Research Article

Design of a Set of Interfaces to Estimate Whether Computer Games Improve User's Skills and Abilities

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Abstract

This paper presents a set of interfaces to estimate the impact of playing computer games over a short period of time on players skills and abilities such as memory, reaction time and hand eye coordination. A review over other studies that have been conducted on the field with compares methodology and results is reported. The a set of 3 different systems is presented with the design of experimental protocols in order to validate such systems. Four subjects are selected at random, with all different ages and past computer game experience. These 4 subjects are all tested with the 3 proposed systems (i) before playing the computer games and (ii) after that. Results of suggest that playing computer games over a short period of time can slightly improve the reaction time and the short-term memory, as well as the hand eye coordination.

Keywords: Computer Games; Reaction Time; Memory; Hand Eye Coordination

Introduction

A computer game is an electronic game played on an electronic device that requires a form of user input such as a controller, keyboard and mouse, joystick, motion sensing device, buttons etc. The input from these devices is used to produce visual feedback on an output device such as television, monitor, touch screen, virtual reality headset etc. Video games are a form of computer game however, computer games do not always depend up on a graphic display as video games do. Computer games are split into genres including, sandbox, real time strategy, shooters (FPS and TPS), multiplayer online arena, role playing, simulation and sport, puzzles and party games, action and adventure, survival and horror, and platformer. According to McGill and Carr [1,2] "the average age of a computer game player is now 33" and "the majority of players are now adults, and the market is constantly broadening".

Computer games started becoming popular in 1978 with the introduction of the Space Invader game. By 1983 there were so many different computer games and consoles available that the market became saturated and crashed. Since 1984 computer game popularity has steadily risen. According to Newzoo as of 2021 the value of the computer game market is worth US $180.3 bn (£146.1 bn) [3].

Previous research and studies have suggested that computer games may improve gamers skills such as memory, reaction time and hand eye coordination. Memory is "the process by which we encode information, store it and eventually retrieve it" [4]. Reaction time is defined as "the time elapsing between the onset of a stimulus and the initiation of a response" [5]. Hand eye co-ordination is the "development of the ability to move muscles under the control of the senses" [6].

Studies into this subject are important because they provide research and data into cognitive enhancements which could be used in a variety of different ways and fields such as dementia care, sports, everyday use, understanding and treating age related decline, health and care, manufacturing [7-13].

In this context, this paper aims at providing an insight into the correlation between playing computer games and cognitive skills. It also aims at exploring whether factors like age, previous computer game experience and gender play a part in any cognitive enhancement games or not.

Finally, the aim of this paper is to find out whether playing computer games can enhance skills and abilities. The objective is to test four randomly selected candidates of different ages and abilities using 3 different experimental set-up to perform tests that will be carried out before and after these candidates play computer games. These tests will then be used to evaluate for any change in memory, reaction time and hand eye co-ordination.

Materials

This section details the plan and the design that will be undertaken during the research phase to test the candidate's skills. There are several different skills to be tested and different ways to test them. The three main skills that were focused on are: reaction time, memory, and hand-eye co-ordination.

The test that will be used to test reaction time is a basic reaction timer that works by a candidate resting their finger on a button and waiting for the red LED to turn on. When the LED is lit the candidate will push the button as fast as they can and their reaction time will be recorded [14-18].

The memory test will be a very basic test. The candidate will be shown a series of colored shapes for 10 seconds and then questions will be asked about the shapes and colors to test the candidates short term memory [19-21].

The hand-eye co-ordination test will be a simple test that involves the candidate throwing a ball at a wall with one hand and catching it with the other [22]. The candidate will be required to do this as many times as they can within a 30 second time frame.

All these tests will be completed, and results recorded before and after playing the game(s).

Reaction time test

To carry out this test a basic reaction timer will be created to record how fast a candidate's reaction time is. To make this test one of the first decisions that had to be made was what hardware and software will be used. There are a number of different methods, programs and hardware that can be used to build a reaction timer. It was decided that the best is an Arduino circuit because the results can be measured in real-time and it is not too complex to build.

Arduino

Arduino is an open-source electronics platform based on easy-to-use hardware and software [23,24]. Arduino boards are used to read many different inputs from many different components such as light sensors, buttons, social media messages etc. These inputs can then be converted into outputs that can be used to activate motors, light LED(s), sound buzzers, post something online etc. Arduino boards work by sending instructions to the board's microcontroller via the Arduino programming language which is based on the wiring and processing programming languages.

The next task is to decide how the test would be created using the Arduino. After researching different reaction timers, it was decided that the most effective way to test the candidates would be to use a red LED that switches off for a random length of time and then relights the candidate would then have to push a push button as quickly as they can. The test was created using a wooden base with the Arduino circuit board and breadboard (a thin plastic board used to hold electronic components) attached to the top. The breadboard contains the red LED and the push button is attached to the wooden base.

