

Article

Not peer-reviewed version

Virtual Reality Can Be Used to Reduce the Simple and Complex Reaction Time of High School Students

[Ștefan Moroșanu](#)*, [Maria Cristina Man](#)*, [Nicola Mancini](#), [Carlos Hervás-Gómez](#), [Emilia Florina Grosu](#),
Mihai Moroșanu, Horațiu Ghejan, Mircea Boncuț, [Dana Ioana Cristea](#), [Vlad Teodor Grosu](#)

Posted Date: 10 November 2025

doi: 10.20944/preprints202511.0521.v1

Keywords: active video games; exercise; Oculus Quest; immersion; reaction time; neuroplasticity



Preprints.org is a free multidisciplinary platform providing preprint service that is dedicated to making early versions of research outputs permanently available and citable. Preprints posted at Preprints.org appear in Web of Science, Crossref, Google Scholar, Scilit, Europe PMC.

Copyright: This open access article is published under a Creative Commons CC BY 4.0 license, which permit the free download, distribution, and reuse, provided that the author and preprint are cited in any reuse.

Disclaimer/Publisher's Note: The statements, opinions, and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions, or products referred to in the content.

Article

Virtual Reality Can Be Used to Reduce the Simple and Complex Reaction Time of High School Students

Ștefan Moroșanu ^{1,*}, Maria Cristina Man ^{2,*}, Nicola Mancini ³, Carlos Hervás-Gómez ⁴, Emilia Florina Grosu ¹, Mihai Moroșanu ¹, Horațiu Ghejan ¹, Mircea Boncuț ¹, Dana Ioana Cristea ⁵ and Vlad Teodor Grosu ⁶

- ¹ Faculty of Physical Education and Sport, “Babes-Bolyai” University, Pandurilor Street 7, 400394 Cluj-Napoca, Romania
 - ² Department of Physical Education and Sports, “December 1, 1918” University, Strada Gabriel Bethlen 5, 510009 Alba Iulia, Romania
 - ³ Department of Education and Sport Sciences, Pegaso Telematic University, 80143 Naples, Italy
 - ⁴ Department of Teaching and Educational Organization, University of Sevilla, 41013 Sevilla, Spain
 - ⁵ Department of Physical Education, Sport and Physiotherapy, University of Oradea, 410087 Oradea, Romania
 - ⁶ Faculty of Industrial Engineering, Robotics, and Production Management, Technical University of Cluj-Napoca, Muncii Street 103–105, 400461 Cluj-Napoca, Romania
- * Correspondence: stefan.morosanu@ubbcluj.ro (S.M.); cristina.man@uab.ro (M.C.M.)

Abstract

Background: The consequences of video games have been a hotly debated topic in recent decades. While the media tend to focus on and publicize the alleged negative effects of video games, the empirical literature continues to research to illustrate the benefits of playing certain types of video games. With this paper we want to highlight the utility of virtual reality technology for improving reaction time. **Methods:** In the intervention program we used the Oculus Quest 2 HMD (Head Mounted Display) device (Facebook Technologies, LLC. 1 Hacker Way, Menlo Park, CA 94025, USA). To assess simple and complex reaction time we used the Deary-Liewald reaction time test. **Results:** Subjects in the experimental group showed statistically significant improvements ($p < 0.05$) between initial and final testing in reaction time tests. Subjects in the experimental group showed statistically significant improvements ($p < 0.05$) at the final test compared to the control group in simple and complex reaction time tests. **Conclusions:** With the development of technology, new opportunities have arisen to reduce reaction time using state-of-the-art technology such as virtual reality. Virtual reality by specific means - exergames or active video games, as they are also called, can be used as physical exercises and can be used as a mean to improve reaction time.

Keywords: active video games; exercise; Oculus Quest; immersion; reaction time; neuroplasticity

1. Introduction

The ability to monitor, identify, process, and respond rapidly to an unpredictable environment is an important aspect of natural behavior. Healthy individuals are skilled at generating appropriate and rapid responses in response to stimuli associated with potentially dangerous situations. These responses are called reactions and are characterized by the ability to generate extremely rapid and spatially precise movement in the face of a situation. Examples include corrective reactions to maintain balance, protective reactions when driving, or in the event of a potentially harmful stimulus.

Reaction time is defined as the time interval between the appearance of a stimulus and the initiation of a response to it [1].

