lumosity video games. Cognitive abilities, focus, speed, executive function, spatial working memory, episodic memory, & subjective health were evaluated. Controlled processing, attention, and both short-term and long-term memory were all areas where the experimental group outperformed the control group.

A study comparing the cognitive capacities of gamers and non-gamers, including memory, was carried out by Boot et al. (2011). Eleven heavy gamers (participants who have averaged seven or more hours of playtime per week during the past two years) and ten casual gamers (those who play an hour or less per week) took part in the poll. Researchers found that specialists exhibited superior fundamental cognitive abilities, including enhanced visual short-term memory and the ability to reliably detect changes to stored things.

In a double-blind randomised controlled trial, Nouchi et al. (2013) tested two popular video games—Brain Age for brain training and Tetris for puzzle solving—to see whether playing video games improved cognitive functions and, if so, whether the types of video games had different beneficial effects. The experiment included 32 people who played either Brain Age or Tetris, with each group given an equal chance of playing. Based on research showing that it improves cognitive abilities, Brain Age has quickly become one of the most played brain games ever made. Each video game training session lasted four weeks, and individuals were required to practice for at least five days straight in either Brain Age or Tetris. The players logged around fifteen minutes of gameplay time on the video game every day of training. Both prior to and following training, cognitive function assessments were carried out. All participants underwent a battery of behavioural and neuropsychological assessments on the initial day of instruction (pre). A battery of behavioural & neuropsychological tests was administered to all subjects again four weeks following training (post). Research shows that playing games designed for the brain improves cognitive abilities involving working memory & processing speed, while playing Tetris improves visual-spatial ability and attention.

In 2015, Clemenson et al. looked into the possibility that playing video games could enhance hippocampal-associated memory by simulating different environments. Video games are thought to have the potential to affect hippocampus function due to their visually exciting virtual worlds. They wanted 39 people who identified as video gamers and 29 people who identified as non-gamers to take part in the study. Gamers who like more difficult 3D games outperformed those who prefer simpler 2D games on a tough recognition memory exercise, according to the results of experiment 1. A two-week training session using the 3D video game Super Mario 3D World improved participants' mnemonic discrimination ability, according to the second trial.

It follows that playing video games may stimulate the brain with meaningful input.

Research by Colzato et al. sought to determine whether and how much cognitive abilities may be enhanced by playing video games. Separated into two groups, there were 26 individuals with extensive experience in video games (VGPs) & 26 players with less or no experience (NVGPs). Standard Progressive Matrices (SPMs), the N-back, and the stop-signal task were all administered to the participants. While both VGPs and NVGPs had similar stopping efficiency, the results demonstrated that VGPs exhibited quicker reaction times and better working memory accuracy.

In order to find out how various learning strategies required by different types of games affect episodic memory—which involves the hippocampus and the caudate nucleus—and the ability to memorise a sequence of actions from a starting point—West et. al. (2018) performed three independent experiments. Neuroimaging scans of the brains of all subjects were performed. Their findings provide more evidence that people's innate navigational strategies are crucial to the experience-dependent hippocampal alterations. People who are able to

encode landmark relationships on their own will employ spatial learning procedures, which causes their hippocampus to grow in a way that is dependent on their experiences. When compared, even if spatial learners are presented with the same amount of environments and the same demands on their gaming, response learners exhibit a decrease in hippocampal grey matter and do not make use of the connections between landmarks.

Using active control groups, training activities, and several tests, Baniqued et al. (2014) aimed to ascertain whether engaging in casual video game play could improve cognitive training. A total of 209 healthy adults (varying in age from 18 to 30) were enrolled in the study. These participants reported spending no more than three hours weekly on gaming (video or board games) and had no major health problems in the preceding six months. They were divided into four groups according to random assignment: one for working memory and reasoning games, one for adaptive working memory and reasoning, one for active control casual games, and one for a no-contact control group. On top of that, participants had ten training sessions, each lasting twenty minutes, and those sessions happened twice or three times weekly. The five areas that made up the cognitive evaluation were working memory, reasoning/fluid intelligence, attentional control, perceptual speed, and episodic memory. Results showed that playing casual games can improve cognition, but only to a limited extent on tasks that were already fully acquired. Working memory and concentration did improve, though.

