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Impact of Online & Video Games on Human Cognitive Abilities

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ABSTRACT: Online gaming and video games, have become quite popular in the recent past, amongst individuals spanning across various age groups. In the last 50 years, the number of people that play games regularly has augmented from a few thousands to an estimate of 2.2 billion people across the globe. Majority of the studies conducted to comprehend how these games influence the human brain, have emphasized more on the negative impacts than positive, such as games eliciting powerful emotions on players such as aggression, fear and anger. According to some studies, these games have also been found to be addictive and thereby attributed to gamer's lassitude and compromised productivity at school and work life, and pitiable social behavior and relationships. However, this recently earned popularity of video games has surpassed entertainment voyaging into the world of education. Modern research has brought to the forefront the benefits of playing these games in the overall human development. There is enough literature evidence to support the growth of educational games specifically. Additionally, playing video games in a social environment with friends and family together, is significantly contributing to better human relations. Further, studies have demonstrated positive impact of playing these games on some of the vital cognitive processes such as quick and precise decision making, recognition, self-empowerment, control and multi-tasking among others. This research paper aims to identify and observe the difference between gamers and non-gamers in cognitive features such as reaction time, ability to perform actions in pressured situations and multi-tasking, based on some experiments conducted on the chosen sample population. The results from these experiments would aid in comprehending the impact of online and video games on some of the vital human cognitive skills.

KEYWORDS: ***Video games; online games; Cognitive skills; multi-tasking; reaction time.***

1. Introduction

A video-game is a game that uses electronics and involves interaction from the user and a general interface. A video-game can be anything from action, to card games, as long as the game involves user interaction and is run on electronics and has a basic objective. Playing a video-game requires a platform to run the game. Some examples of such video game platforms include computer, PlayStation and Xbox (varied upgraded versions) to name a few, the latter being the most common platforms in modern times. Videogames were first marketed in 1971 with the first game being space by Nutting Association, with

Pong, the first commercially successful video game, being published in 1972 by Atari. Throughout history, video-games have improved drastically from when they were first created, with some games costing over $100 million to create. The most expensive game to be created was Grand Theft Auto five (GTA V) which cost $265 million but broke the industry record by making $800 million on release and surpassed $1 billion by the end of 3 days and has amassed over $6 Billion in revenue. The game with the highest revenue is world of warcraft, with revenues of over $10 billion over its 15 year lifetime.

Video games have also significantly contributed to the global economy. In 2018, the video game industry made $134.9 Billion with mobile games generating almost half the revenue, with $63.2 Billion, marking it up 12.8% from the previous year.

According to a research in 2017, out of 7.6 billion people in the world, 2.2 billion people play games on a regular basis, which is 34.5% of the total world population, with this high proportion of people playing, researchers have had enough patients and volunteers to research both positive and negative side-effects of playing games.

The video games, however, in recent times, have been accused of causing more negative than positive impacts on human brain and cognition, such as desensitization to violence by playing video games (Carnagey et al., 2006),. Yet, studies have indicated the positive impact of video games on specific human skills such as decision making. (Buelow et al., 2015).

Psychology refers to the branch of studies that discusses the interface between science, social science and cognitive science. Human cognitive abilities refer to brain based skills that are essential for carrying out daily crucial tasks and are crucial to human survival and the process of adaptation, as they aid in information processing. (Newman and Newman, 2020). They are the core concept and the necessity to process the information. These abilities are also helpful in learning new knowledge or information, understanding and speech thereby also aiding brain in improving these abilities.

Humans possess 7 forms of cognitive abilities, all having different skills involved. These include: Perception (recognizing and interpreting the 5 senses - Sight, touch, taste, smell and hearing), Attention (ability to concentrate on certain objects, actions or thoughts and managing the demands of each environment), Memory (one's ability to remember based on 3 types of memories - sensory, Short term and long term memory), Motor skills (the precise moment of bones and muscles to carry out specific tasks), Language (translating sounds into words and outputting a response to the sounds in a way that is understandable by the second party), Visual and Spatial Processing (ability to process visual and spatial distance between objects and react accordingly to them) and Executive Functions (ability to work towards a goal, execute a plan, and finish the goal. These include: Flexibility, Anticipation, Theory of mind, Working Memory, Problem solving, Decision making, Emotional self-regulation, sequencing and inhabitants). Each of these skills plays a vital role in overall human development by significantly aiding in understanding of new information and comprehending the ever changing environment around. In case of loss or damage or weakness of any of these, it may lead to majorly affect the process of understanding, grasping, retaining or using any information.

