Article • Comparison of Reaction Time, Accuracy, and Practice Effects Between Gamers, Semi- Gamers, and Non- Gamers

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ABSTRACT

Background: Video games are largely favoured by younger generations. Many researchers have shown the positive effect of video games on the brain and cognitive functions. This study aims to compare visual reaction time, accuracy, and practice effects between gamers, semi-gamers, and non-gamers and to investigate whether previously inexperienced participants can improve their performance with practice.

METHODS: A cross-sectional study was conducted among gamers, semi-gamers, and non-gamers, in which each group comprised 15 subjects. A mobile-based reaction time application and a reaction trainer application were used to measure reaction time, score, and accuracy rate. Practice sessions were administered for all of the subjects over a period of one week, and the measurements were repeated. Paired-t test was used to compare various parameters before and after practice. Comparison between the three groups was made using a one-way ANOVA.

RESULTS: Reaction time decreased significantly after practice in all groups. The semi-gamers and non-gamers, however, showed significant improvement compared to gamers. Comparing the three groups, the gamers displayed the shortest reaction time, both before (mean=251.20 msec, p=0.015) and after (mean=240.60 msec, p=0.113) practice. The accuracy rate was highest among the gamers. Gamers achieved higher scores both before (p=0.009) and after practice (p=0.001) compared to those having little or no gaming experience.

CONCLUSION: Regular involvement in action video games resulted in improvement in attentional and cognitive skills in gamers, leading to better performance in reaction time, score, and accuracy rate compared to semi-gamers and non-gamers. The administration of practice over a short period of time drastically improved the performance of the non-gamers.

Keywords: action video games, practice effects, video gaming

Introduction

Vision is necessary for processing information regarding the spatial location of an object. The ability to detect or to recognize a visual stimulus can be assessed by measuring reaction time. Reaction time is defined as "the interval of time between the presentation of stimulus and the initiation of appropriate voluntary response."[1] Reaction time and speed are closely associated. These two components are difficult to separate. As a consequence, reaction time is also referred to as response speed. Visual reaction time (VRT) is the time required to respond to visual stimuli.[1] Reaction time can be divided into two components, mental processing time and movement time. Mental processing time is the time required by the responder to perceive the stimulus and to decide on the proper motor response, while movement time is the time required to perform the movement after selection of the response.[2] Eye-hand coordination is regarded as the coordinated control of eye movement with hand movement and the processing of visual input to guide reaching and grasping, along with the use of hands to guide the eyes.[3]

With advancements in technology, video games are largely favoured by younger generations. An individual is termed as a gamer if he/she participates in video gaming four hours or more per week.[4]

Participating in video games poses a positive effect on individuals' reaction time and problem solving skills.[5] Various studies have shown performance differences between video game players and non-video game players.[3,6] Some researchers have demonstrated that practice can decrease reaction time.[1,7,8] Therefore, we aim to compare visual reaction time and accuracy between gamers, semi-gamers, and non-gamers and to investigate whether previously inexperienced participants can improve their performance with practice.

Methods

Subjects: Forty-five optometry students ranging from 18-24 years were enrolled. The study adhered to the tenets of the Declaration of Helsinki and was approved by the Institutional Ethics Committee. A written informed consent was completed by all of the subjects after hearing a brief explanation about the study. The study included 15 gamers, 15 semi-gamers, and 15 non-gamers. The division of subjects was based on the average number of hours that they played video games per week for the prior three months. Individuals who played action video games for more than 5 hours per week were grouped as gamers. Individuals who played action video games for 1-5 hours per week were grouped as semi-gamers. Those who did not report gaming were labelled as non-gamers. The subjects included in the study had best-corrected visual acuity of 6/6 in both eyes while wearing refractive correction. Slit lamp examination was carried out to ensure that the subjects did not have eye infections. The subjects did not report any history of upper limb deformity and were non-alcoholic and non-smokers.

Apparatus: Two applications, the reaction time application by Banensoft, version 1.12.3 and the reaction trainer application by Jilder.com, version 2.2.0, were downloaded from the Play Store and installed on an Android mobile phone (Xiaomi Redmi 5) with a touchscreen display of 5.70 inches (~75.9% screen-to-body ratio), a resolution of 720 x 1440 pixels, (~282 ppi density), and a refresh rate of 60 Hz. The tests were conducted in a well-illuminated room. Subjects were asked to sit on a chair with an attached desk. The mobile phone was placed horizontally on the desk. The brightness of the phone was set to 100%.

