# The Effects of Video Games on Reaction Times

**Utku Aktu**

Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Master of Science
in
Developmental Psychology

Eastern Mediterranean University
December 2019
Gazimağusa, North Cyprus

Approval of the Institute of Graduate Studies and Research

Prof. Dr. Ali Hakan Ulusoy
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science in Developmental Psychology.

Assoc. Prof. Dr. Fatih Bayraktar
Chair, Department of Psychology

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and quality as a thesis for the degree of Master of Science in Developmental Psychology.

Asst. Prof. Dr. Çığır Kalfaoğlu
Supervisor

Examining Committee

1. Asst. Prof. Dr. Vahit Doğu Erdener _____

2. Asst. Prof. Dr. Çığır Kalfaoğlu _____

3. Asst. Prof. Dr. Burcu Kaya Kızılöz _____

# ABSTRACT

This study investigates the effects of video game play on reaction time. Past research/studies indicate that playing video games has a positive effect on reaction time under the scope of video game players (VGP) have faster reaction time (RT) compared to non-gamers (NG). On the other hand, past studies indicate that video games not only have an effect on reaction times but video games also has an effect on divided attention, attention allocation, visual attention etc. In this research, investigator used simple reaction time task where a program that detects participants reaction time, when did they pressed the button or the time that participants pressed the button. Results of the current study showed that there is no significant difference in reaction times between VGP and NG. For future suggestion, both simple reaction time task and a choice reaction time task can be used to investigate deeper the connection between video gaming and reaction times.

**Keywords:** video games, gamer, non-gamer, simple reaction time, younger adults, older adults.

# ÖZ

Bu çalışma video oyunlarının reaksiyon hızının üzerindeki etkisini araştırmıştır. Önceki çalışmalar video oyunları oynayan bireylerin reaksiyon hızlarının video oyunu oynamayan bireylere kıyasla daha hızlı oldukları belirlenmiştir. Diğer bir taraftan, daha önceki çalışmalarda video oyunlarının sadece reaksiyon hızının değil bölünebilir dikkate, dikkat paylaşımına, görsel dikkate vs. gibi unsura da etkisi olabileceğini kanıtlamıştır. Bu çalışmada basit reaksiyon hızını ölçmek için bilgisayar programı kullanılmıştır ve bu program katılımcı ne zaman tuşa basar ise veya hangi zaman aralıklarında tuşa basmış ise onu algılayabilecek bir program kullanılmıştır. Araştırmanın sonucu bizlere video oyunu oynamanın reaksiyon hızında herhangi bir etkisi olmadığını gösteriyor. İleriye dönük olarak öneri ise sadece basit reaksiyon hızı değil ayni zamanda tercih reaksiyon hızının da kullanılmasını öneriyoruz.

**Anahtar Kelimeler:** Video oyunu, oyuncu, oyun oynamayan, basit reaksiyon, genç erişkinler, yaşlı erişkinler.

# DEDICATION

I want to dedicate this thesis to my grandfather, Aydın and to my grandmother, Hanife who sadly passed away together.

# ACKNOWLEDGEMENT

I would like to record my gratitute to Assist. Prof. Dr. Çığır Kalfaoğlu and Assist. Prof. Dr. İlmiye Seçer for their supervisions over this journey. Their advices, guidance and road showing abilities helped me really well to complete this hard journey.

I especially want to thank to Prof. Dr. Şenel Hüsü Raman for her unending support all over the years including this long journey that I took in masters.

Above all I want to thank to my father Erbay, mother Şerif and to my brother Tutku since they were there as my family and stand with me no matter what obstacle appeared. I want to thank to my close friends as well as people I forgot to mention. Everybody was helpful and caring during this process.

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# Chapter 1

# INTRODUCTION

Video games (VG) can be defined as auditory and visual output from a screen that allows individuals an interactive activity (e.g., console or computer), which can be based on a story (Esposito, 2005). Therefore, video gamer players are also called 'gamers' and these individuals who play VG (e.g., card games or based on a story) with the audiovisual output on personal computers (pc) or consoles (The Entertainment Software Association, 2014; Esposito, 2005). The first video game called 'tic, tac, toe' was developed in 1952 and was played using atari machines (Wolf, 2012). Today with the advancement of technology, the type of VG available for play is numerous and can be played on several mediums such as mobile phones or pc/ game consoles in one's home either against a computer opponent (Artificial Intelligence/ A.I.) or other players around the world (Wolf, 2012). Some game genres include: (a) role playing games that require the player to choose a different role based on the game, (b) action games, in which an individual is required to act quickly and reach to the pace of the game, (c) strategy games, where an individual is required to come with a solution to overcome either a computer based opponent or another player, (d) puzzle games, in which the individual is required to solve little hints granted to them by the computer, (e) simulation games, where individuals can manipulate the world and find themselves controlling environmental factors and (f) online games, where people play against each other using the internet as a source of connection.

Worldwide, the number of VGP in 2015 was around 1.8 billion (Global Gaming Stats, 2014), which reached 2.2 billion in 2017 and is estimated to reach 2.73 billion by the year 2021 (Statista, 2014). With the increasing number of VGP, a number of studies (Bailey, West & Anderson, 2009; Castel, Pratt & Drummond, 2005; Colzato, Leeuwen, Widenberg & Hommel, 2013; Goldstein et al., 1997; Green & Bavelier, 2003; Durkin & Barber, 2002; Dye, Green & Bavelier, 2009; Murphy & Spencer, 2009) have been interested in the beneficial and detrimental effects that VGP has on the social and cognitive development of individuals. While some studies (Anderson et al., 2010; Anderson & Bushman, 2001; Anderson & Ford, 1986; Sherry, 2001) show that violent VG can lead to increased aggression and violence in VG players, others show that non-violent VG can lead to improved emotional well-being in older adults (Goldstein et al., 1997) and higher levels of family closeness, activity involvement, and positive school engagement in 16 year old adolescents compared to their peers who have never played VG (Durkin & Barber, 2002). Others further show that VGP can enhance attention (Mayas, Parmentier, Andres & Ballestros, 2014), working memory (Poudel, et., al.2015), perception and reaction time (Geneve, 2017), divided attention (Bavelier & Green, 2004), speed of processing (Dye, Green & Bavelier, 2009), and cognitive plasticity (Lövden et al., 2010).

Skills that require quick reaction times are important for the performance of daily activities of living such as the ability to keep one's balance while walking without falling, especially in older adults (Lajoie & Gallagher, 2004). Therefore, it is important to investigate ways to maintain and/or enhance reaction times. In light of the literature on VG and cognitive skills, one way to accomplish this may be via VGP. For this purpose, the aim of the current thesis is to investigate whether there

are significant differences between VGP and non-VGP in reaction time skills. In this study we aim to determine whether VGP leads to an improvement on reaction times and in line with previous findings (Geneve, 2017), the current study expects that VGP will have improved reaction times compared to non-VGP.