Since the early 1980s, computer games have gained significant popularity as a fun and relaxing activity and more recently the creators of these games have tried to direct the objective of playing these games to aid in skill acquisition and enhancement, learning, behavioural changes and attitude alteration for good, beyond the traditional shackles of these games being looked upon as violent, gender pigeonholed, addictive, aggressive and other harmful effects on human attitude.

1.1 Objectives

This paper aims to examine the positive influence of playing video games on various human cognitive skills. The research shall examine some crucial cognitive skills, namely, reaction time, multitasking and working under time pressure/memory, thereby helping to address the key research question - Whether playing games improve cognitive abilities? The key objectives that the research is intended to work upon include:

1. To explore the impact of gaming habits on the reaction time of Gamers and Non-Gamers
2. To examine whether the online and video games positively impact the multi-tasking capabilities of regular gamers when compared to non-gaming subjects.
3. To inspect whether Gamers can perform better under time constraints and yet maneuver their memory, vis-à-vis their non-gaming counterparts.

Further, the paper may serve as a connecting link for further studies on the lines of looking at the charm of games and the potential ability of games in assisting with the process learning and behavior and attitude change.

2. Literature review

A research conducted at University of Rochester exhibited that video games could be considered a source of offering a potent training routine to speed up decision making skills and reactions in various real-life situations. The study involved dozens of 18- to 25-year-old typically non video game playing individuals, The subjects were divided into two groups – where one group was engaged in playing 50 hours of fast action video games, namely, "Call of Duty 2" and "Unreal Tournament", while the second group was exposed to 50 hours of the slow paced scheme oriented game "The Sims 2." Post this, all the subject individuals were examined by showing them certain situations followed by answering questions in minimum time. It was found that the first team, exposed to fast action based video games, was up to 25 percent faster than the second team at decision making and concluding, and was abreast with second team in answering equal number of questions correctly, strongly indicating that the team exposed to action video games, was more are more competent in gathering audio-video information as compared to the latter, and therefore turned out to be faster in decision making process. (Green et al,. 2010).

In 2008, a study was conducted with the objective to observe if real-time strategy games could be applied on older adults to reduce cognitive decline with age. The experiment conducted employed 40 participants separated into 2 groups. Group 1 being a control group, while group 2 had participants being taught how to play the real time strategy game "Rise of Nations" for 23.5 hours spanning across 7-8 weeks. The results of this experiment showed that playing "rise of nation" helped the older adults with cognitive abilities such as: task switching, focusing on objects, visual short term memory and the Raven's Advanced Matrices task. (Basak et al., 2008)

Experiments were conducted to measure the effect of action video games on visual attention using Bundesen's (1990) Theory of Visual Attention. The research involved 42 young male participants, who were divided into 3 groups based on the amount of time they spent on playing action video games. The first group consisted of participants that played less than 2 hours a month and were named the 'Non-players group', the second group consisted of participants that played between 4-8 hours a month and were named the 'Casual players group', and the last group consisted of participants that played over 15 hours a month and were named the 'Experienced group'. All participants were then given 3 tests – the first test based on the Theory of Visual Attention (TVA), followed by an enumeration test and an Attentional Network test (ANT). The results showed that while there was no relationship between gamers and capacity of visual short-term memory, however, playing video games did improve encoding speed of visual information into visual short term memory. This conclusion mushroomed as a crucial support to the theory that playing action video games did influence the attention function and short term memory. (Wilms et al., 2012)

Further, in a yet another experiment in 2014, it was clearly confirmed that action gamers demonstrated a sharper and better memory when compared to non-action gamers (McDermott et al,. 2014).

A yet another study was conducted that aimed to detect the immediate reaction time difference between gamers and non-gamers. This research involved 87 healthy adults aged 18-40 and put them into 2 different groups. Group 1 being gamers and group 2 being non-gamers. These groups were further sub-divided into sub-groups based on gender thus leading to six groups: Gamers, Gamer males, Gamer Females, Non-gamers, Non-gamer males and Non-gamer females. The methodology that they applied was that they conducted a visual Oddball Task to measure reaction time to visual stimuli, which was performed using mouse click reactions. The results of this study indicated that the Gamers had a lower reaction time with 301 milliseconds while non-gamers had a reaction time of 346 milliseconds and the lowest mean reaction time going to Male gamers with 299 milliseconds. These results and conclusions depicted that playing video-games reduced the reaction time of the gamers, making them more alert (Richardson et al., 2014).