There are so many situations where the ability to act a little faster can make a difference. This could apply while playing sports or in everyday life. Among the activities that a person does that

rely on fast reaction times to perform successfully are: while driving a car, when another car suddenly pulls out in front, fast reaction time can make the difference between being safe and getting into an accident. The same goes for simple falls. For a simple inattention, the brain must respond quickly to visual and tactile stimulation so that it can signal the hands to act in a timely manner. Even exposure to blinding light relies on fast reaction times to prevent any long-term damage to vision [2].

With the development of technology, new opportunities have emerged to reduce reaction time using cutting-edge technology, such as virtual reality. Active video games require visual-spatial skills, hand-eye or eye-foot coordination, and quick reaction time to successfully operate these games. In order for exergames to influence physical development, designers have developed systems to track and respond to players' gross motor movements [3].

Virtual reality through specific means - exergames or active video games, as they are also called, can be used as physical exercises and can represent a means of improving psychomotor skills and increasing the physical activity of subjects [4]. In addition to the already known effects of physical exercise, exergames would increase the brain's adaptive potential, a phenomenon known as neuroplasticity, which would result in improved problem-solving ability, as well as greater sensorimotor integration [5,6].

There is no universal definition of exergaming available. According to Bogost (2007), exergaming has been labeled by the media as "the combination of exercise and video games." Although this description is used by both the commercial industry and the scientific community, it does not serve as an adequate formal definition. This becomes apparent when we adhere to the traditional definition of "exercise" as consciously and systematically accomplishing certain set goals, according to which many available exergames (e.g., those with alternative intentions than fitness improvement) would be excluded [7,8].

Exergames differ from sedentary video games due to the physical exertion and physical capabilities required to play. Many exergames stimulate auditory and visual reaction time and hand-eye coordination. However, exergames also require other physical capabilities such as aerobic endurance, strength, balance, and flexibility to support the gameplay and narrative of the games [9]. For example, the active video game Eleven Table Tennis transposes table tennis into virtual reality through the Oculus Quest platform, it requires fast body movements, good eye-hand coordination complemented by a low reaction time to perform the specific movements of this sport [10]. The device has sensors that capture players' movements and provide instant feedback [11].

Active sports-based video games require virtual movements that provide opportunities for the user to practice skills used during sports (e.g., kicking a ball). These games were primarily designed for entertainment, but can also be a gateway to later involvement in various physical activities by developing movement skills [12].

The improvement in reaction time through exergames comes from improving the transmission of nerve impulses through neural pathways. When engaged in new experiences, the brain establishes a series of neural pathways. These neural pathways, or circuits, are routes made up of interconnected neurons. These routes are created in the brain through daily use and practice; just as a mountain path is made by the daily use of a shepherd and his flock. The neurons in a neural pathway communicate with each other through connections called synapses, and these communication pathways can regenerate throughout life. Each time we acquire new knowledge (through repeated practice), the synaptic communication between neurons is strengthened. Better connections between neurons mean that electrical signals travel more efficiently when a new pathway is created or used [13].

The VR interventions in our study could produce changes in functional cortical interactions by increasing activation in specific brain areas responsible for movement control. There is evidence of positive transfer from virtual training to real-world psychomotor improvements, supporting the use of these virtual exercises [12,14,15].

Through our work, we aimed to investigate the effects of an intervention program based on immersive virtual reality to improve reaction time in 17-19 year old students.

2. Materials and Methods

Participants

A total of 32 Romanian students, aged 17-19, were recruited from a high school in Cluj-Napoca. Participants were informed about the risks of participating in the research, and written consent was obtained from the students, and from their parents or legal representatives for minor students.

To determine the effect of the intervention program, participants were divided into two groups, one experimental (n=16) and the other control (n=16). Subjects in the experimental group participated in the virtual reality-based intervention program, subjects in the control group only participated in physical education classes in the school curriculum.

Intervention

The actual research was conducted in the high school gym, the intervention program lasted 6 months, 2 times a week, with 40 minutes each session (of which 5-7 minutes represent the preparation of the body for the effort, 30 minutes the fundamental part and 1-3 minutes the recovery of the body after the effort). Each session began with a standard warm-up, variations of the exercises to prepare the body for the effort, selective influence of the locomotor system, used in the physical education and sports lesson and ended with the recovery of the body after the effort. In the intervention program we used the HMD (Head Mounted Display) device Oculus Quest 2 (Facebook Technologies, LLC. 1 Hacker Way, Menlo Park, CA 94025, USA).