# Chapter 2

# REACTION TIME

Reaction time (RT) can be defined as the amount of time that an individual's brain takes to receive a stimulus and respond to it (Sternberg, 2010). There are subtypes to RT; simple reaction time (SRT) and choice reaction time (CRT). SRT can be defined as a response to only one stimulus with only one type response (Deary, Liewald & Nissan, 2010). For example, the task in a simple reaction time can be to press the spacebar as soon as a tone is heard or a visual stimulus is presented on the screen (Deary et., al., 2010). On the other hand, CRT can be defined as a task where an individual must respond to one of multiple possible stimuli wherein each stimulus requires a unique/different response (Deary et. al., 2010). For example, the task might be to press the "F" button with the left hand if a high pitch tone is heard (or an "X" is shown on screen) and press the "J" button if a low pitch tone is heard (or an "O" is shown on screen).

## 2.1 Simple Reaction Time

Below, we summarize finding related to simple reaction time and factors that are reported to affect it. A past investigation done by Teichner (1954) report that RT can be affected by environmental factors such as age, sex, and the sleep pattern of the participant that can affect reaction times (Teichner, 1954). A study done by Howes and Boller (1975) investigated a total of 49 participants, 29 of them with a lesion of the left hemisphere of the brain and 20 of the participants with a lesion on the right hemisphere of their brain. In addition to 49 neurological patients, there were 39

participants in the control group in this study. Participants were required them to press a key using their index finger when a noise was placed on a loudspeaker. Furthermore, participants had been separated into sub-categories based on their dominant hand, however, patients with a lesion affecting their hand used their non preferable hand to participate in this study. They found out that when participants used their non-preferred hand, their reaction time to the stimuli is slower compared to the control group.

Another past study done by Gottsdanker (1982) tried to signify the effect of age in reaction times. Researchers divided participants to the age groups and results of the study showed that there is a significant difference among the age groups, but their reaction time lengthening was minimal, meaning as the age increases reaction times decreases. However, in their second experiment group there was a significant difference among the experiment groups (Gottsdanker, 1982). So, based on the findings of the study younger adults were faster compared to the older adults in the second experimental group yet older adults in the second group were faster compared to the older adults in the first group.

Another research done by Shelton and Kumar (2010) tried to investigate the difference between using visual vs. auditory stimuli in simple reaction time task with the main purpose of seeing which leads to faster reaction time. Researchers used 14 participants that were randomly divided into groups that has 2 members of each. Researchers gave participants both visual and auditory tests after one another. In visual test, participants were required to press the „spacebar" key to indicate when the yellow box appeared in the middle of the screen and for the auditory test, when the

sound („beep") was provided to them. Results of the study show that auditory reaction is faster compared to visual reaction, plus researchers indicated that mean point for the visual SRT is 331 milliseconds and for auditory SRT it was 284 milliseconds. Basically, researchers pointed out that reacting to the auditory input was faster compared to visual input (Sheldon & Kumar, 2010).

# Chapter 3

# REACTION TIME AND VG

One way in which reaction times can be improved is via video game training. A past study done by Orosy-Fildes and Allan (1989) tested the effect of *Atari 2600* VG on a CRT task. Twenty participants were tested at pre and post-test for their reaction time with 20 trials and experimental group received 15 minutes to complete the pre and post-tests. Results of this study showed that VG affects participants reaction time, meaning they become faster when pre and post-tests are compared on RT (Orosy-Fildes & Allan, 1989). Another past study by Goldstein et al. (1997) examined the effect of VGP on older adults' reaction times using the Sternberg test. Older participants (*N*=22) were required to play Super Tetris for five hours a week for five weeks. Findings of this study showed that participants who played VG for five weeks demonstrated faster reaction time (via using Sternberg test) compared to the control group in which participants did not play any VG.

A study done by Dye, Green and Bavelier (2009) found that playing action VG (such as *God of War, Call of Duty*) might increase the speed of processing. Researchers conducted a research that has been made on 25 non-gamer participants who were randomly assigned into two different groups. Experimental group played action games, *Call of Duty,* and control group played non action VG, *Sims.* Participants played 50 hours over 8-9 weeks between pre and post testing. Results showed that there is no relationship between action VGP and speed of processing. However,

researchers trained the participants by presenting them with video games and participants were reintroduced to play VG to test their speed of processing. In re-test situation participants were tested based on the attention condition. Results showed that video gamers responded quicker and more accurately compared to the non-gamers (Dye et al., 2009). Report by these authors strengthens the idea that gaming experience might be related to faster reaction times.

Green, Sugarman, Medford and Klobusicky (2012) further showed that VGP have higher task-switching abilities compared to non-gamers. Researchers conducted a study on 46 participants and they separated the participants into two groups: gamer and non-gamers. Researchers defined gamers as individuals who played action VG a minimum of 5 hours per week over the previous six months. Participants were required to respond to two shapes: A red circle and A blue square. Participants were required to press corresponding keys to signify which *colour* the object was if it appeared below the horizontal line. However, if the object is above the horizontal line, participants were required to press keys to signify which *shape* was displayed on the computer screen. Researchers found out that video gamer participants demonstrated better task switching ability as well as faster reaction times and smaller error rates compared to non-gamers (Green et al., 2012). This study also supports the idea that gamers have better cognitive skills than non-gamers in tasks that require task switching.

Another past research done by Bavelier, Green, Pouget and Schrader (2012) showed that playing VG has a positive effect on attention (both divided and selective), vision, cognitive function, resource allocation, speed of accuracy, and reaction time.

Researchers stated that a meta-analysis of 80 reports using various experimental conditions where non-gamers and gamers were compared showed that video gamers are 12% faster and more accurate under reaction-time test conditions compared to non-gamers, possibly due to increased attentional resources, which leads to better selective attention (Bavelier et. al.,2012). Researchers explained their findings by using learning theory (Seligman & Johnston, 1973). According to this theory, new tasks that individual comes across in daily life require more attentional resources to understand and learn. However, if this new task is repeated over time, individual gains the knowledge and the task will be learned through the repeated action. For example, when learning to drive a car for the first time, individuals tend to be more attentive while driving the car on the road, trying to learn when to stop properly etc. However, after spending more time driving the car, the task becomes easier. Individual becomes less attentive compared to the first driving experience thus this leads to individual to know, while driving the car, realize when to stop, when to signal a turn and even able to drive similar types of cars (manual or automatic) with ease due to learning. Based on the information Bavelier et., al. (2012) signifies the importance of the learning theory on reaction time by suggesting, if the task is learned the reaction time increases, meaning individual responds to environmental factors faster. In other words, the time between stimuli and the response reduces.