In support of the above study, another research in 2015 described how cognitive abilities could be enhanced by playing action video games. The study included 5 healthy males between the ages of 20 and 27, one participant being the control, while the other 4 participants were pre-tested then made to play the action shooter game "Tom Clancy's

Rainbow Six: Vegas 2" for 50 hours practicing not more than 1 hour a day. The experimental group of 4 participants underwent a pre-testing and post testing session after a span of 2 months in which they played the aforementioned action video game, whereas on the other side, the control individual underwent the pre-testing followed by post testing phase after 1 month, without any training session. Upon examination post completion of the exposure phase, it was observed that the participants from the experimental group exhibited a significant change in some cognitive abilities by way of better reaction time, lesser stress levels and higher information processing speed, mainly attributed to the training sessions for the former group leading to a better hand eye co-ordination. The evaluated results show the effectiveness of the methods proposed to examine the increase in cognitive abilities and performance after training (Chandra et al, 2015).

In the same year, another study was conducted to observe the impact of a virtual environment towards improving hippocampal associated memory, which would further increase memory efficiency and effectiveness. The experiment involved 68 volunteers, 39 of which were self-described gamers and 29 self-described non gamers, attempted a video game based questionnaire to check the volunteers' background with videogames, an Enumeration task which focused on the participants quickly and accurately reporting flashing dots on the screen and MST test which measured the Lure Discrimination index and Recognition memory score which was also done later during the 2015 Winter GameFest with competitive action gamers. (Clemenson and Craig, 2015). The results were that unlike previous studies (Green and Bavelier, 2006), there were no found relationship between actions gamers and visual perception using an enumeration task, experience in video games also related to Mnemonic Discrimination with the gamers group showing better mnemonic discrimination than non-gamers on the LDI measure and lastly, gamers that play spatially complex 3D video games have a higher LDI score on the MST than those that primarily play 2D games and non-gamers. This was later replicated in a study where similar results were replicated in healthy older adults (Clemenson et al., 2020).

To comprehend the impact of video games and online games specifically on the reaction time of individuals, a research was conducted with 60 participants, who had no prior experience with video games, with the first experiment being "...presented with targets on a screen and responding using triggers held with each hand." Post this, they were assigned to one of 4 groups. The first 2 groups played games for 1 hours a day for 10 days differing with the game they played, group 3 played visual no-action games, and group 4 played no games. After 10 days, they were given the first experiment again which gave the results that "reaction times were found to be significantly quicker following action game training". The results indicated a reduction in reaction time of the gamer sin group 1, indicating the positive impact of video games on reaction time of individuals (Hutchinson et al., 2016).

A 2017 study emphasizes about the eight cognitive benefits of playing video games for kids. The skills covered in the study include memory and multitasking skills. For memory, the study indicated that when playing a game, the subjects were provided with a tutorial (how to play) which they had to remember throughout the game. Also, they were to memorize either the keyboard layout or the controller layout as certain keys were

necessary to perform simple functions in the game. For multitasking, this research suggested that when playing a game, the subjects had to focus on many features at once, such as energy level, oncoming adversaries, ammunition left, available time among other factors. Thus, the subjects had to be extremely observant and react accordingly to ensure they won. (Eugenio, S. 2017).

3. Methodology

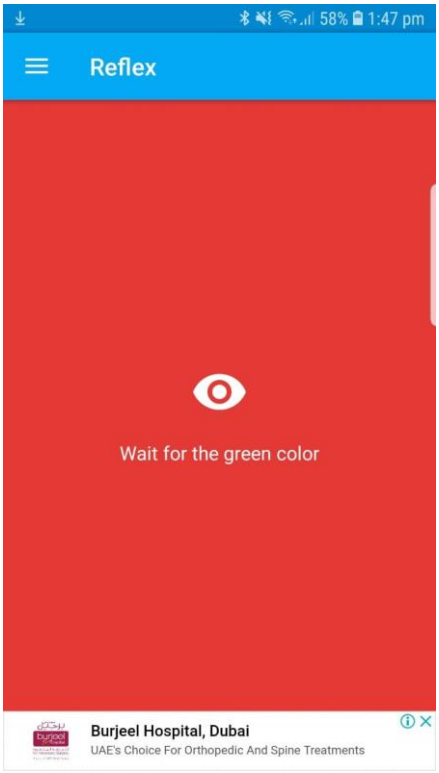
The study comprises of elaborate research on three areas in cognitive ability: visual reaction time, multitasking and working under time pressure and memory. The study is based on a combination of primary and secondary research. The primary research involved a sample size of 8 healthy participants – subjects (Age range 16 – 22 years), divided in to 4 gamers (2 males and 2 females) and 4 non-gamers (2 males and 2 females).