Procedure: The study was conducted in two sessions: before practice and after one week of practice. The subjects were instructed to sleep for at least seven hours the night before testing. Clear instructions were given regarding the procedure, and readings were taken after giving a practical demonstration. The following tests were carried out.

Measurement of simple visual reaction time: The simple visual reaction time was measured using the reaction time application. The subjects had to tap on the mobile phone screen once the screen colour changed from red to green. The test had 5 trials to it, and the application displayed the average reaction time in milliseconds. Two readings were obtained from each participant.

Reaction trainer game: The reaction trainer mobile-phone based application was used in timed play mode and endless play mode. In timed play mode, 28 circular visual targets (stimulus) with a diameter of 7.5 mm were presented at a constant rate for one minute. The subjects had to tap on the targets accurately with only the index finger of their right hand. Average reaction speed, successful taps, score, and number of targets missed were noted. In endless play mode, the subjects continued to play until they missed the targets or tapped on the targets incorrectly three times. The frequency of stimulus presentation increased with time. Score was recorded at the end of the session. Two readings were obtained from each participant.

After the baseline measurement, the participants were asked to install both of the applications on their mobile phones. The participants were then asked to practice the tasks at least twice per day for one week. The second measurement was taken after one week of practice.

Statistical Analysis: Data was collected and compiled in Microsoft Excel and analysed using SPSS software version 14.0.0, LEAD technologies, United States. Comparison was made between the before- and after-practice results using the paired-t test for various parameters. In addition to this, one-way ANOVA was performed to compare mean differences in reaction time, reaction speed, and accuracy between the three groups. The level of significance was set at $p<0.05$.

Results

The subjects were divided into three groups (gamers, semi-gamers, and non-gamers) based on the number of hours that they reported playing action video games. The age and gender details of the subjects are described in Table 1.

Table 1. Age and Gender Details of the Subjects

	MEAN AGE (years)	MALES (%)	FEMALES (%)
GAMERS	20	60	40
SEMI – GAMERS	21	33.33	66.67
NON – GAMERS	21	13.33	86.67

Table 2. Parameter Comparison Before and After Practice

		BEFORE PRACTICE	AFTER PRACTICE	P–VALUE
		Mean ± SD	Mean ± SD	
GAMERS	REACTION TIME (msec)	251.20 ± 35.51	240.60 ± 32.73	0.044*
	TIMED MODE			
	REACTION SPEED (msec)	484.13 ± 49.42	458.33 ± 42.64	0.007*
	SUCCESSFUL TAPS (%)	99.17 ± 1.19	99.67 ± 0.96	0.211
	MISSED	0.07 ± 0.26	0.07 ± 0.26	1.000
	SCORE	236.40 ± 15.29	244.67 ± 15.86	0.018*
	ENDLESS MODE			
	SCORE	1763.87 ± 1002.41	3159.33 ± 1588.54	0.000*
SEMI - GAMERS	REACTION TIME (msec)	301.07 ± 53.45	264.60 ± 37.90	0.011*
	TIMED MODE			
	REACTION SPEED (msec)	528.00 ± 47.11	492.27 ± 40.72	0.000*
	SUCCESSFUL TAPS (%)	98.17 ± 2.30	95.27 ± 11.5	0.349
	MISSED	0.13 ± 0.35	0.00 ± 0.00	0.164
	SCORE	221.20 ± 13.97	234.20 ± 15.53	0.000*
	ENDLESS MODE			
	SCORE	860.47 ± 262.08	1638.93 ± 1577.11	0.051
NON - GAMERS	REACTION TIME (msec)	292.60 ± 52.75	268.87 ± 45.23	0.023*
	TIMED MODE			
	REACTION SPEED (msec)	540.87 ± 54.64	500.00 ± 45.46	0.001*
	SUCCESSFUL TAPS (%)	98.03 ± 2.48	98.73 ± 2.21	0.421
	MISSED	0.13 ± 0.35	0.07 ± 0.26	0.582
	SCORE	224.20 ± 14.29	236.67 ± 12.68	0.003*
	ENDLESS MODE			
	SCORE	767.73 ± 312.36	1347.87 ± 718.51	0.003*