Means

One of the tools used in our study is the active video game Eleven Table Tennis. Table tennis is characterized by perceptual uncertainty and time constraints. As a dynamic sport, it involves a constantly changing visual environment. To respond to such a variable stimulus, the player must be able to obtain superior visual information about the approaching object. As a result, hitting the ball requires constant eye convergence, estimating the speed of the ball, and anticipating its direction, which is moving rapidly in space, without any special cues [11,16].

Another means used was the active video game Reakt, which directly targets complex reaction time, requiring the choice of the appropriate motor response depending on the stimulus that appears [17].

Measures

For the evaluation of simple and complex reaction time we used the Deary-Liewald reaction time test, and the Ruler Drop test was used to evaluate the reaction time of the dominant and non-dominant hands. The subjects were tested before and after the application of the intervention program. The tests were done in the same time frame, and the testing manner was similar, so that there were no errors in the experiments.

Statistical Analysis

The Shapiro-Wilk test was used to decide whether the data were normally distributed within the two groups.

Descriptive statistics and t-test were conducted for comparison of subject characteristics between both groups. Independent T test was conducted to compare mean values of the measured variables between both groups and paired t test was conducted to compare between pre and post treatment mean values of the measured variables in each group. ANCOVA was not required given baseline equivalence and small sample size.

The level of significance for all statistical tests was set at $p < 0.05$. All statistical tests were performed through the statistical package for social sciences (SPSS) version 29 for windows (IBM SPSS, Chicago, IL, USA).

3. Results

The experimental research was conducted on a group of 32 subjects, of which 16 subjects in the experimental group and 16 subjects in the control group.

To compare differences within the same group before and after the intervention program, we used the paired t-test when the data distribution was normal and the Wilcoxon test when the data distribution was not normal.

To compare differences between the control and experimental groups, both before and at the end of the study, we used the independent t-test when the data distribution was normal and the Mann-Whitney U test when the data distribution was not normal.

Independent t-test was performed to compare the results of the initial testing on the Deary-Liewald test for simple (SRT) and complex reaction time (CRT) between the experimental group and the control group.

Independent t-test was performed to compare the results at baseline on the simple Ruler Drop reaction time test (dominant and non-dominant hand) between the experimental group and the control group.

There are no statistically significant differences ($p > 0.05$) between the 2 groups at baseline in any of the tests (Table 1).

Table 1. Mean, standard deviation and significance of difference for the reaction time tests at the beginning of the experimental study.

Pre-test	Group	N	Mean	SD	t	p	d
Deary-Liewald Test - SRT	Experimental	16	268.5	18.69	-0.15	0.87	-0.05
	Control	16	269.19	14.27			
Deary-Liewald Test - CRT	Experimental	16	402.06	26.31	0.40	0.68	0.14
	Control	16	398.25	26.72			
Ruler Drop – Dominant Hand	Experimental	16	16.61	3.21	-0.29	0.77	-0.10
	Control	16	16.93	2.99			
Ruler Drop – Non-Dominant Hand	Experimental	16	17.48	2.85	-0.50	0.61	-0.18
	Control	16	18.01	2.97			

SRT, simple reaction time, CRT, complex reaction time; N, number of subjects; SD, Standard Deviation; t, t-value; p, p-value; d, Cohen's effect size.

The independent t-test was performed to compare the results at the final testing on the Deary-Liewald test for simple and complex reaction time between the experimental group and the control group.

The independent t-test was performed to compare the results at the final testing on the simple Ruler Drop reaction time test (dominant and non-dominant hand) between the experimental group and the control group.

Subjects in the experimental group showed statistically significant improvements ($p < 0.05$) at final testing compared to the control group on the simple and complex reaction time Deary-Liewald test. In the Ruler drop test, statistically significant improvements are observed only for the dominant hand (Table 2).

Table 2. Mean, standard deviation and significance of difference for the reaction time tests at the end of the experimental study.

Post-test	Group	N	Mean	SD	t	p	d
Deary-Liewald Test - SRT	Experimental	16	253.81	14.03	-2.03	0.02	-0.71
	Control	16	266.25	20.08			

Deary-Liewald Test -	Experimental	16	382.75	21.30	-1.70	0.04	-0.60
CRT	Control	16	396.88	25.37			
Ruler Drop –	Experimental	16	14.91	3.07	-1.71	0.04	-0.60
Dominant Hand	Control	16	16.84	3.28			
Ruler Drop – Non-	Experimental	16	16.72	2.38	-1.24	0.11	-0.44
Dominant Hand	Control	16	17.88	2.87			

SRT, simple reaction time, CRT, complex reaction time; N, number of subjects; SD, Standard Deviation; t, t-value; p, p-value; d, Cohen's effect size.