For the first ability, reaction time of the participants, an online application called "Reflex" was used to get accurate value for this component. Each participant was given five chances to respond, followed by which average reaction time was calculated for each, after removing all anomalies. For the second cognitive ability, multi-tasking score, an online application called "2 cars" was used, where each participant had to control 2 cars simultaneously and get the highest score. Each participant was given five chances to respond, followed by which average multi-tasking score was calculated for each, after removing all anomalies. Finally, for the third cognitive ability, working under time pressure and memory, an online application called "Indefinite" was used, which interrogates the user and the user is expected to answer each question in a limited time and remember the answer the user gave for each question as he/she may be asked the same question afterwards. Each participant was given five chances to respond, followed by which average score was calculated for each, after removing all anomalies.

4. Findings and Discussions

4.1 Experiment 1

For studying the first cognitive ability – reaction time, under experiment 1, an online application called "Reflex" was employed to test the visual reflexes of the subjects. For this, after pressing the START option on the application, the screen turned red showing the text -"Wait for the green color" and then turned green prompting the subject with the text - "Tap now", followed by which, the application calculated the time between the green screen and when the subject tapped the screen. Visual representation of the screen is mentioned below:



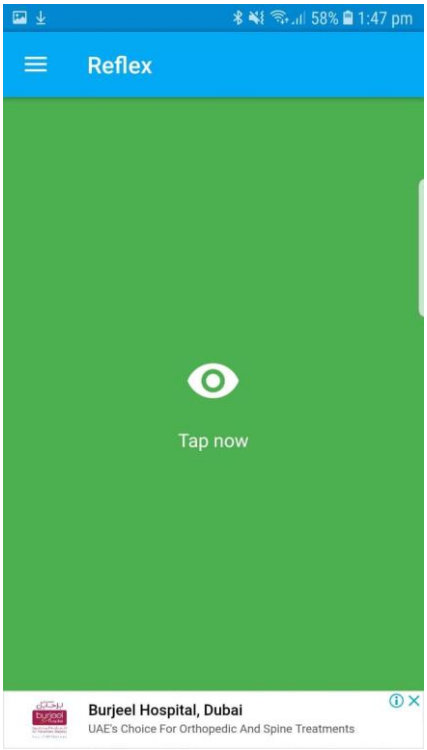


Figure 1. Before touching the screen *Figure 2. When the app prompts to tap the screen*

Once each subject finished this activity five times, time taken by each subject to tap the screen correctly at every chance was calculated using a stopwatch.

4.2 Experiment 2

For studying the second cognitive ability – multi-tasking capacity, under experiment 2, an online application called "2 cars" was deployed, where each subject was expected to simultaneously move two cars, one on each side of the screen. While maneuvering the cars, the subject was also to collect all the circles and avoid all the squares. If the subject missed a circle or hit a square, it would lead to disqualification of the subject followed by end of the game. Maneuvering two cars while collecting one shape and rejecting the other is considered as multi-tasking as the subject had to focus on two cars plus collecting one type of shape, while ignoring or rejecting the other. Visual representation of the screen is mentioned below:

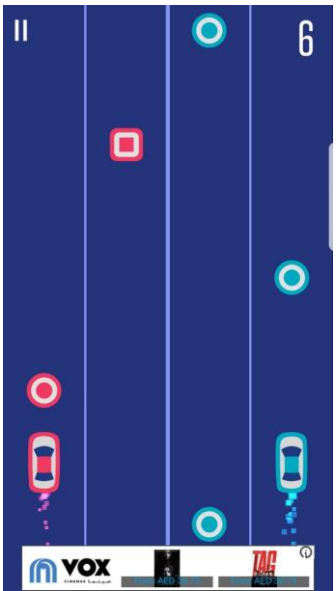
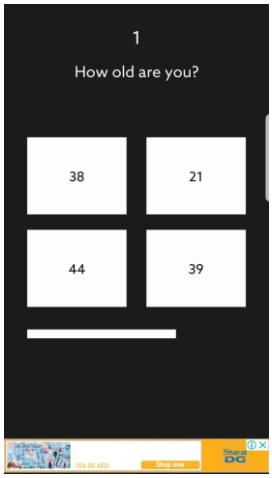
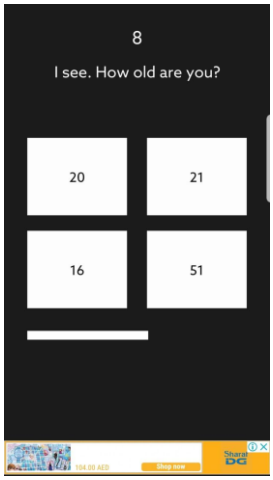