Another past study done by Chandra, Sharma, Salam, Jha and Mittal (2016) made a study among 5 participants, 4 experimental and 1 control, using post- and pre-tests and EEG to determine the effects of action VG on participants. Participants in the experimental group were given video game training for two months before post testing where control participant didn’t receive any kind of training. Experimental

group received a total of 50 hours of action VGP within 2 months. This was equal to 1 hour of training per day. Experimental group played the game Tom Clancy's Rainbow Six: Vegas 2 which is a First Person Shooter game where participants/players have to eliminate the targets within the game. Results of the study showed that after 2 months of action video game training scores of video gamers on pre and post-tests differed more compared to non-gaming control group: They had improved speed of processing, reaction times and reduced stress levels (Chandra et. al. 2016). This study once again shows that playing VG can enhance mental abilities.

Rosenbaum and Burt (2017) focused on response time and problem solving of two groups of gamers and non-gamers. A total of 68 participants took part in this experimental study, 24 gamers and 26 non gamers, the remaining 18 participants were identified by the researchers as people who sometimes play VG (1-8 hours of gaming in a week). Participants were required to complete tower of Hanoi puzzle and MOART board (this board was used to measure either simple or choice reaction time). Results of the study showed that 80% of gamers completed the tower of Hanoi where only 38% of non-gamers completed the tower of Hanoi (Figure 1) within the limited time allowed. Furthermore, gamers were faster in solving and completing the MOART puzzles compared to non-gamers.

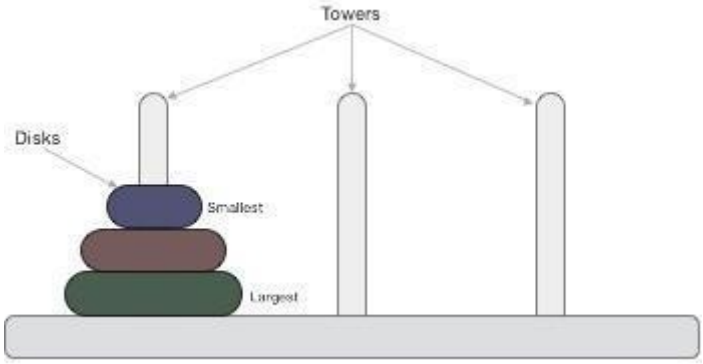


Figure 1. The objective in the Tower of Hanoi task is to move the discs from the leftmost tower to the rightmost tower without violating the following rule: A larger disc can't be placed on top of a smaller disc.

Deleuze, Christiaens, Nuyens and Billieux (2017) investigated the effect of multiplayer online battle arena (MOBA), a massive multiplayer online role-playing game (MMORPG) and online first person shooter (FPS) games on participants' reaction time. A total of 81 younger adults undertook a hybrid-stop task to measure reaction time. Hybrid-stop task is done in computer and when participants begin the experiment, five different boxes appear and in one of the boxes an arrow appears and participants are required to press the correct corresponding key to complete the task, for example in the hybrid-stop task each trial starts with 500 ms on the screen and a blue arrow appears either pointing to the left, which means participant is required to use his/hers left and to press the button or a blue arrow pointing to the right and again participants required to press right arrow with their right arm. "Go" stimuli stayed on the screen for 1000 ms and 50% stop signal appeared and in the stop signal the blue arrow appeared as black arrow which indicates that participants should not press any button and wait for the arrow to disappear. Findings of this study showed that individuals who played online FPS games had faster reaction times compared to MOBA and MMORPG game players. According to Deleuze et al. (2017) having to

play FPS from the perspective of the character leads to better reaction time compared to MOBA and MMORPG gamers, who do not need to play games from the perspective of the character in the game. Although the study by Deleuze et al. (2017) has demonstrated that VGP had improved RT, this study did not include a comparison non-gamer group. Therefore, it is difficult to conclude that improved reaction times were purely due to game play.

Not all past studies, however, show that VG leads to improved reaction times. For example, Bhattacharyyia, Das and Ashwin (2017) did a study on 9-12 years old children and divided them between two different groups, an experimental group where children were exposed to video gaming media for 7-9 hours every day in one week and control group were non-gamers, not exposed to video game media, made daily physical activity. A total of 76 students participated in this research. Researchers recorded visual-attention which was measured via the red lights which participants had to press a corresponding key to signify the red light is active. Results showed that participants who were regularly playing VG has faster reaction times compared to control group where participants were non-players.

A number of theories have been proposed to explain the observed positive effects of gaming on reaction times. For example, Gottsdanker (1982) stated the theory of practice, meaning that doing the same thing over and over again, in this case playing VG, creates the effect of individual getting faster compared to their previous speeds. Gottsdanker (1982) also pointed out that practice effect also affects learning however practice arrives before learning ideation meaning with enough practice individuals are able to learn. On the other hand, Bavelier, Green, Pouget and Schrader (2012)

stated the theory of learning, meaning that doing the same behaviour leads to learning of the task which results in spending less attention to the task compared to the first time when the individual come across the task.

# Chapter 4

# REACTION TIME, AGE AND VIDEO GAMES

The aim of this chapter is to summarize current findings related to how age is related to reaction time and VGP. Toril, Reales and Ballesteros (2014) conducted a meta-analysis of studies between 1986 and 2013 on younger and older adults concerning VGP. They tried to find if it was possible to train older adults via playing VG to see if it affects cognitive enhancement. Researchers noted that results are mixed: Some past studies found significant difference, others not. Toril et., al. (2014) investigated and compared 20 past studies and they found out that **video game training improves cognitive functions** in older adults. Researchers found out that, playing vg has different results on the individuals based on their age range, meaning older adults have less attentional resources whereas younger adults showed increased attention. Furthermore, researchers also stated that people who were playing VG at older age showed **increased well-being** and **less depression** compared to non-gamers. Also, researchers touched upon the effect called transfer effect, transfer effect theory suggests that learned effect might be 'transferred' to the other parts in the individual's life. For example, Toril et. al. (2014) suggested that the effects of VGP had an effect on older adults' cognitive abilities. This can be seen in the increase of untrained tasks within the individuals' life like playing VG increased the memory and attention of the individual because of transference effect (Toril et. al. 2014). In summary, report by Toril et. al. (2014) shows that even the older adult participants

managed to show increased reaction time and because of the „transfer effect" other cognitive functions such as attention was also increased.

Another past study done by McLaughlin, Gandy, Allaire and Whitlock (2012) stated that age defines the type of game older adults choose to play. For example they found that older adults, participants who were generally were 60 to 65 years old, preferred to play *Solitaire, Tetris, Crosswords* etc. which are more slow paced VG compared to the younger adults who play *Call of Duty, Rise of Nations, GTA*, games that require more attention and faster reaction times since in these games participants were required to shoot the enemy player or build a strategy to defeat the enemy compared to *Solitaire* where individual just plays card and tries to put them in order to win the game. Researchers also suggested that older adults generally prefer the VG if they have a high benefit to the participants. If the video game that older adults presented with does not has complicated structure, this allows individuals to engage in social activity or where they can learn new things from that video game. Which showed that older adults prefer VG that are easy to grasp and for them to understand whereas younger adults prefer the VG that are challenging and competitive in nature (McLaughlin et. al., 2012).