The paired t-test was performed to compare the results between the initial and final testing on the Deary-Liewald test for simple and complex reaction time within the experimental group.

The paired t-test was performed to compare the results between the initial and final testing of the experimental group on the simple Ruler Drop reaction time test (dominant and non-dominant hand).

Subjects in the experimental group showed statistically significant improvements ($p < 0.05$) between baseline and final testing on reaction time tests (Table 3).

Table 3. Mean, standard deviation, and significance of difference for the experimental group’s initial and final results on reaction time tests.

Experimental Group		N	Mean	SD	t	p	d
Deary-Liewald Test - SRT	Pre-test	16	268.25	18.69	7.16	<0.001	1.79
	Post-test	16	253.81	14.03			
Deary-Liewald Test - CRT	Pre-test	16	402.06	26.31	7.60	<0.001	1.90
	Post-test	16	382.75	21.30			
Ruler Drop – Dominant Hand	Pre-test	16	16.61	3.21	7.22	<0.001	1.80
	Post-test	16	14.91	3.07			
Ruler Drop – Non-Dominant Hand	Pre-test	16	17.48	2.85	3.53	0.002	0.88
	Post-test	16	16.72	2.38			

SRT, simple reaction time, CRT, complex reaction time; N, number of subjects; SD, Standard Deviation; t, t-value; p, p-value; d, Cohen's effect size.

The paired t-test was performed to compare the results between the initial and final testing on the Deary-Liewald test for simple and complex reaction time within the control group.

The paired t-test was performed to compare the results between the initial and final testing of the control group on the simple Ruler Drop reaction time test (dominant and non-dominant hand).

There are no statistically significant differences ($p > 0.05$) between pre- and post-test in the control group in neither of the two tests (Table 4).

Table 4. Mean, standard deviation, and significance of difference for the control group’s initial and final results on reaction time tests.

Control Group		N	Mean	SD	t	p	d
Deary-Liewald Test - SRT	Pre-test	16	269.19	14.27	1.19	0.25	0.29
	Post-test	16	266.25	20.08			

Deary-Liewald Test - CRT	Pre-test	16	398.25	26.72	0.64	0.52	0.16
	Post-test	16	396.88	25.37			
Ruler Drop – Dominant Hand	Pre-test	16	16.93	2.99	0.74	0.46	0.18
	Post-test	16	16.84	3.28			
Ruler Drop – Non-Dominant Hand	Pre-test	16	18.01	2.97	1.07	0.30	0.26
	Post-test	16	17.88	2.87			

SRT, simple reaction time, CRT, complex reaction time; N, number of subjects; SD, Standard Deviation; t, t-value; p, p-value; d, Cohen's effect size.

4. Discussion

This study was conducted to determine the effect of the virtual reality exergames intervention program on reducing simple and complex reaction time in high school students.

We can't talk about improving reaction time without talking about muscle memory. Muscle memory makes all the difference. At anything we're good at, we were probably slow and pretty clumsy to begin with. Through practice and repetition, we develop muscle memory. Muscle memory allows our bodies to be more efficient in our movements. Over time, our minds will rewire themselves to increase the speed at which we access the information we use most. Much like a computer will store information from a hard drive in RAM that it needs to use quickly and more often. The brain has about 10 thoughts per second, but we can only choose one. If we choose the same one every time, the brain will access that thought faster, more automatically. The speed of transmission of nerve impulses is the same, but the latency has improved. For example, a tennis player can improve his court movement or his forehand. While the speed of nerve signals does not change with practice, practice improves the coordination of complex signals between nerves, also known as muscle memory. Brain cells adapt to communicate differently, making these activities more automatic. The real key to reaction time is practice. By repeating the same movements, you make them almost automatic. This is why professional baseball players can hit balls coming at them at 93 mph. It is possible to improve reaction time through practice. When we begin to acquire a new physical skill through repetition, our nervous system creates new neural pathways. The more we practice something, the better connected and more efficient the members of that neural pathway (eyes, brain, muscles) become. This is often referred to as muscle memory [18].

One of the tools used in our study is the active video game Eleven Table Tennis. Table tennis is characterized by perceptual uncertainty and time constraints. As a dynamic sport, it involves a constantly changing visual environment. To respond to such a variable stimulus, the player must be able to obtain superior visual information about the approaching object. As a result, hitting the ball requires constant eye convergence, estimating the speed of the ball, and anticipating its direction, which is moving rapidly in space, without any special cues [11,16].