The test will work as follows: the red LED will light, the candidate will then push the button to start the test, the LED will then switch off, the software will then choose a random length of time for the LED to relight. As soon as the LED relights the candidate will have to push the button as quickly as they can. Once the button has been pushed the candidate's reaction time will be sent to the serial monitor in the Arduino program. This test will be repeated 10 times and all the results will be inputted onto the spreadsheet, an average will be calculated, this will be the candidate's reaction time and can be compared after and before they play the game.

Memory test

To carry out this test a basic memory test will be created to test the candidate's memory skills. This test will be based upon short term memory tests carried out by neuropsychologist when testing people for dementia or memory assessments. These types of tests can be found easily on the internet.

Software programming language

To make this memory test the first decision that had to be made was what programming language will be used. There are many different programming languages that can be used to create this game such as Python, JavaScript, Java, C#, C, C++, Go, Ruby, Swift, MATLAB, Scala that all have advantages and disadvantages over one another. A breakaway version of the Java programming language called processing will be used as Java is an object-oriented programming language which means it easy to display images for the candidates to study and memorize.

Processing programming language

Processing is an Integrated Development Environment (IDE), it is a visual programming language that allows to sketch with codes. Processing is not a programming language on its own, it is what's known as Java-esque which means it's a language that has been created from the java programming language but it's not exactly Java SE.

Thanks to this language a set-up will be prepared where the subjects will be shown images of shapes before they play the game. After the candidate is shown the image, they will be asked to list as many of the shapes as they could recall and then answer 5 simple questions regarding the shapes and their positions. A different set of shapes will be shown to the candidates after they play the computer game(s) and different questions will be asked similar to the first ones. This will ensure that the candidates are not too familiar with the first set of shapes shown. All the candidates will be asked the same sets of questions. A first set of 5 questions decided upon were:

- What color was the heart?
- How many shapes were black?
- hat shape was above the hexagon?What color was the cylinder?
- What was the shape located in coordinate 2,3?

The second set of 5 questions decided upon were:

- What color was the L?
- How many shapes were red?
- What shape was above the arrow?
- What color was the face?
- What was the shape located in coordinate 1,3?

The scores from the first set of questions will then be compared to the scores from the second set of questions to determine if the computer game improved the candidate's ability to remember.

Lastly the program for the test will need to be created, it will work by loading and displaying the jpg image of the shapes for a set amount of time (i.e., 10s). After this time the image will disappear so the questions can be asked. Once the image has gone a reset button will appear to allow the test to be restarted.

Hand-eye coordination test

Hand-eye co-ordination is the ability to carry out activities that require use of both the hands and eyes simultaneously. Hand eye coordination is used in everyday life when driving, working, doing chores, playing sports, children playing with toys etc. Hand-eye coordination is something that is learned from a young age.

As hand-eye coordination is both a physical and mental skill the best way to test it is by carrying out a physical test with some mental input.

The test will require the candidate to stand 10 feet (i.e., 3 m) away from a wall and throw a ball at the wall with one hand and catch it with the other hand when it bounces back. The candidate would repeat this action as many times as possible within a 30 second time frame. A count will be taken of how many times the candidate catches the ball successfully. This count will determine the candidate's hand-eye coordination level.

The score levels will be as follows:

- Over 30 - Above average
- 25 to 29 - Average
- 20 to 24 - Below Average
- nder 20 - Low.

Methodology

This section will detail and discuss the implementation of the tests that were researched and designed in the previous section and will also discuss how the tests will be used once implemented to test the candidate's skills before and after they play the computer game(s).

The candidates were selected at random from a group of volunteers, they are of different age groups ranging from 18 -

65, they are of different genders (male or female), have different occupations and varying levels of previous computer game experience ranging from none to regular players. Before the study was carried out all candidates consented by signing a consent form for some of their personal information to be included in the study such as age, gender, occupation and previous computer game experience.

All the information recorded during the test will be inputted onto a password protected spreadsheet to maintain integrity and privacy.

Reaction time test

Firstly, an overview of how the reaction timer is implemented will be presented followed by a more detailed explanation which will be expanded and elaborated upon to explain key parts of the Arduino code and what it does.

To design the reaction timer the Arduino Uno board is attached with the breadboard to a wooden platform which is then attached to a wooden block which holds the push button (Figure 1). The wiring and code for the breadboard are taken from [23]:

- The LED pins connect to GND/13 on the Arduino.
- The Button pins connect to GND/2 on the Arduino.

Figure 1: Set-up of the reaction Time test.

The software loop within the Arduino board begins by picking a random amount of time from 2 to 3.5 s. This value is then stored within a variable (waitTime) and it is then used to delay the LED from switching on. Another loop is then started and runs until the button is pushed. The reaction time is then calculated, and the LED is switched back off. The reaction time is then printed and reported to the serial monitor in ms.

Memory test

An overview of how the memory test is implemented will be presented followed by a more detailed explanation which will be expanded and elaborated upon to explain key parts of the code and what it does. The program was developed in Processing Language. Images of the task were designed by means of a graphical software interface (Figure 2).