Many other studies also investigated the effects of the VG on older adults. A past study done by Boot, Champion, Blakely, Wright, Souders and Charness (2013) investigated the effects of the VG on cognitive functionality on older adults. Researchers suggested that playing vg affects cognitive functions in a positive way, which means that based on the findings of the researchers, older adults showed increased potential to learn new things around them after playing VG. In this study

there were 62 participants with the age range of 52 and 82, these participants were separated into 3 groups: one experimental group where participants received VGP, where they played action VG and another experimental group played 'brain fitness' games and a third control group which involved no VGP. Researchers found out that participants in the action VGP group showed increase attention levels, improved memory compared to the 'brain fitness' group and non-gamer group, (Boot et. al., 2013). In summary Boot et. al. (2013) showed that playing action VG improved attention levels and memory in older adults.

Overall findings summarized above suggests that how gaming affects cognitive abilities such as reaction time is related to age.

## 4.1 Theories that predict that gaming might affect reaction times

### 4.1.1 Practice Effect Theory

Although a number of theories have been mentioned partially and in the context of individual studies, we would like to outline explicitly a number of theoretical frameworks that predict a relationship between gaming and reaction time.

***The practice effect:*** Gottsdanker (1982) introduced the practice effect. Practice effect explains how individuals can manage tasks using less attention. Because while an individual is learning new information related to environment, that individual's attentional resources generally shifts to the new incoming information in order to help the individual better understand the information. Due to repeated exposure to the same material (i.e. practice), individual becomes able to complete the task with less attentional resources compared to the first time exposure to the material. Thus, overtime practice of the incoming information allows individual to act quickly.

This effect can be seen in video gaming as well where individuals who play VG that require fast reactions to visual and auditory stimuli tend have faster reaction times compared to non-gamers. For example, in many action VG you have to use the mouse as well as 'W, A, S, D and Spacebar' to move your character. If the individual is a new beginner to the concept it will take time to adapt to this new situation, however in time these keys become automatic and they begin to move faster or without hesitation while using these specified keys.

***Learning theory:*** However, the same concept can be adapted to the situation that an individual is learning via practicing which leads to the other theory suggested by Bavelier, Green, Pouget and Schrader (2012). These researchers pointed out that individuals begin to learn after countless trial and errors and due to the factor of practice effect. Learning theory overlaps with the practice effect, which means over time practice of a newly concept leads to a factor to let individuals learn the concept inside out, or develop mental shortcuts/strategies to quickly adapt to the new information. Furthermore learning theory allows individuals to generalize the information, for example "W, A, S, D and Spacebar" is main keys on a computer video game to move a character and over time exposure to this information pushes individual to learn these keys. Thus, after time individual learns these keys and purposes and this individual generalize the same key pattern to the other video games.

***Transference Effect:*** Past study done by Toril, Reales & Ballesteros (2014) showed that there is an effect called 'transference effect'. Transference effect can be explained as a function that affects the other functions. It suggests that when an

individual is learning a new skill or behaviour, that skill can be transferred to the other functions in the brain, cognitively speaking. For example, Toril et., al. (2014) showed that video games are affected by video game playing and one of the effects is transference. Transfer effect is able to improve untrained tasks that individuals did not trained for in their life. With this sense if the individual continues to play VG thus this event would increase an individual's attention. However, with the help of the transfer effect individual will also be able to increase the memory span.

***The present study:*** A look at the literature on age, gaming and reaction times presented above suggests that VG can have a positive effect on reaction times on both younger and older adults. Theories which predict that VG must enhance reaction times include practice and transference theories outlined in the previous paragraphs above. According to these theories the following hypotheses should be supported:

Hypothesis 1: VG players will have faster reaction times compared to non-VG players, because gaming requires quick responses depending on visual output of the screen (a characteristic of reaction time tests);

Hypothesis 2: There will be a difference in reaction times between younger and older adults.

One novel contribution of our study to the literature is that past studies generally used simple and choice reaction task combined, however in this study we aim to use pure simple reaction on both younger and older adults by using quasi-experimental study. Also, past studies concerning video game play did not rule out expectations of video game play does improve the brain of the individual. We asked participants

whether they knew if VGs would impact their brain to rule this expectation out. We conducted our study to test the hypotheses outlined above.

# Chapter 5

# METHOD

## 5.1 Participants

A total of 60 (30 younger adult males and 30 older adult males) participated in the study. In the table 1, the average age for all separated groups can be seen. Undergraduate students from Eastern Mediterranean University (EMU) and older adults were reached via word of mouth to collect data from them. All participants were classified as either gamers (i.e., individuals who self-report more than 5 hour of gameplay within a week) or non-gamers (i.e., individuals who self-report either no game playing or game play of less than 1 hour per day). Six individuals, two younger adults (one gamer and one non gamer) and four older adults (two gamers and two non-gamers), have been removed from the study as outliers after the inspection of the box plot distributions of reaction time data. These participants' average reaction times were slower than 1.5 times the interquartile range of all participants reaction times.

Table 1. Average age range and standard deviation of each group

| | Average age range and SD |
|---|---|
| Younger Adults | |
| Gamer | 23.14 (3.46) |
| Non-Gamer | 21.53 (2.06) |
| Older Adults | |
| Gamer | 42.64 (6.92) |
| Non-Gamer | 47.23 (6.61) |

## 5.2 Materials

The following materials have been used to collect data for the current study:

For basic understanding, researchers did not include post-computer game questionnaire to the results section of this study. Since post computer game questionnaire was developed by the researchers to understand the ideations of the participants. However, post-game computer game questionnaire was distributed to the participants before the end of each research to each participant yet the collected data was more comment based on the existing question, rather than a likert scale like demographic questionnaire or computer game questionnaire. That is why post-computer questionnaire was not investigated within the results section of this study. On the other hand, Demographic Questionnaire, Computer Game Questionnaire and Deary-Liewald Reaction Time Task were also tested yet were added to the SPSS and their results were added to the research.

**Demographic Questionnaire.** Demographic questionnaire was used to obtain demographic information (e.g.,gender ,age, education, marital status, handedness, occupation) from participants and to match groups (i.e., gamer versus non-gamer). Also, participants answered the questions regarding their video game playing habits based on years of experience and weekly video game play activity.