Politopoulos et al. (2015) presented a case study in which an active video game called Tennis Attack was used to exercise and improve the reaction time of tennis players. After evaluating the game, the researchers analyzed the players' reaction times to see if there was any significant change. The results were positive as there was an improvement in the players' reaction times. Players between the first and fifth rounds had statistically significant changes in their times (<0.05) [19].

There are various mechanisms to explain the faster reaction time after the virtual environment intervention program. This may be due to improved concentration, alertness, and improved speed and accuracy of muscle coordination [1,20].

Active video games have the potential to stimulate neuroplasticity through the complexity of the task in the virtual environment. Neuroplasticity refers to "the ability of the nervous system to modify its organization" [21]. These adaptations, for example, can occur as a consequence of coordination training, resulting in the learning and acquisition of new skills. Since research has shown that virtual environments appear to stimulate cognitive functions, as well as improve neural connections, active video games therefore have the potential to promote neuroplasticity [22].

Although the literature has mainly focused on the use of exergames for health improvement or maintenance [23,24] and rehabilitation [25] and most studies have investigated the effects of exergames on the elderly [23] or people with disabilities [26], we were also able to identify studies that are consistent with our study and that aim to improve psychomotor skills [27–29].

According to Costa et al. (2019) the virtual environment has a double task, requiring not only physical but also cognitive participation simultaneously. The high intensity of cognitive and sensory flow can be associated with adaptive changes in the functional and structural brain, also mediated by trophic factors. In short, according to the physical effort provided by the virtual environment, the increased muscular demand would increase the synthesis of peripheral trophic factors and anti-inflammatory cytokines, which would circulate to the brain and increase the neuroplastic potential in the hippocampus and in the frontal and parietal cortex. Synaptic plasticity is perhaps the pillar on which the amazing malleability of the brain rests.

Devranche et al. (2005) examined the effect of an experimental manipulation on complex reaction times, fractionating it into premotor and motor time and the possibility of determining whether the effects of the manipulation on reaction time occur after or before the onset of electromyographic activity and, therefore, whether they affect the execution of the response. Premotor time represents the time interval between the triggering of the response signal and the onset of electromyographic activity, while the time interval between the onset of electromyographic activity and the onset of the required motor response is called motor time. Motor time reflects the duration of the actual execution of the response, which constitutes the neuromuscular component of the motor adjustment stage, while premotor time reflects the duration of all preceding processes [30].

The results of the study show that complex reaction time was faster in the exercise condition (262 ms) than in the resting state (275 ms). The authors emphasize that physical exercise affects motor time, but exerts little influence on premotor time [30].

Another study that focused on the acute effects of active video games is that of Guzmán & López-García (2016) in which aerobic exercise alone and aerobic exercise combined with active video games decreased reaction time and motor reaction time, showing an improvement in perception, decision-making and neuromuscular processes. However, like the study by Barbosa et al. (2020), they failed to support the second hypothesis, according to which aerobic exercise performed in combination with active video games would improve choice reaction time more than aerobic exercise performed alone [31].

Barbosa et al. (2020) investigated the acute effect of a single session of virtual reality exercise (exergames). The games used were: “Sword Play Speed Slice” and “Table Tennis”, both from the Wii Sports Resort package. The mean age of the participants was 9.71 ± 1.27 years. A reduction in simple reaction time from $(1.04 \pm 0.22 \text{ s})$ to $(0.93 \pm 0.19 \text{ s})$ was found after the exergames session ($t = 2.39$, $df = 16$, $p = 0.02$), with a moderate effect size (Cohen $d = -0.48$). However, no statistically significant improvement was found in complex reaction time between the initial test $(1.26 \pm 0.50 \text{ s})$ and the final test $(1.06 \pm 0.19 \text{ s})$ ($t = 0.89$, $df = 16$, $p = 0.38$). This may be due to the too short intervention time (a single session), as a long time is needed for improvements in neuroplasticity to occur in order to speak of an improvement in complex reaction time. The improvement in simple reaction time after a single session may be due to the improvement in the concentration and vigilance of the participants [15].

A study conducted by Politopoulos & Tsiatsos (2022) involving 60 students (31 males and 29 females, $M = 22.57$ years, $SD = 1.88$) randomly selected from the Department of Physical Education and Sports Science and the Department of Computer Science showed impressive results on reaction time tests, as there was a significant difference ($\text{sig} < 0.005$) between the initial and final testing.