Table 3. Comparison Between Gamers, Semi-Gamers, and Non-Gamers

		GAMERS (MEAN ± SD)	SEMI-GAMERS (MEAN ± SD)	NON-GAMERS (MEAN ± SD)	P-VALUE
BEFORE PRACTICE	REACTION TIME (msec)	251.20 ± 35.51	301.07 ± 53.45	292.60 ± 52.75	0.015*
	TIMED MODE				
	REACTION SPEED (msec)	484.13 ± 49.42	528.00 ± 47.11	540.87 ± 54.64	0.009*
	SUCCESS-FUL TAPS (%)	99.17 ± 1.19	98.17 ± 2.30	98.03 ± 2.48	0.272
	MISSED	0.07 ± 0.26	0.13 ± 0.35	0.13 ± 0.35	0.809
	ENDLESS MODE				
	SCORE	1763.87 ± 1002.41	860.47 ± 262.08	767.73 ± 312.36	0.009*
AFTER PRACTICE	REACTION TIME (msec)	240.60 ± 32.73	264.60 ± 37.90	268.87 ± 45.23	0.113
	TIMED MODE				
	REACTION SPEED (msec)	458.33 ± 42.64	492.27 ± 40.72	500.00 ± 45.46	0.029*
	SUCCESS-FUL TAPS (%)	99.67 ± 0.96	95.27 ± 11.5	98.73 ± 2.21	0.186
	MISSED	0.07 ± 0.26	0.00 ± 0.00	0.07 ± 0.26	0.610
	SCORED	244.67 ± 15.86	234.20 ± 15.53	236.67 ± 12.68	0.139
	ENDLESS MODE				
	SCORE	3159.33 ± 1588.54	1638.93 ± 1577.11	1347.87 ± 718.51	0.001*

Table 2 shows the mean and standard deviation for various parameters before and after practice. Paired-t test was used to compare between parameters before and after practice. The visual reaction time when measured using the reaction time application decreased significantly after practice in all three groups. Reduction in the reaction time was greater in semi-gamers and non-gamers compared to gamers.

The reaction trainer application was used in timed mode and endless mode. Timed mode revealed data on reaction speed, success rate, number of targets missed, and score. There was a significant decrease in visual reaction speed after practice in all three groups. The results also showed that in comparison to the gamers, the semi-gamers and non-gamers showed greater improvement after practice.

The success rate depicted how accurately the subjects tapped on the targets. The gamers and non-gamers showed improvement in the success rate after practice. This indicates improvement in accuracy; however, the results were not significant. The results also did not reveal a significant difference in the number of targets missed by the subjects pre- and post-practice.

The score in timed mode was based on the reaction speed, the number of targets missed, and the success rate of the taps. Statistically significant improvement in scores was seen after practice for all groups. In the endless mode of the application, the subjects continued to tap on the targets, with three chances to miss or tap the targets incorrectly. Accelerated differences in scores were seen after practice in all groups.

Table 3 describes the comparison between the groups. When comparing the three groups, there were significant differences in terms of the average reaction time and scores pre- and post-practice. The gamers had significantly shorter reaction times both pre- and post-practice. The gamers also had significantly shorter reaction speeds pre- and post-practice.

The success rate parameter noted differences among the three groups: the gamers had the highest success rate, thereby being the most accurate compared to semi-gamers and non-gamers pre- and post-practice. However, the difference was not significant.

There was not a statistically significant difference in the number of targets missed by the participants. In timed mode as well as in endless mode, the gamers scored higher compared to semi-gamers and non-gamers both pre- and post-practice, revealing statistically significant differences.

Our results demonstrate that pre- and post-practice, the gamers who were actively involved in action video games on a regular basis showed significantly better reaction time, reaction speed, score, and accuracy rates compared to the semi-gamers and the non-gamers who had very little or no gaming experience. Improved reaction speed was proportional to the improvement in accuracy. One interesting finding was that the semi-gamers and the non-gamers improved drastically after practice compared to gamers, revealing improvement in attentional and cognitive skills even with a short duration of practice.

Discussion

This study focused on comparison of reaction time and accuracy among three groups: gamers, semi-gamers, and non-gamers. The study involved measurement of visual reaction time alone and then in association with accuracy. We were looking for significant changes in various parameters after practice. We were also looking to compare between the three groups and to investigate which group improved their skills to a greater extent.