**Computer Game Questionnaire.** This questionnaire, developed by Karakuş, Inal and Çağıltay (2008) was used to investigate participants' computer usage and VGP habits such as how many hours they spend playing VG and the types of games they play. Based on participants' answers to the questions on this questionnaire, they will be separated into the two comparison groups that is gamer and non-gamer**.**

**Deary-Liewald Reaction Time Task.** This computer program was used by Deary, Liewald and Nissan (2010) and can run both SRT and CRT tasks, in which, the number of trials and how many milliseconds (ms) participants were expected to react to the symbol "X" by pressing "Spacebar" to signify the appearance of the symbol. Deary et al. (2010) used the same method on younger adults with 8 practice trials and 20 experimental trials. According to the Dictionary of Biology (Encyclopedia, 2019), visual reaction time is 180 ms but average value is generally considered between 150 ms and 250 ms. For the present study, participants had been seated in front of a standard laptop. The laptop was a black *ASUS* brand laptop with processor of Intel(R) Celeron(R) CPU 1000M and 180 GHz, with 4.00 GB RAM. It had 1366 x 768 screen resolution with a keyboard and mouse connected through the USB port. Operating system on the Laptop was a 64bit *Windows 7 Ultimate.* The SRT task nearly took 8 to 10 mins for each single participant for them to complete and this

task was downloaded via online. Researchers used 8 practice trials and 40 experimental trials. When the study began, a white empty box nearly 0.9° × 0.9° in size would be positioned in the middle of the screen against a blue coloured background. At the same time, below the box "Please press a button to begin" command was present. A black cross 0.7° × 0.7° in size would appear in the white box at random times between 1000 ms and 3000 ms after the response of the participant to the previous trials. “X” stayed on the screen until a response was made by the participant. Furthermore, if the participant reacts faster than 150 ms or slower than 15000 ms, that response is not recorded by the program.

In this scenario, participants were required to press "B" button to both begin the experiment also react/indicate when the 'X' symbol appeared on the computer screen. Firstly, participants had to complete 8 practice trials before experimental condition. After practice trials programs thanks to the participant. The test environment was silent the whole time to avoid distraction when participants were seated. The program was able to detect and ignore the untimely press of the participant, meaning if participant pressed the “B” button before appearance of “X” on the screen program ignores the pre-reaction of the participant. With this sense, participants were expected to press the “B” key with their dominant hand’s index finger when the “X” symbol appeared on the screen to test participants’ reactions using this program where simple reaction time task was measured. At the end of 40 experimental trials a message will read “Test Completed Thank You!” and participant was asked to wait for the message to disappear, nearly about 5 to 10 seconds, from the screen since the program closes itself at the end of trials signaling the end of the reaction time task experimentation.

**Post Computer Game Questionnaire.** This questionnaire was given to the participants at the end of the research to assess their knowledge regarding the cognitive benefits of VG and ensure that participants in both groups (i.e., gamer and non-gamer) had an equal level of knowledge and expectations regarding the effect of gaming on cognitive skills. Participants were required to answer questions with either yes and give a little explanation or simply signifying no to the question. Some of the questions on this questionnaire included: (1) "Do you believe that playing VG has an effect on our behaviors and cognitive skills?" "If so, what kind of effect do you think VG can have on us and can you please explain how you acquired this knowledge (e.g., via the media)", (2) "Do you think that playing VG can affect reaction time?". "If so, what kind of effect do you think gaming will have on reaction time?" This questionnaire was also filled on the computer. Researcher used the items and these items were created by the researcher to learn about the participants expectations. This survey was not used in the statistical analysis section since this questionnaire has no statistical value that contributes to the research when investigated from statistical perspective.

### 5.2.1 Design

We used a 2 (age group: Younger vs. older adults) x 2 (gamers vs. non-gamers) between subjects design. The cut off used for grouping participants into younger vs. older adults was 35 (younger adults were aged 18-34, older adults were aged 35 or older), followed by the cutoff determined for gaming was if the participant was playing 5 hours within a week they were considered as gamers. Computer Game Questionnaire (Karakuş, Inal & Çağıltay, 2008), described in the materials section above, was used for grouping participants into gamer vs. non-gamer groups. Dependent variable of interest was simple reaction time. The method (Deary,

Liewald & Nissan, 2010) used for measuring reaction time is also detailed in the materials section.

## 5.3 Procedure

Upon ethics approval from EMU Research and Ethics Committee, prospective participants were approached, informed of the study aims, and invited to partake in the study. Those willing to participate signed the Informed Consent Form indicating of their voluntary participation. Each participant was tested individually at the EMU Faculty of Arts and Sciences Laboratory and each session lasted approximately 20 minutes. Voluntary participants first completed the demographic questionnaire and then the computer game questionnaire. Following this, participants first practiced the "Deary- Liewald reaction time task" before completing the experimental section of this task. In reaction time task Participants had been seated in front of a standard laptop and required to complete the task. The screen turned dark blue colour and in the middle of the screen a white empty box nearly 0.9° × 0.9° in size would be presented and below the box "Please press a button to begin" command was present. A black cross 0.7° × 0.7° in size would appear in the white box that is located in the middle of the screen at random times between 150 Ms and 1500 Ms. In this scenario, participants were required to press "B" button to both begin the experiment and indicate when the 'X' symbol appeared on the computer screen. In this test participants were required to do 8 practice trials and 40 experimental trials and after their completion of both practice and experimental, were saved to the laptop. After the 8 practice trials and 40 experimental trials, program thanked the participant indicating the end of the experiment. After completing the reaction time task, participants were then required to complete the post computer game questionnaire to evaluate their level of expectancy regarding the effect of VGP on reaction time.

Finally, they were provided with the Debrief Form and thanked for their participation.

# Chapter 6

# RESULTS

A two way between subjects ANOVA was conducted to compare means of reaction time in all 4 conditions. Years of experience mean for participants are presented in Table 2. Neither gaming ($F(1,50)=1.17$, $p = .474$) nor age ($F(1,50)= 0.58$, $p= 0.58$) was found to affect reaction times. Mean reaction times in the 4 conditions are presented in Table 3. ($F(1,46)= 0.143$, $p=0.707$). Levene's test results showed assumption of equal variances was not violated ($p=0.511$).

Table 2. Average years of experience in each condition

| | Mean years of experience (Standard Deviation) |
|---|---|
| Younger Adults | |
| Gamers | 5.78 (0.55) |
| Non-Gamers | 2.30 (1.72) |
| Older Adults | |
| Gamer | 3.71 (0.58) |
| Non-Gamer | 1.46 (0.49) |

Table 3. Average reaction times in each condition

| | Mean Reaction Time in ms. (StandardDeviation) |
|---|---|
| Younger Adults | |
| Gamer | 296.78 |
| Non-Gamer | 292.92 |
| Older Adults | |
| Gamer | 292.21 |
| Non-Gamer | 292.61 |

**Participant expectations and reaction times**

We wanted to eliminate the possibility that the null results we obtained in the ANOVA were due to the effects of confounding variables related to participant expectations from gaming experience. For example, it is possible that our participants thought that spending too much time playing games make people lazy, and this might lead to a decrease in reaction times. If this expectation effect is stronger in gamers and non-gamers, this might have shadowed any potential benefits of gaming on reaction times in the current experiment. We tested the effect of expectations on reaction times using participants' answers to the post-game questionnaire.