Figure 3. Visual Representation of the App "2cars"

4.3 Experiment 3

For studying the third cognitive ability – working under time pressure and memory, under experiment 3, an online application called "Indefinite" was arrayed, where the subject was interrogated and had to answer questions within a given time frame, and as the questions would proceed, the time limit would decrease. The subject was also expected to have memorized the answers given by him/her as the questions might reappear at a later stage during the game with shorter time limits. This process aided in testing both - memory and working under time pressure, as the subject would not be just under the pressure of time as the time limit kept on reducing, but also would be memorizing every answer given and repeat them when asked. Visual representation of the screen is mentioned below:





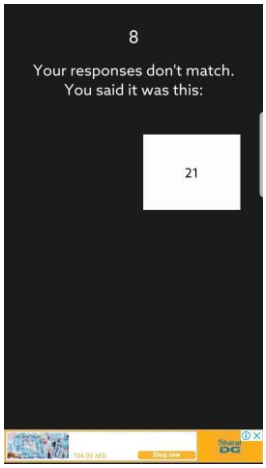


Figure 4. Question About Age *Figure 5. Same question being* *Figure 6. End of Game*

As evident, the first question asked was about the subject's age, then the same question was asked again as question 8.

4.4 Results

4.4.1 Experiment 1

Table 1. Reaction Time Comparison for Gamers Vs Non-Gamers

Reaction time								
	Name	**Try 1**	**Try 2**	**Try 3**	**Try 4**	**Try 5**	**Average**	**Total average**
Gamers	Johnathan	0.225	0.224	0.231	0.213	0.211	0.2208	0.2346
	William	0.243	0.233	0.265	0.244	0.212	0.2394	
	Danial	0.235	0.244	0.212	0.255	0.247	0.2386	

	Sarah	0.265	0.212	0.254	0.234	0.233	0.2396	
Non-gamers	Savraj	0.253	0.282	0.252	0.284	0.272	0.2686	0.2714
	Ankur	0.292	0.285	0.315	0.291	0.266	0.2898	
	Hannah	0.301	0.263	0.291	0.285	0.251	0.2782	
	Isbah	0.254	0.244	0.245	0.243	0.265	0.2502	