Action Video Games

The function of video game genre in cognitive enhancement was investigated by Dobrowolski et al. (2014). Specifically, they were able to do this by conducting a study that contrasted the cognitive capacities of FPS & RTS players. The study's ninety participants were evenly distributed among three groups. game players, players of real-time strategies, and a control group that does not play video games (NVGP). There seems to be genre-specific variation in the beneficial effects of action video games on the dynamic component of executive functions and visual attention. Task switching & Multiple Object Tracking (MOT) were areas where real-time strategy players outperformed non-gamers. When compared to first-person shooter players, real-time strategy players exhibited a slight edge in MOT performance. Even while FPS players had lower switch costs on a trend level, they still couldn't beat NVGPs at MOT.

The hypothesis that alterations in the systems that regulate the allocation & efficiency of attention are responsible for the enhanced attention experienced by action game players was investigated by Baavelier et al. (2012) using brain imaging. They achieved this by using a visual search paradigm to compare the recruitment of front-parietal networks in two groups: one consisting of players of action video games & other consisting of non-game players. The researchers have used both an easy search & more difficult search to investigate how search complexity affects the processing of unrelated motion information all at once. The study included 26 men, ranging in age from 18 to 26, divided into two groups based on their level of expertise playing video games. The study found that the group that played video games had reduced activation of the fronto-parietal attentional network and performed the search task faster. These findings are in line with the theory that suggests action game players might naturally distribute their attentional resources, which could lead to better early filtering of irrelevant information.

Krcmar et al. (2011) compared Doom 1 and Doom 3 to determine the impact of realism on players' ability to pay attention, remember information, and act aggressively. There were 130 undergraduates total, with 76 men and 54 girls with an average age of 19.6. There was a control group that played under varied conditions (n=45), one that played Doom 3 (n=44), and one that played Doom 1 (n=41). Our working hypothesis was that compared to Doom 1, players would report paying more attention in Doom 3. There were three measures that tested attention; each item had a seven-point scale, with higher scores indicating more attention. The findings provided evidence in favour of the idea. Compared to Doom 1, players of Doom 3 reported a more realistic experience. In addition, compared to Doom 1, players of Doom 3 reported feeling more present and paying more attention. To sum up, players' attention, retention, and aggressive results are all positively impacted by video games with more realistic graphics.

Researchers Green et al. (2014) looked at how playing action video games affected the ability to switch between tasks. One of the executive functions is task switching, often called set-shifting, which is the capacity to subconsciously move focus from one activity to another. This was accomplished by showing that AVGPs' switching cost advantage applies to:

- Responses that are vocal in addition to the more conventional manual ones
- Activities requiring more mental processing power than visual processing
- Switches for both goals and motors. They carried out four independent experiments.

Their findings indicate that:

- When responding vocally, the AVGPs exhibit the same advantage.
- The Twitch-cost advantage was most pronounced in a cognitively demanding task.
- The AVGPs benefit was nearly identical in two scenarios: one in which the switch necessitated a change in objectives, and the other in which the switch entailed merely a modification to the motor response set.

- Switch-cost reductions were higher after training on an action game compared to a control game.

McDermott et al. [2011], Utilising four activities that target different parts of the brain responsible for memory processing, researchers looked at how playing action video games improves players' memory capacities. They were especially interested in seeing whether visual short-term memory helped with long-term memory retention. Twelve male NVGPs and twenty-eight male AVGPs took part. Compared to NVGPs, AVGPs demonstrated quicker and more reliable memorisation on the Posner letter identification task. As the level of interference rose, NVGPs slowed considerably, making AVGPs the quicker option in the proactive interference challenge. When it came to the N-back task, which tests the ability to recall information from numerous memories, AVGPs once again proved to be the fastest. On the visual short-term memory test, that is dependent on visuospatial memory, AVGPs showed better accuracy than NVGPs.