A one way ANCOVA was conducted to compare the RT between younger adult gamers (M=292.50, SD=6.14) and non-gamers (M=294.80, SD=4.49) plus older

adult gamers (M=291.60, SD=3.87) and non-gamers (M=296, SD=5.49) whilst controlling for years of video game play. We found out that there was no significant difference on video game year experience between gamer and non-gamer, $F(1,54)= 0.235$, $p= 0.630$ also there was no significant difference between younger and older participants, $F(1,54)= 0.001$, $p=0.976$ when we control the years of experience. Furthermore there was no interaction between age (younger vs. older adults) and gaming (gamers vs. non-gamers), $F(1,54)=0.066$, $p=0.799$.

Another one-way ANCOVA was conducted to compare RT whilst controlling hours that individuals play. We found out that there was no significant difference on both gamer and non-gamer, $F(1,54)=0.106$, $p=0.746$. Also there was no significant difference between older and younger participants, $F(1,54)=0.148$, $p=0.702$ when we control hours of video games within a week. There was no interaction between younger gamer/non-gamer participants and older gamer/non-gamer participants, $F(1,54)=0.351$, $p=0.556$.

We also tested the possibility that our results were affected by the expectations of the participants (related to the effects of game playing on behavioural and mental abilities). One statement in the computer game questionnaire that was provided to the participants after the SRT session was ‘Video gaming causes laziness’. We found that the expectation of gamers and non-gamers were not significantly different, $F(1,54)= 0.061$, $p=0.806$). The same was true for younger vs. older adults, $F(1,54)=0.235$, $p=0.630$). Plus there was also no interaction between younger non-gamer/gamer and older non-gamer/gamer, $F(1,54)=0.131$, $p=0.719$.

One other item on this questionnaire was “Video gaming improves your eye-hand coordination” and the results show that the expectation of gamers and non-gamers were not significantly different, $F(1,54)=0.007$, $p=0.932$ and the same was true for younger and older adults too, $F(1,54)=0.003$, $p=0.956$. This suggests that a non-symmetric effect of expectations regarding eye-hand coordination can’t explain the lack of difference in reaction time in gamers vs. non-gamers. Plus there was also no interaction between age and gaming group, $F(1, 54)=0.632$, $p=0.430$.

One other question that was provided to the participants was “VG helps you to learn new things” and results shows that the expectation of gamers about learning new things both gamer and non-gamer were not significant, $F(1,54)=0.226$, $p=0.608$, as well as younger adults and older adults, $F(1,54)=0.001$, $p=0.717$, was not significantly related to the expectation of learning new things based on while playing VG. Again, this suggests that a non-symmetric effect of expectations about learning new things can’t explain the lack of difference in reaction time in gamers vs. non-gamers.

# Chapter 7

# DISCUSSION

Aim of this study was to investigate whether VGP and age are related to improvements in reaction times. Our hypothesis was that VGP will improve reaction times compared to non-gamers. Results of statistical analyses do not support this hypothesis. Second hypothesis of the study was that younger adults' reaction time will be faster compared to older video gamers. However, the results of the study showed that this hypothesis was not supported either.

Similar results to ours exist in the literature. For example, a study by Bhattacharyyia, Das and Ashwin (2017) used simple reaction time test on participants that played VG less than 7-9 hours/week and a control group who did not play VG but had normal physical activity. Like those of the current study, their results also showed that VG does not have any effects on reaction times.

Another past experimental study done by Orosy-Fildes and Allan (1989) studied the effect of video gaming and reaction times on twenty participants. They measured choice reaction time before and after a 15-minute *Atari* VGP session. The choice reaction task session included 20 trials. During choice reaction time task, participants in the experimental group were presented with red, green, blue and white lights and were required to press a corresponding key on the keyboard to signify the colour that was on the screen, while those in the control group stayed in a room. Their results

showed that the experimental group who played VG showed *faster* reaction times compared to the control group.

These findings do not directly fit our findings. This might be due to methodological differences. First difference is that, Orosy-Fildes and Allan (1989) used an experimental design: They measured CRT before and after video gaming. However, in the current study there was no pre-test to identify participants' ability before gaming experience and current study participants did not play VG during the experiment. This might explain why the current study was not able to find any difference between gamers and non-gamers since current study relied on self-report. That is, we only asked for self-reports for the playing experience rather than making participants play VG like Orosy-Fildes and Alan (1989). Secondly, while we measured simple reaction time, Orosy-Fildes and Allan (1989) measured choice reaction time. This is one of the more important differences between the two studies. It is possible that VGP has a stronger effect on choice reaction time than simple reaction time, since choice reaction task requires more involvement from cognitive processes such as holding information regarding stimuli in memory, mapping between the stimuli and responses, selecting the correct motor response among multiple competing motor responses based on those representations (Simon & Pouraghabagher, 1978). It is possible that gaming improves skills related to such higher level cognitive processes to a greater extent than simple reaction time tasks, which doesn't involve many of the cognitive steps associated with CRT. Thus, this might be one reason why we did not see an effect of gaming, while Orosy-Fildes and Allan (1989) did.

Another study done by Goldstein et al. (1997) examined the effect of VGP on older adults' reaction times using the Sternberg test. Sternberg test involves a list that is given by the researcher to the participant and this list contains numbers and words. In order to test the memory of the participants researcher asks an item that might take part in the study or might not even presented in the list and researcher asks participants to respond with "yes" or "no" and the time taken between these responses gets taken down and these trials can take several times in an experimentation (Sternberg, 1966). And in this post-test only study, participants in the experimental group played *Tetris* for five hours a week for five weeks. The results of this study showed that participants in the experimental group had faster RT compared to the control group who did not play VG.

In summary Goldstein et. al. (1997) study signified that older adults who played video games in the experimental condition had faster reactions when their scores were compared between pre and post-test of the study.

Again, the findings of this study do not seem to fit directly with our findings in that playing VG were shown to affect performance in a task that involves responding to stimuli. This difference might be caused by the fact that participants received training before they were tested. In the current study participants did not receive a pre-test or experimental condition like the past studies. Using pre-test, researchers were able to claim that the RT difference between groups was largely affected by the game playing session that took place between pre- and post-test. However, in the current study, we used only post-test, so we couldn't be certain that the RT results were caused only by gaming experience. Another methodological point is that Goldstein et

al. (1997) used Sternberg test which is generally used to test executive function deeply. Sternberg test relies more on executive function abilities such as decision making, resolving conflict between multiple competing responses. However, in current research, researcher only used pure simple reaction task without getting to deep of the concept of both executive function and choice reaction task.