The researchers also found that the improvement was not related to gender. Both female and male students had the same improvement, as there were no statistically significant differences between their mean values [32].

Tharani et al. (2020) conducted a study consistent with our study and regarding the age of the selected sample, the study was conducted on 10 participants aged between 18-24 years. with the aim

of discovering the effect of virtual reality games on stress, anxiety and reaction time after 4 weeks of intervention. Analysis of the results indicated a significant difference between the initial and final testing for all variables ($p < 0.05$) [33].

Another study that aimed to improve reaction time through exergames conducted by Ziagkas et al. (2018) reported an improvement in reaction time after the intervention program. The experimental group presented a mean reaction time $M = 0.844$ s, $sd = 0.092$ and the control group $M = 1.045$ s, $sd = \pm 0.205$. The experimental group presented a significant improvement ($p = 0.000$).

They confirm the hypothesis regarding the improvement in reaction time, as the intervention group that played Tennis Attack twice a week for half an hour, presented significantly better results in the reaction time test than those in the control group [34].

Amprasi et al. (2021) conducted a study to define the effect of two educational interventions, an immersive virtual reality program and a traditional program, on improving reaction time in children aged 8-10 years. Similar to our study, the researchers confirmed the hypothesis that participants who practiced in immersive virtual reality improved their reaction time [35].

Technology such as video games plays a complicated role in physical inactivity. Traditionally, video games have contributed to the epidemic of physical inactivity, being blamed for individuals' sedentary lifestyles. On the other hand, newly emerging active video games have been increasingly used to promote physical activity and health among diverse populations [36].

Regarding the theoretical impact, we note that we did not identify any study in the literature that used a long-term structured intervention program in immersive virtual reality in clinically healthy high school students to improve their reaction time and this was an opportunity for us to test the effectiveness of this tool. Our study shows that a well-structured 6-month virtual reality program can improve simple and complex reaction time in high school students.

At the level of practical impact, following our research we can state that our hypotheses have been confirmed and this means could be used by high school students to decrease simple and complex reaction time, which represent some of the most important psychomotor skills for the current or future involvement of students in various forms of organized physical exercise.

5. Conclusions

Following the experimental research, we were able to reach the following conclusions:

The virtual exercise program proved to be a pleasant but also demanding activity for the students, as evidenced by the fact that none of the participants abandoned the study, even though it had a relatively long duration, namely 6 months.

Subjects in the experimental group showed statistically significant improvements ($p < 0.05$) between the initial and final testing in the reaction time tests.

Subjects in the experimental group showed statistically significant improvements ($p < 0.05$) at the final testing compared to the control group on both tests.

We can therefore state that virtual reality through specific means - exergames or active video games, as they are also called, can be used as physical exercises and can represent a means of improving students' reaction time.

However, the study has some limitations. One of them is the relatively small number of subjects. Another limitation is that the participants, even though they stated that they did not participate in organized motor activities in their free time, participated in physical education classes in the school curriculum in addition to our intervention program, which could have contributed to some extent to the improvements observed in our study.

Author Contributions: All authors contributed equally to the current study. All authors contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by the lead author. The first draft of the manuscript was written by the lead author. All authors reviewed and edited the manuscript, before approving the final manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: This study adhered to the principles of the Declaration of Helsinki. The study involving human participants were reviewed and approved by The Scientific Council of the Babeş-Bolyai University of Cluj Napoca (Nr. 1083/27.01.2023).

Informed Consent Statement: Informed consent was obtained prior to conducting this original investigation.

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

Acknowledgments: The authors are grateful to all volunteer participants.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

HMD	Head Mounted Display
VR	Virtual Reality
SRT	Simple reaction time
CRT	Complex reaction time