Our results demonstrated significant decrease in reaction time and reaction speed after practice in all groups. The semi-gamers and non-gamers showed greater improvement after practice compared to the gamers. The scores in the timed mode as well as in endless mode drastically improved with practice in all groups. The improvement in reaction time with practice is in parallel with a study conducted by Ghuntla et al., where they found that visual reaction time decreased after practice for both simple and choice visual reaction time tasks.[1] Similar results were obtained by Del Rossi et al., where they measured simple reaction time using the Ruler-Drop test.[7] Participants were given 10 trials, and data was compared. Simple reaction time decreased after repeated assessment. They suggested that visual information related to how the task was completed at the outset provided valuable information, which subsequently guided the participants to make appropriate adjustments during future test sessions. Ando et al. reported reduction in reaction time post-practice for both central as well as peripheral visual fields.[8] In another study, Ando et al. also demonstrated that practice effects were retained over a period of three weeks.[9]

Another purpose of this study was to investigate whether individuals who were actively involved in action video games had an advantage on standardized cognitive tasks in comparison to non-video game players (NVGPs). A variety of studies have found digital games to be helpful in stimulating cognition.[10-12] In our study, we found that the gamers not only had a faster reaction speed, but they were also more accurate compared to the semi-gamers and the non-gamers. In timed mode as well as in endless mode, the gamers scored significantly higher compared to semi-gamers and non-gamers, both before and after practice. These results are in agreement with the results found by Kowal et al., where action video game players (AVGPs) displayed significantly faster reaction times compared to NVGPs, suggesting that AVGPs

possess enhanced attentional capacity.[13] A similar study was conducted by Rosenbaum et al., where a comparison was made between gamers, semi-gamers, and non-gamers.[5] The study did not reveal any significant changes in initially comparing the groups for puzzle completion and completion time in response time. However, aggregation of the response time data revealed a significant difference between gamers and non-gamers. Richardson et al. revealed shorter reaction times on a visual oddball task for individuals who played 4+ hours of video games per week.[6] Another study revealed that neural processing of visual stimuli is faster in expert video game players than in non-video game players, thus resulting in shorter reaction times.[14] We also found certain studies whose results contradicted our findings. For example, Bhattacharyyia et al. included participants who played video games less than 7-9 hours/week and a control group who did not play video games but had normal physical activity; their results showed that video games did not have any effect on reaction time.[15] Similar findings were obtained by John et al. and Utku.[16,17]

On speaking about reaction speed in conjunction with accuracy, we found that not only were our gamers were fastest at responding to the stimuli, they were also more accurate compared to the semi-gamers and the non-gamers. Dye et al. found that VGPs had significantly faster response times compared to NVGPs with equivalent accuracy.[18] They noted that AVGPs have enhanced attentional skills that allow them to make faster correct responses to targets. However, Kowal et al. argued that while AVGPs may possess task-switching ability and enhanced processing speed, an AVGP adopts a strategy that favours speed over accuracy on a task evaluating cognitive inhibition ability.[13] Speed-accuracy trade-off findings reported by McDermott support the idea that tasks with a strong focus on reaction time may lead to lowered accuracy, whereas without time constraints, AVGPs outperform NVGPs.[19] In their study, Nelson et al. demonstrated that playing an action video game resulted in faster reaction times but lower accuracy on a location task, while playing a puzzle game resulted in slower reaction times but higher accuracy.[20] This may be due to certain strategic shifts that are perhaps implemented by video gamers in subsequent tasks that require both speed and accuracy. Certain video games demand more focus on speed, while others demand greater accuracy. Although the reaction trainer application that we chose in this study is not a standardized test, we particularly chose it because we wished to test both speed and accuracy hand-in-hand. This test required the subjects to focus on speed as well as accuracy while playing. Other games might have differing demands on speed and/or accuracy.

In our study, we tried to limit external factors' effects on our results. We monitored the participants diet, including alcohol and caffeine consumption; fatigue level; and amount of sleep; all of which are known potentially to affect reaction time.[21-24] The largest limitation of this study is that the information regarding video game use was self-reported by the subjects; thus, there is a chance that the data is not as accurate as it would have been if the study was a controlled-intervention study.

In order to comment thoroughly on the link between video game use and resulting cognitive strategies, it is necessary to monitor the long-term effect of action video game play closely. Whether the gamers would continue to respond with the highest speed while keeping the accuracy intact or would favour speed over accuracy is in question. An issue that may be left for further research is that of monitoring whether these practice effects are temporary or whether they might persist over the course of weeks or months. In addition, a topic for further investigation is how action video game play affects day-to-day activities, especially at the workplace, which requires increased screen time.

Conclusion

Regular involvement in action video games resulted in improvement in attentional and cognitive skills in gamers, leading to better performance in reaction time, scores, and accuracy rate compared to semi-gamers and non-gamers. Administration of practice over a short period of time drastically improved the performance of the non-gamers.

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