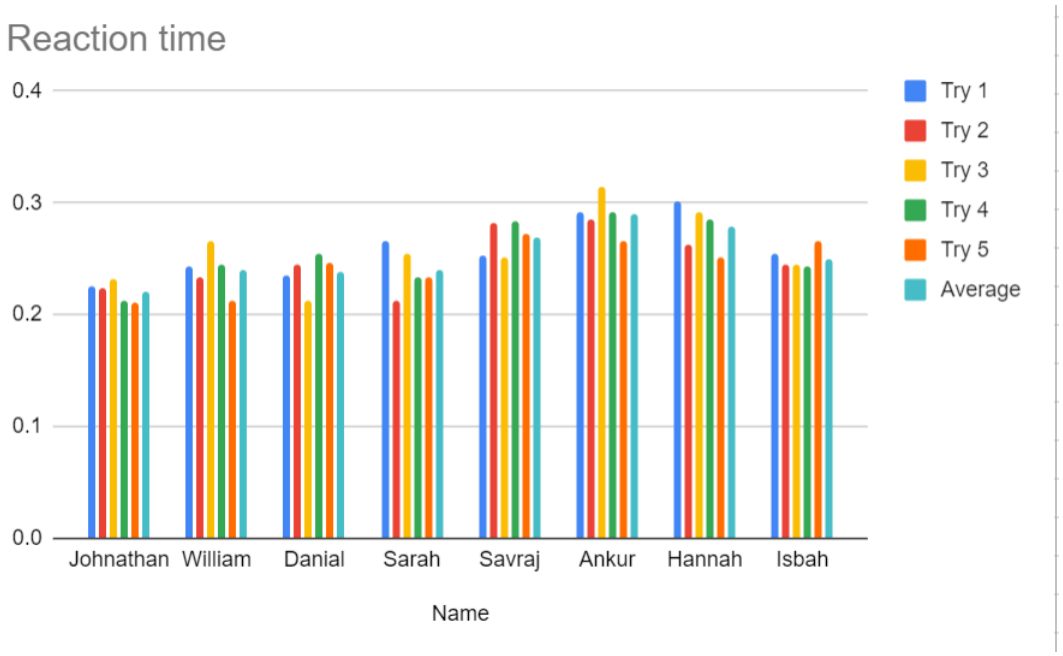


Figure 7. Graphical Representation for Reaction Time: Gamers Vs Non-gamers

4.4.2 Experiment 2

Table 2. Multi-tasking Capacity Comparison for Gamers Vs Non-Gamers

Multi-tasking								
	Name	**Try 1**	**Try 2**	**Try 3**	**Try 4**	**Try 5**	**Average**	**Total average**
Gamers	Johnathan	54	34	21	71	65	49	31.65
	William	23	20	12	43	13	22.2	
	Danial	53	10	35	34	31	32.6	
	Sarah	13	23	33	21	24	22.8	
Non-gamers	Savraj	12	20	21	18	23	18.8	20.25
	Ankur	31	23	11	14	23	20.4	
	Hannah	12	18	23	19	29	20.2	
	Isbah	23	16	21	25	23	21.6	

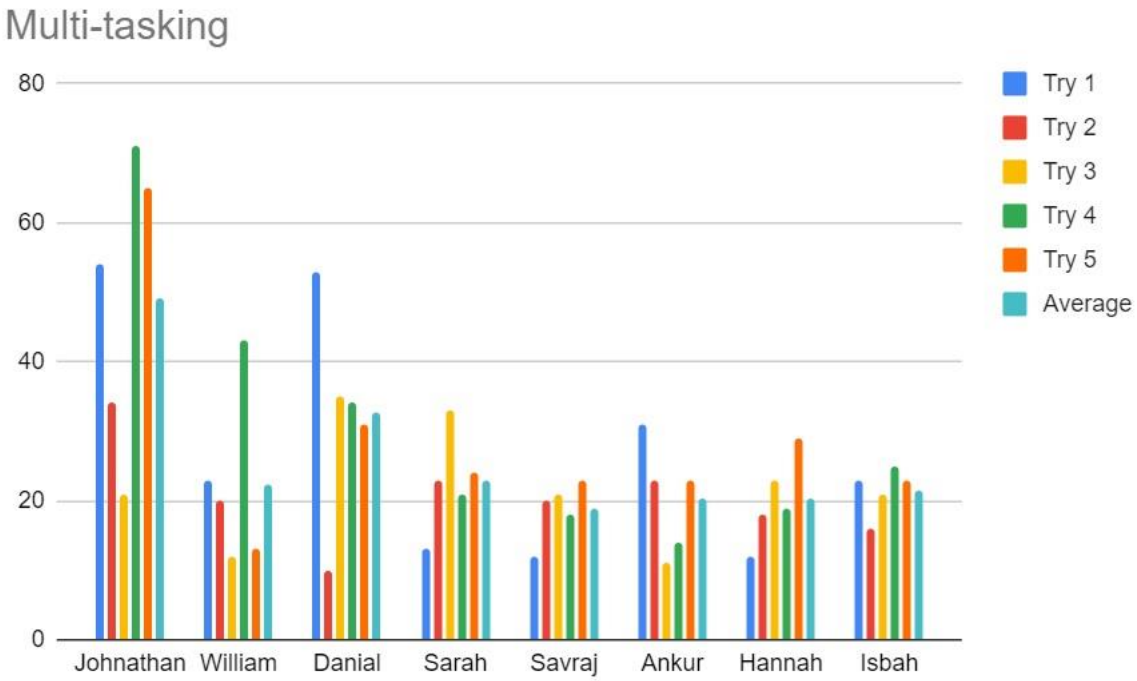


Figure 8. Graphical Representation for Multi-tasking Capacity: Gamers Vs Non-gamers.