Another past study done by Dye, Green and Bavelier (2009) investigated the effects of action VG play on RT. Researcher divided the groups randomly into two groups and their experimental group played action VG such as *Call of Duty* and control group played non-action VG such as *The Sims*. *Call of Duty* is an action phased video game, where players are required to take fast actions to shoot the enemy player or enemy computer, however *The Sims* is a simulation video game where player required to build a house, create a human and play their daily life, it is calm and relaxing and slow paced video game compared to *COD*. 25 participants took part in this study and all of them were classified as non-gamers. Both experimental and control group played VG for 50 hours over 8-9 weeks between pre and post testing. The results showed that the experimental group had faster reaction time compared to the control group. This is different to our results. One methodological difference between this study and the current one is that all the participants in the past study were non-gamers whereas our participants were either gamers or non-gamers. The difference in the findings might have occurred since the current study had ex-gamers that were in the group of non-gamers due to the limitation of "In order to classify a person as gamer they had to play VG 5 hours a week over 6 months" and in the group of non-gamers some participants were ex-gamers meaning they had VGP experience however, these individuals gave up upon playing VG for various reasons

and this might be the reason that the current study was unable to detect any difference in reaction timing. Secondly in Dye et., al. (2009) participants in the experimental study played action VG and participants in the control group also played VG but none of them were action VG, however in the current study the kind of video game was not considered. Participants were simply divided into two groups based on their VGP years or hours. This is why there might be difference between the current study and Dye et., al. (2009) since past studies control group also played non-action VG even if they had no experience. However, in the current study some non-gamers did not played computer-based video games in their whole life. Third difference is that again in Dye et., al. (2009) researchers used pre and post-test to find the effect of the VGP, however in the current study pre-test were absent and post-test game questionnaire was asking about generalized ideation of the participants. Thus, this might be the reason why we do not see a difference between VGP and non-gamers like Dye et., al. (2009).

Another past study done by Boot, Champion, Blakely, Wright, Souders and Charness (2013) investigated the effects of the VG on cognitive functionality on older adults. Researchers suggested that playing vg affects cognitive functions in a positive way, which means that based on the findings of the researchers, older adults showed increased potential to learn new things around them after playing VG. Also, researchers stated that older adults showed increased attentional levels, improved memory.

These findings do not match with the current study. Because in the current study older adults was not tested for memory vise. Also based on the findings there is no

difference between younger and older adults when reaction times considered, plus individuals atrentiona was not also been checked during this study. Boot et. al. (2013) conducted an experimental study, however current study focused on quasi-experimental research.

So generally speaking, comparing the past studies and the current study's findings about the effect of gaming on reaction times suggests that the incompatible findings might be caused by differences in the methodology used. In the current study, participants did not play video games, because the current study is quasi-experimental design, but other past studies, for example Dye et. al. (2009), conducted an experimental study where participants actually played video games for a certain amount of time until the end of the experimentation.

Toril, Reales and Ballesteros (2014) done a meta-analysis on vg play between older and younger adults. Researchers stated that older adults prefer to play video games older adults have less attentional resources compared to younger adults. Based on their findings older adult participants managed to show increased reaction time.
However, in the current study showed that there is no significant difference between playing video games and reaction time when considering older adults. Also, another difference is that Toril et. al. (2014) done meta-analysis investigating past researches, however current study was quasi-experimental study where participants were collected and tested on reaction times.

In the past study done by Gottsdanker (1982), researcher stated that gamers were faster due to the over exposure to VG which allowed them to learn quickly due to the practice effect. Thus, with the help of the practice effect video gamers were faster

compared to the other groups. However, comparing the results, theory of practice and findings of the Gottsdanker (1982) to the current study it can be said that practice effect had a confounding effect on ou results due to the ex-gamers in the non-gamer group. Since results showed that there is no difference between gamers and non-gamers in reaction time. Gamers spends more time on VG however non-gamers less time or they do not play at all, the point is that ex-gamers had an experience on VG for years and they gave up on playing VG. This might resulted in reaction time results near to the gamers and this might indicate the existence of the practice effect.

On the other hand, current study investigated the laziness expectation and reaction time and the correlation within the results shows that participants do not expect that VG causes laziness. Also follow up correlation showed that there is no direct relationship between reaction time and laziness expectation. Which is a sign that participants do expect issues before hand or they have pre-existing knowledge that shapes their ideation to a certain topic thus affecting the belief system that participant does have. But we uncovered that deeper search reveals the truth about no direct relation between two different options.

Another difference between our study and past studies is the age differentiation. In current study older adults were recognized between 36 and 60, however a past study done by Goldstein et. al. (1997) older adult participants were between 69 and 90, also another past study done by Gottsdanker et. al. (1982) older adult participants were between 73 and 84 years old. This understanding between age range and the gap between past studies age group and current studies age group can lead to a different

understanding thus not giving the exact results of age differentiation compared to old studies.

There were several limitations in this study. One of the limitations might be is that all the participants were all male, both in younger and older adults category. Because during the data collection phase, female younger adults and non-gamer adult participant numbers were not near to a balance compared to male population. That is why female population was excluded from the study. Another limitation could be that some of the participants that were in the non-gamer group turned out to be ex-gamers, meaning they were playing VG in the past but they gave up on playing VG for various reasons. Researcher was not able to exclude the ex-gamers in both category because 7% of the participants in the young non-gamer group were ex-gamers, 4% of the participants in the old non-gamer group were ex-gamers. That is why researcher avoided exclusion of the ex-gamers since it would decrease the reliability of the non-gamer group. This might be an effect in findings since results signified that some ex-gamers reaction time scores were faster than gamers. Another point might be that generally combine SRT and CRT together to get the results from the participants. Past studies such as (Dye at. al., 2009) investigated video gaming by combining SRT and CRT, thus able to achieve data richness rather than just focusing SRT like the current study. Another limitation can be that most of the past studies (Dye et., al., 2009, Deleuze et., al. 2017 etc.) investigated reaction time on specified VG, such as action, MOBA, or block games etc. However, the current study tried to investigate the effect of VG on RT as a hole rather than investigating the concept based on a specific video game type.

Another limitation can be individual differences of the participants, which can be effective to the whole process Although we recorded the individual differences with respect to expectations about gaming, we were not able to control for all differences such as types of games individuals play, the amount of time they spend on video gaming, participants and their view on video gaming etc. and these items might have affected the current results.

One reason why we didn't find a difference between gamers and non-gamers might be related to the task we have chosen. Simple reaction time might be very general measure, which is affected not only by computer game experience, but also experience in daily computer related tasks, attention, personal differences etc. This might have affected the RT of participants in the non-gamers group since groups were separated by their weekly activity and past experiences. However, pure simple reaction time task did not deeply investigated the difference we suggest to use Choice Reaction Time task and Simple reaction time task combination to get way deeper results for future studies.

For future studies it is highly suggested to use a pre- post-test experimental design to find the effects of the active playing on both gamers and non-gamers. Another point is that combining choice reaction task rather than pure reaction task to see the possible effects that might occur. This would allow researcher to get rich data and able to witness the real effects of video gaming before and after the experimental condition. We also suggest to use more specific task to clearly determine which can be added to the result section since in this research, investigator look it shallow rather than intense detail. Another future direction to use SRT and CRT to achieve a rich data by comparing both methods. Another point for future studies is to investigate a

certain video game type, for example action video games, or to combine video game type, such as action video games vs strategy games. This can create a difference in order to understand the effects of the reaction times on specific VG types.