References

1. Garg, M.; Lata, H.; Walia, L.; Goyal, O. "Effect of aerobic exercise on auditory and visual reaction times: a prospective study," *Indian J Physiol Pharmacol* **2013**, vol. 57, no. 2, pp. 138-145.
2. Roda. (2020) <https://reflexion.co>. [Online]. <https://reflexion.co/blog/improve-reaction-time/>
3. Staiano, A.; Calvert, S. "Exergames for physical education courses: Physical, social, and cognitive benefits.," *Child Dev. Perspect.* **2011**, vol. 5, no. 2, pp. 93-98. doi: 10.1111/j.1750-8606.2011.00162.x.
4. Moglia, A. et al. "A Systematic Review of Virtual Reality Simulators for Robot-assisted Surgery," *J. Eur. Urol.* **2016**, vol. 69, no. 6, pp. 1065-1080. doi: 10.1016/j.eururo.2015.09.021.
5. Dye, M.W.; Green, C.S.; Bavelier, D. "Increasing speed of processing with action video games," *Curr. Dir. Psychol. Sci.* **2009**, vol. 18, no. 6, pp. 321–326. doi: 10.1111/j.1467-8721.2009.01660.x.
6. Moroşanu, Ş. et al. "Enhancing psychomotor skills in high school students using virtual reality," *Journal of Physical Education and Sport* **2024**, vol. 24, no. 6, pp. 1434–1440 <https://doi.org/10.7752/jpes.2024.06162>.
7. Bogost, I. *Persuasive games: the expressive power of videogames.*: The MIT Press, **2007**.
8. Mancini, N. et al. "The relationship between reaction time and agility performance in young athletes: A study using perception–action technological devices," *Journal of Physical Education and Sport (JPES)* **2024**, vol. 24, no. 12, pp. 2205- 2215. <https://doi.org/10.7752/jpes.2024.12320>.
9. Vaghetti, C.A.; Monteiro-Junior, R.S.; Finco, M.; Reategui, E. "Exergames Experience in Physical Education: A Review," *Physical Culture and Sport. Studies and Research* **2018**, vol. 78, no. 1, pp. 23-32. DOI:10.2478/pcssr-2018-0010.
10. Bhabhor M.; Vidja, K. "A comparative study of visual reaction time in table tennis players and healthy controls," *Indian Journal of Physiology and Pharmacology* **2013**, vol. 57, no. 4, pp. 439-442.
11. For Fun Labs. (2020) <https://elevenvr.com/>. [Online]. <https://www.meta.com/experiences/1995434190525828/>
12. Hulteen, R.M.; Johnson, T.M.; Ridgers, N.D.; Mellecker, R.R.; Barnett, L.M. "Children’s movement skills when playing active video games," *Perceptual and Motor Skills* **2015**, vol. 121, no. 3, pp. 767–790. <https://doi.org/10.2466/25.10.PMS.121c24x5>.
13. CogniFit. (2024, May) <https://www.cognifit.com/>. [Online]. <https://www.cognifit.com/brain-plasticity-and-cognition>
14. Gray, R. "Transfer of Training from Virtual to Real Baseball Batting," *Frontiers in Psychology* **2017**, vol. 8, pp. doi: 10.3389/fpsyg.2017.02183.