4.4.3 Experiment 3

Table 3. Working Under Time Pressure & Memory Comparison for Gamers Vs Non-Gamers

Working under time pressure / memory								
	Name	**Try 1**	**Try 2**	**Try 3**	**Try 4**	**Try 5**	**Average**	**Total average**
Gamers	Johnathan	32	40	24	29	42	33.4	36.7
	William	43	48	37	30	51	41.8	
	Danial	32	23	39	41	42	35.4	
	Sarah	34	21	53	41	32	36.2	
Non-gamers	Savraj	30	34	29	41	31	33	30.45
	Ankur	29	26	31	35	29	30	
	Hannah	23	32	35	31	24	29	
	Isbah	25	27	31	34	32	29.8	

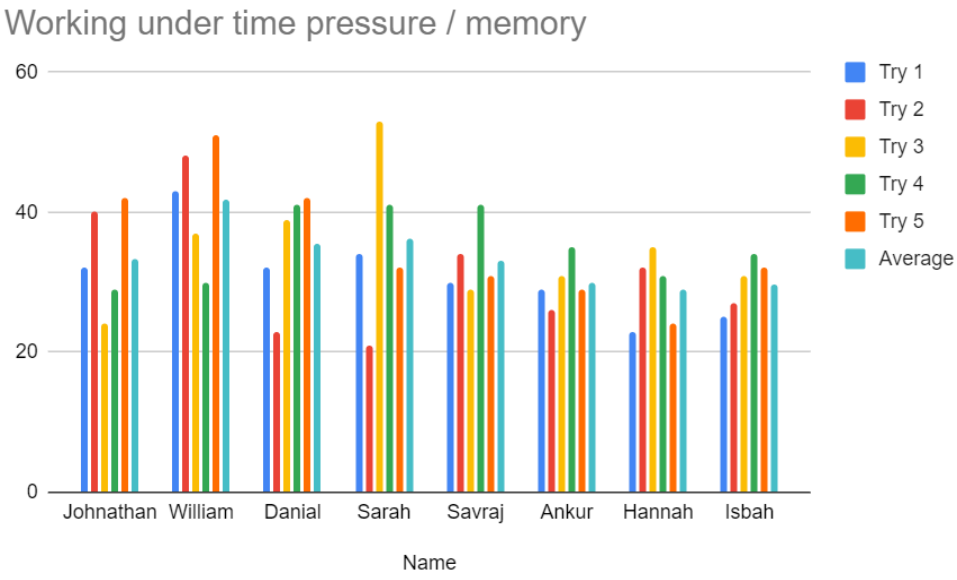


Figure 9. Graphical Representation for Work under Time Pressure & Memory: Gamers Vs Non-gamers

4.5 Analysis and discussion

As per the previously conducted experiment and studies, for visual reflexes, the average human reaction time has been found to be 0.253 seconds (Semmelmann and Weigelt 2016). The results obtained with the subjects of the current study were found to be that all the gamers had their reaction time readings under 0.25 seconds with the total average being 0.2346 seconds, while on the other hand, all the non-gamers subjects exhibited an average of over 0.25 seconds with the total average being 0.2714 seconds.(Table 1 and Fig. 7).

This clearly indicated that exposure to video gaming may possibly improve reaction time in teenagers and young adults. Another observation from the results obtained was that the average of highest reaction time from the gaming group was overall lower that the average of the lowest reaction time of the non-gaming group, thereby further bolstering the idea that gamers possibly have a lower reaction time.

This may be attributed to the fact that constant video games may require the gamer (subject) to do certain action or moved before the opposition, for example: In a first person shooter game such as “Call of Duty”, If the opponent has a faster reaction time than you, the opposition will most likely win, thus games requires the player to have low reaction time to make progress and get better.

For the second skill, multi-tasking, as evident from the results achieved, the total average score for the Gamers group came to 31.65, while the total average for the Non-gamers group came to 20.25, (Table 2 and Fig. 8) wherein both 31.65 and 20.25 referred

to the score the subjects achieved on the online application “2 cars". As observed, the Gamers group showcased a higher average than the Non-gamers, by a visible difference of 11.4 points.