In conclusion, this study found that simple reaction time is not affected by gaming experience or age.

# REFERENCES


Anderson, C., A. & Bushman, B., J. (2001). Effects of violent VG on aggressive behavior, aggressive cognition, aggressive affect, physiological arousal, and prosocial behavior: A meta-analytic review of the scientific literature. *Psychological Science, 12* (5), 353-359.

Anderson, C., A. & Ford. (1986). Affect of the game player; Short-term effects of mildly aggressive VG. *Personality and Social Psychology Bulletin, 12* (4), 390-402.

Anderson, C., A., Shibuya, A., Ihori, N., Swing, E., L., Bushman, B., J., Sakamoto, A., Rothstein, H., R., & Saleem, M. (2010). Violent video game effects on aggression, empathy, and prosocial behaviour in eastern and western countries: A meta analytic review. *Psychological Bulletin, 136* (2), 151-173.

Bailey, K.,West, R. & Anderson, C.(2009). A negative association between video game experience and proactive cognitive control. *Psychophysiology, 47,* (1), 34-42.

Bavelier, D. & Green, C., S. (2004). Effects of VGPing on visual functions. *Journal of Vision, 4* (11), 23.

Bavelier, D., Green, C., S., Pouget, A. & Schrater, P. (2012). Brain plasticity through the life span: Learning to learn and action VG. *Annual Review of Neuroscience, 35,* 391-416.

Bhattachariyya, P., Das, S. & Ashwin, R. (2017). Exposure to VG shortens simple visual reaction time: A study in indian school children. *Original Article, 4* (1), 19-23.

Castel, A.,D., Pratt, J. & Drummond, E. (2005). The effects of action video game experience on the time course of inhibition of return and the efficiency of visual search. *Acta Psychologica, 119* (2), 217-230.

Colzato, L., S., Leeuwen, P., J., Wildenberg, W., P., & Hommel, B. (2013). DOOM‟d to switch: Superior cognitive flexibility in players of first person shooter games. *Frontiers in Psychology*, 1-8.

Chandra,S., Sharma, G., Salam, A., A., Jha, D. & Mittal, A., P. (2016). Playing action VG a key to cognitive enhancement. *Procedia Computer Science, 84,* 115- 122.

Deary,I.,J., Leiwald D. & Nissan, J. (2011). A free, easy-to-use, computer-based simple and four-choice reaction time programme: The deary-liewald reaction time task. *Behavior Research Methods, 43,* (1), 258-268.

Deleuze, J., Christiaens, M., Nuyens, F. & Billieux, J. (2017). Shoot at first sight ! First person shooter players display reduced reaction time and compromised inhibitory control in comparison to other VGP. *Computers in Human Behaviour*, 72, 570-576.

Durkin, K. & Barber, B. (2002). Not so doomed; Computer game play and positive

adolescent development. *Journal of Applied Developmental Psychology, 23* (4), 373- 392.

Dye, M., W., G., Green, S., C. & Bavelier, D. (2009). Increase speed of processing with action VG. *Current Directions in Psychological Science, 18* (6), 321-326.

Esposito, N. (2005). A short and simple definition of what a videogame is. *Worlds in Play*.

Glass, B., D., Maddox, W., T. & Love, B., C. (2013). Real-time strategy game training: Emerge of a cognitive flexibility. *Plos One, 8* (8), 1-7.

Goldstein, J., Cajko, L., Oosterbroek, M., Michielson, M., Houten, O., V. & Salverde, F. (1997). VG and the elderly. *Social Behavior and Personality, 25* (4), 345-352.

Gottsdanker, R. (1982). Age and simple reaction time. *Journal of Gerontology, 37*(3), 342-348.

Green, C., S. & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature, 423* (6939), 534-537.

Green, C., S., Sugarman, M., A., Medford, K., Klobusicky, E. & Bavelier, D. (2012). The effect of action video game experience on task switching. *Computers in Human Behavior, 28* (3), 984-994.

Howes, D. & Boller, F. (1975). Simple reaction time: Evidence for focal impairment from lesions of the right hemisphere. *Brain: A Journal of Neurology, 98* (2), 317- 332.

Kühn, S., Gleich, T., Lorenz, R.,C., Lindenberger, U. & Galliant, J. (2014). Playing super mario induce structural brain plasticity: Gray matter changes resulting from training with a commercial VG. *Molecular Psychiatry, 19* (2), 265-271.

Lajoie, Y. & Gallagher, S., P., (2004). Predicting falls within the elderly community: Comparison of postural sway, reaction time, the berg balance scale and the activities- specific balance confidence (ABC) scale for comparing fallers and non-fallers. *Archives of Gerontology and Geriatrics, 38* ,(1), 11-26.

Lövden, M., Backman, L., Lindenberger, U., Schaefer, S., & Schmiedek, F. (2010). A theoretical framework for the study of adult cognitive plasticity. *Psychological Bulletin, 136, (4),* 659-676.

Mayas, J., Parmentier, F.,B.,R., Andres, P. & Ballesteros, S. (2014). Plasticity of attentional functions in older adults after non-action video game training: A randomized controlled trial. Plos One, 9 (3), 1-10.

Murphy, K. & Spencer, A. (2009). Playing VG does not make for better visual attention skills. *Journal of Articles in Support of the null Hypothesis, 6* (1), 1-20.

Orosy-Fildes, C. & Allan, R., W. (1989). Psychology of computer use: XII. VGP:

Human reaction time to visual stimuli. *Perceptual and Motor Skills, 69,* 243-247.

Poudel, G.,R., Stout, J., C., Dominguez, J.,F., Gray, M., A., Salmon, L., Churchyard, A., Chua, P., Browsky, B., Egan, G., F & Karistianis, N., G. (2015). Functional changes during working memory in huntington‟s disease: 30-month longitudinal data from the IMAGE-HD study. *Brain Structure and Function, 220* (1), 501-512.

Rosenbaum, A., R. & Burt, D., J. (2017). Response time and puzzle solving skills in gamers vs. non-gamers. *International Journal of Exercise Science Conference Proceedings, 2* (9).

Shelton, J. & Kumar, G., P. (2010). Comparison between auditory and visual simple reaction times. *Neuroscience & Medicine, 1* (01), 30-32.

Sherry, J., L. (2001). The effect of violent VG on aggression. *Human Communication Research, 27* (3), 409-431.

Sternberg, S. (2010). Reaction-time experimentation. *Research Methods Prosem,* 1-17.

Teichner, W.,H. (1954). Recent studies of simple reaction time. *Psychological Bulletin, 51* (2), 128-149.

Wolf, M. (2012). "Introduction". In Wolf, Mark. *Encyclopedia of VG.* Westport,

Connecticut: Greenwood Press.