Action video game players (AVGPs) have better attentional control, but how exactly does this happen? Chisholm and Kingstone (2015) looked into this. Fifty-seven male undergraduates took part in the study; half were assigned to the AVGPs group based on their level of gaming experience, while the other half were assigned to the NVGPs group. After recording participants' eye movements while they completed a basic search task on a display, they compared the two groups' performance in terms of selection and reaction. Based on their findings, AVGPs outperform humans when it comes to target selection and making rapid, precise manual reactions. Cognitive resource availability and prefrontal cortical area integrity are closely correlated with both processes.

In their 2018 study, Qiu et al. sought to determine if there is any discernible cognitive or brain plasticity following a short session of action video gaming. After one hour of AVG, they used behavioural & electrophysiological methods to investigate the plasticity of visual selective attention (VSA). Participants, ranging from AVG experts to complete beginners, were given a UFOV assessment before and after the session. While playing the game, researchers monitored the individuals' EEGs. Finally, they compared a participant's performance before and after the AVG session.

The outcomes were:

- Response times for both experts & non-experts have improved.
- Amplitudes of specific EEG components indicating neural plasticity in non-experts. Therefore, the results indicated that having expertise with AVG was linked to a quick improvement in VSA.

Researchers Blacker et al. (2013) looked at how action video game players use their visual short-term memory (VSTM). Using coloured stimuli, the first experiment compared the processing speeds of AVGPs & NVGPs to see whether one was faster overall, regardless of how long it took to encode the memory elements. One hundred twenty-one undergraduates (106 men and 15 girls) from Temple University made up the sample; their average age was 21 and 16. The results showed that VSTM was the best AVGP. Experiment 2 confirmed the VSTM advantage among AVGPs; this time, the task's processing cost was increased by using more complicated form stimuli, and this effect persisted regardless of the encoding time. The 47 subjects from the first experiment were split into two groups: one consisting of 23 AVGPs and the other comprising 24 NVGPs. This means that AVGPs maintain their VSTM advantage and have proven that more complicated forms are more challenging than simpler ones.

ADHD/Dyslexia: Special Learning Difficulties

Using assessments of reading comprehension, visual-spatial attention, auditory-visual stimuli localisation, cross-sensory attentional shifting, phonological working memory, and audiovisual stimuli, Franceschini et al. (2017) compared two groups of English-speaking children with dyslexia before and after playing AVG or NAVG. The study included 28 dyslexic children, 8 of whom were girls and 20 of whom were boys, with an average age of 10.1 years (range: 7.8–14.3). Three to five days prior to treatment initiation and one to three days following treatment completion were the testing windows for participants. They found that word reading and phonological decoding speed increased without sacrificing accuracy. Without specifically addressing phonological, orthographic, or grapheme-to-phoneme decoding, AVG training does increase reading abilities.

Research has shown that training with Action Video Games (AVGs) improves reading fluency and certain attentional components in children with dyslexia. Antzaka et. al. (2017) sought to discover the attentional components shared by playing AVGs and reading. A total of 38 right-handed adults (with ages ranging from 18 to 45) were enlisted, all of whom had normal or corrected-to-normal vision. The participants were divided into two categories: average VG players and non-players (NVG). In order to gauge VA span, we administered a single-letter identification control task in addition to two other tasks: global and partial report. Their research indicated that AVG players had a longer VA span than non-players.

Before and after nine 80-minute sessions of playing either action or nonaction video games, two groups of dyslexic youngsters were evaluated. The children were matched according to their reading, phonological, and attentional abilities (Franceschini et al., 2013). Their reasoning is based on the fact that current therapies for dyslexia are contentious and resource-intensive, and that new research suggests that addressing attentional deficiencies

may be essential to the remediation process. With that in mind, they looked into how video games affected dyslexic children on the premise that, given the proven effects of video game training on attention abilities, attentional AVG training should lead to learning that transcends the task domain. Their findings showed that playing action video games was the sole way to boost kids' reading speed—not accuracy—and that this improvement was greater than or equal to that shown in rigorous traditional reading programs and one year of children's natural reading growth. Training with action video games also helped with attention.