However, one very crucial observation in this experiment was, as shown, the average of the subject - “Johnathan” was higher than everyone else, with an average of 49 while the second highest subject – “Danial” had an average score of 32.6, this shows that gaming may not be the most efficient way of enhancing one’s multitasking skills or capacity. However, if the subject “Jonathan” was to be excluded from the total average of the Gamers group, the new total average would have been 25.86, which would still be a higher total average than the Non-gamers 20.25. A plausible reason Gamers may have a higher multi-tasking abilities may be that, during the games, the subject would have to look out for and maintain different objects on screen. Going back to Call of Duty, an example of multi-tasking video game, the subject was expected to focus on multiple inputs and criteria such as their navigation, their ammunition contents, checking for presence of any enemy on screen, other players’ positioning on the map and where they are aiming, thus the subjects who played games like these, would be better at keeping track of multiple tasks at once owing to their constant exposure to similar situations while playing the game.

And finally, for the third cognitive skill, working under time pressure and memory, upon comparing the results, the total average score of the Gamers group was at 36.7, while on the other hand, the total average score for the Non-gamers side came to 30.45 (Table 3 and Fig.9). Further from the individual scores of the Gamers group, it is visibly apparent that every subject from the Gamers group had a higher working under time pressure and memory score than the Non-gamers group. This may conceivably be owing to the fact that video games are majorly target oriented and/or time bound, a factor that constantly puts gamers under time pressure to win certain games and knowledge of each area of the game can yield useful results and may be a hidden equipment to further aid the gamer/subject. Some examples of such games include the online game “Call of Duty”, where certain game modes such as “domination” each team 45 gets seconds to defuse a bomb, or else the opposition wins, thus both teams are constantly under a time pressure. For memory, players are expected to memorize the best path to take in order to avoid conflict and reduce the overall time taken to reach the destination, thus the gamer would once again here would to memorize each map to help him/her succeed, thereby enhancing gamer’s memory skills.

4.6 Limitations

Whilst conducting these experiments, there were some limitations that were experienced. Firstly, the sample size was categorized only on the basis of whether the subject played online/video games or not, thereby dividing them into two groups - “gamers” and “non-gamers”, however, the study did not take into consideration the frequency of exposure to gaming for each subject. This was observed as a strong limitation in Experiments 1 and 2 with “Johnathan” who received the best results for “reaction time” and “multitasking” as he played most games.

Another limitation, that could impact the study and results could be the fact that each subject in the Gaming group may not have played the same game or similar kind of games in the past, prior to volunteering as a subject for the study, owing to which, each one would have their own caliber and weaknesses as while on one side, some games would focus more on reaction time, others might focus on memory and multitasking.

Further, all the experimental studies for quantitative results and analyses, were conducted on a mobile application and mobile game, wherein the Gamers group had an advantage as they were more used to playing and being in that environment.

Several studies are being conducted to check if learning and outcomes from these studies may be employed to benefit students in their school and university life, and individuals at work front to perform better, by managing deadlines, quick reaction time and decision making and overall improved cognitive skills, based on exposure to online and video games. The results and conclusions from this research may be appropriately utilized by other workers researching in similar related fields.

Lastly, all the aforementioned studies and experiments were conducted at the unprecedented times of the pandemic, where social distancing was a must, which led to a small sample size volunteering for the study. More conclusive results might have been achieved with a higher sample size.

5. Conclusion

From the experiments, it is evident that the Gamers group overall exhibited a better reaction time than Non-gamers group, as Gamers had not only the overall best total average but also the average of highest reaction time from the Gaming group was still lower than the average of the lowest reaction time of the Non-gaming group. Further, as per the results from the experiments, the Gamers group were found to be more efficient at multi-tasking as the total average for Gamers was higher than the total average of Non-Gamers, but as one Non-gamer had a higher average than some Gamers, games may not be the most efficient method for improving the multi-tasking capability among human beings. And finally, for working under time pressure and memory, the Gamers group had not only the overall best total average but also the average of lowest reaction time indicating that exposure to gaming platforms could possibly be the cause among the Gamers group to focus more on deadlines and remember and recall facts as and when required, thereby aiding in refining these cognitive skills in gamers. The focus of this study was to comprehend the positive impacts of gaming on some of the human cognitive skills and abilities. There are seven core cognitive skills that are essential for human understanding and learning. This research has focused on positive impact of online and video gaming exposures on very few of these skills. The conclusions, however, may be taken as a steppingstone for other researchers working in the same field to further their research by exploring the impact of online and video gaming on other cognitive skills that control and let humans develop. Further, the overall efficacy of these studies may be

further enhanced by offering appropriate training sessions to the subjects in order to achieve uniformity across the study.

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