15. Barbosa, E.O.; Frankly, D.; Sales, O. "Virtual Reality-Based Exercise Reduces Children's Simple Reaction Time," *International Journal of Sports Science* **2020**, vol. 10, no. 5, pp. 112-116. DOI:10.5923/j.sports.20201005.03.
16. Asar, S.; Ezabadi, R.R.; Baghini, A.S.; Maleksabet, N. "The Relationship Between Reaction Time, Eye-Hand Coordination with Visual Field in Elite Table Tennis Players," *Asian Journal of Sports Medicine* **2022**, vol. 13, no. 2, pp. <https://doi.org/10.5812/asjsm-115787>.
17. Neurotrainer. (2021) reakttrainer. [Online]. <https://www.reakttrainer.com/>
18. Rochester, University of Rochester Medical Center. <https://www.urmc.rochester.edu/>. [Online]. <https://www.urmc.rochester.edu/encyclopedia/content.aspx?ContentTypeID=1&ContentID=562>
19. Politopoulos, N.; Tsiatsos, T.; Grouios, G.; Ziaqkas, E. "Implementation and evaluation of a game using natural user interfaces in order to improve response time," in *International Conference on Interactive Mobile Communication Technologies and Learning (IMCL)*, Thessaloniki, Greece, **2015**, pp. 69-72. doi: 10.1109/IMCTL.2015.7359557.
20. You, S.H. et al. "Virtual Reality-Induced cortical reorganization and associated locomotor recovery in chronic stroke," *Stroke* **2005**, vol. 36, no. 6, pp. 1166-1171. doi: 10.1161/01.STR.0000162715.43417.91.
21. Bavelier, D.; Neville, H.J. "Cross-modal plasticity: Where and how?," *Nat. Rev. Neurosci.* **2002**, vol. 3, no. 6, pp. 443-452. doi: 10.1038/nrn848.
22. Brown, J. et al. "Enriched environment and physical activity stimulate hippocampal but not olfactory bulb neurogenesis," *Eur. J. Neurosci.* **2003**, vol. 17, no. 10, pp. 2042-2046. DOI: 10.1046/j.1460-9568.2003.02647.x.
23. Anderson Hanley, C. et al. "Exergaming and older adult cognition," *American Journal of Preventive Medicine* **2012**, vol. 42, no. 2, pp. 109-119. doi:10.1016/j.amepre.2011.10.016.
24. Buettner, R.; Baumgartl, H.; Konle, T.; Haag, P. "A Review of Virtual Reality and Augmented Reality Literature in Healthcare," **2020**, pp. 1-6. doi: 10.1109/ISIEA49364.2020.9188211.
25. Taylor, M.; Griffin, M. "The use of gaming technology for rehabilitation," *Multiple Sclerosis Journal* **2015**, vol. 21, no. 4, pp. 355-371. DOI: 10.1177/1352458514563593.
26. Lee, H.S.; Park, Y.L.; Park, S.W. "The Effects of Virtual Reality Training on Function in Chronic Stroke Patients: A Systematic Review and Meta-Analysis," *BioMed Research International* **2019**, pp. doi: 10.1155/2019/7595639.
27. Dos Santos, H.; Bredehoft, M.D.; Gonzalez, F.M.; Montgomery, S. "Exercise video games and Exercise Self-Efficacy in children," *Global Pediatric Health* **2016**, vol. 3, pp. 1-6. doi: 10.1177/2333794X16644139.
28. Ye, S.; Lee, J.E.; Stodden, D.F.; Gao, Z. "Impact of Exergaming on Children's Motor Skill Competence and Health-Related Fitness: A Quasi-Experimental Study," *J. Clin. Med.* **2018**, vol. 7, no. 9, pp. doi: 10.3390/jcm7090261.
29. Rutkowski, S.; Adamczyk, M.; Pastuła, A.; Gos, E. "Training Using a Commercial Immersive Virtual Reality System on Hand-Eye Coordination and Reaction Time in Young Musicians: A Pilot Study," *International Journal of Environmental Research and Public Health* **2021**, vol. 18, no. 3, pp. doi: 10.3390/ijerph18031297.
30. Davranche, K.; Burle, B.; Audiffren, M.; Hasbroucq, T. "Information processing during physical exercise: a chronometric and electromyographic study," *Exp. Brain Res.* **2005**, vol. 165, no. 4, pp. 532-540. DOI: 10.1007/s00221-005-2331-9.
31. Guzmán, J.F.; López-García, J. "Acute effects of exercise and active video games on adults' reaction time and perceived exertion," *Eur. J. Sport Sci.* **2016**, vol. 16, no. 8, pp. 1197-1203. doi: 10.1080/17461391.2016.1186744.
32. Politopoulos, N.; Tsiatsos, T. "Tennis attack: an exergame utilizing a natural user interface to measure and improve the simple reaction time," *Applied Sciences* **2022**, vol. 12, no. 19, pp. <https://doi.org/10.3390/app12199590>.
33. Tharani, S.A.; Kothari, P.; Shah, M.; Shah, V. "Effect of Virtual Reality Games on Stress, Anxiety and Reaction Time in young Adults: A Pilot Study," *International Journal of Health Sciences and Research* **2020**, vol. 10, no. 4, pp. 156-161.
34. Ziaqkas, E. et al. "The effect of a 12 week reaction time training using active video game tennis attack on reaction time and tennis performance," in *Interactive Mobile Communication Technologies and Learning. IMCL 2017. Advances in Intelligent Systems and Computing*, vol. 725, **2018**, pp. https://doi.org/10.1007/978-3-319-75175-7_63.

35. Amprasi, E.; Vernadakis, N.; Zetou, E.; Antoniou, P. "Effect of a Full Immersive Virtual Reality Intervention on Whole Body Reaction Time in Children," *International Journal of Latest Research in Humanities and Social Science (IJLRHSS)* **2021**, vol. 4, no. 8, pp. 15-20.
36. Huang, H.C.; Wong, M.K.; Lu, J.; Huang, W.F.; Teng, C.I. "Can using exergames improve physical fitness? A 12-week randomized controlled trial," *Computers in Human Behavior* **2017**, vol. 70, pp. 310-316. <https://doi.org/10.1016/j.chb.2016.12.086>.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.