In their 2016 pilot trial, BlandÕn et al. used Harvest Challenge, a neurofeedback video game that was developed specifically for the purpose. The game tracks the player's focus levels using a Brain Computer Interface so they can control the game with their brainwaves. Playing the game for 30 minutes at a time, nine youngsters with the diagnosis ranged in age from five to twelve. The EEG signals were also recorded, which allowed for the post-processing signal to be in both the time & frequency domains. The findings demonstrated that players' levels of sustained attention improved, and that the alpha and beta bands, not the delta and theta, had higher resting power values. One breath-controlled biofeedback game that Sonne et al. (2016) made for kids with ADHD is ChillFish. Breathing into a LEGO fish equipped with a sensor allows the player to control ChillFish. Children with ADHD may find relief from their anxiety by doing breathing exercises. The participants in the pilot trial ranged in age from 25 to 41.

Children with ADHD can benefit from physically regulated activities that are both fun and therapeutic, according to the findings, which can help them maintain their focus and calm down. Students with attention deficit hyperactivity disorder (ADHD) were the focus of a 3D game developed by Chin-Ling Chen et al. (2017). Through neurofeedback training, individuals learn to regulate their attention and meditation, as well as to concentrate and relax. At least twice a week, the ten participants would lay the theme to fourteen games from the game training course. Pre- and post-training assessments were conducted. Additionally, the training included many forms of attention, including: selective attention, divided focus, sustained attention, and vigilance attention. The results show that children's attention and meditation may be greatly enhanced by gaming training, which also provides feedback.

At the University of Helsinki, Cowley et al. (2016) tested a new approach to neurofeedback (NFB) treatment for adults with attention deficit hyperactivity disorder (ADHD). For this study, 54 adults from Finland, ranging in age from 18 to 60, were enlisted. Out of the total, 44 had been diagnosed with ADHD, while the remaining 10 were listed as having ADD. In addition, individuals were randomly assigned to either a treatment or control group. The theta-beta and sensorimotor rhythm neurofeedback training regimens formed the basis of the intervention. In actuality, there were forty sessions spread out over two to four months for the instruction. Each session, which the participants attended anywhere from twice to five times weekly, lasted for an hour. During each session, they went through a number of different game trials, and the visual reinforcement for classier matching states that were recognised in their EEG happened right after. Results demonstrated that compared to the control group, those receiving treatment for ADHD/ADD reported more significant improvements.

In order to train adults' attention, Ochi et al. (2017) created a neurofeedback game and ran a pilot trial. Based on their initial assessment of ADHD symptoms, 17 adults were divided into two groups: high risk and normal. Using a dry electrode placed on the forehead in the right prefrontal lobe area, the game was able to identify the players' attention levels through brain activity. The game's backdrop gradually faded to black, allowing the user to see only the centre of the screen when their concentration level was low. The player can refocus their attention by concentrating on a particular part of the game using this technique. Because the high-risk group showed improvements in attention level, retention of heightened levels, and refocus time, their results imply that neurofeedback training could be a viable alternative treatment for ADHD.

CONCLUSION

This research shows that video games can significantly affect players' attention & memory, which can have positive and negative effects on their cognitive abilities. Research has demonstrated that playing video games, especially those with an action or strategy element, can improve cognitive flexibility, working memory, and attention span capacity. A large body of research in recent years has examined the impact of gaming on many cognitive processes, including visual working memory, attention, and executive control. Such treatments have the potential to help people of all ages, according to a large body of research. Simple and inexpensive treatments could help many people, but those with developmental dyslexia in particular could see improvements. Though encouraging, the topic of whether or whether training with video games enhances cognitive abilities remains unanswered. Things to think about include the game's genre, how long the training will take, and the fact that different strategies will yield different results. Further study is required to identify which demographics might benefit most from cognitively enhancing video games and to identify the features of these games themselves.

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Corresponding Author

Duggi Sridevi*

Research Scholar, University of Technology, Jaipur, Rajasthan, India

Email: sridevi.duggi@gmail.com