Figure 2: Set up of the Memory Test 1 (left panel) and 2 (right panel).

When the program runs the image is displayed and a timer is started that counts to 10000 ms (i.e. 10 s). Once this time has been reached the image will be replaced by a white screen via an instruction if (passedTime > totalTime) where the passedTime variable contains the amount of time that has passed (timer). The totalTime variable contains the time that is allowed to pass (10 s). Once passedTime becomes greater than totalTime the background is set to white and a button is displayed on the screen. Once the button is pressed, the program loops again and the image is redisplayed for another 10 s.

Hand-eye coordination test

The hand eye co-ordination test will be carried out in an empty room. The candidate will stand 10 feet (3 m) away from a wall and throw a tennis ball at the wall with one hand and catch it with the other this will be done as many times as possible in 30 s.

Games

The candidates will be tested with the above tests before they play any games and after they have played them. Results will be recorded before and after they play the games and compared to establish if there is an improvement in the candidate's skills. The candidates will play 6 games in total, specifically focused on the skills: reaction time, memory, hand-eye co-ordination 2 games will be played in relation to each skill. The games will be played over 6 days, 1 hour for each game. The games the candidates will play are:

- **Brain spark** - It is an arcade game that tests concentration and reaction skills. The game is straight forward. A colored circle is shown which can either be green or red. The player must tap the corresponding colored button as quickly as possible while the colored circle keeps changing color.

- **Reaction Trainer** - It is an arcade game that tests concentration and reaction skills. The game presents a number of circles in the shape of a star. These circles light up one by one and the player must tap the circle straight away.

Figure 3: The Simon game based on Arduino board.

The matching game

It is known by many different names such as pairs, concentration, tile matching. The purpose of the game is to memorize the location of the cards showing a certain picture and then to match it when a duplicate on is found.

Simon game

It is an electronic game (Ralph H. Baer and Howard J. Morrison, 1978). Simon is typically a disc shaped game with 4 different colored pads, red, yellow, blue and green. It is programmed to display a sequence of lights and sounds. We made it by using an Arduino circuit board and code from [24]. Figure 3 shows the design of the system.

Beat Saber is a virtual reality game which was developed and published by Beat Games. It takes place in a virtual world. The player uses the VR controllers which represent two colored sabers [25].

Call of Duty is a first-person shooting game based on wars. It was developed and published by Activision. The player takes control of SAS and CIA operatives as they help rebel forces in a fictional country [26].

Results

This section reports the findings of the study, discusses the results in detail and analyses what is discovered. It also compares the findings with other studies that have been carried out previously to conclude whether there are any similarities or discrepancies. All the candidates went through a pre-testing phase this entailed a reaction time test, memory test and a hand eye co-ordination test. These results refer to the final tests after this pre-testing phase.

Reaction time test

Four subjects were tested. Results are reported within table 1. The two candidates that had the quickest reaction time after playing the computer games were one male and one female, the male aged in the range of 18-30 and the female in the range of 50-55. One candidate has previous experience of playing computer games and is a regular player. The other candidate has no previous experience of playing computer games and does not play regularly. The other two subjects with the slower reaction times are both male, one aged between 60-65 and the other aged between 18-25. One candidate has no previous experience of playing computer games and is not a regular player. The other candidate has previous experience of playing computer games and is a regular player.

Memory test

The next post game test was the memory test. All candidates were shown a different set of shapes than the first test. They looked at them for the same length of time i.e., 10 s and then asked a different set of 5 questions. The results were recorded and are reported within table 2 and figure 4.

Reaction	Time 1	Time 2	Time 3	Time 4	Time 5	Time 6	Time 7	Time 8	Time 9	Time 10	Mean Time [ms]
Subject 1	236	211	299	246	222	235	217	345	280	352	264.3
Subject 2	238	239	238	220	232	230	233	251	236	235	235.2
Subject 3	421	300	260	259	297	267	273	271	279	263	289
Subject 4	188	142	173	192	190	174	186	156	169	181	175.1

Table 1: Reaction Time Test.

Subject	Questions Correct	Questions Incorrect
1	3	2
2	3	2
3	2	3
4	5	0

Table 2: Memory Test.

Subject	N of times Ball Caught
1	14
2	16
3	7
4	6

Table 3: Hand-Eye Coordination Test

One candidate answered all 5 questions correctly, two candidates answered 3 questions correctly and the last candidate answered 2 questions correctly.

Figure 4: Results of the Memory Test vs the 4 subjects.

Hand-eye coordination test

Finally, the candidates did the post-game hand eye co-ordination test. Again, all candidates were tested separately, they threw a tennis ball at a wall standing at least 10 feet (3m) away from it and they were timed for 30s. The results were recorded and are reported in table 3 and figure 5.

Two of the candidates scored 16 after playing the computer games, one was female in the age range 50-55 with no previous experience of playing computer games and is not a regular player and the other is male in the age range 18-30 with previous experienc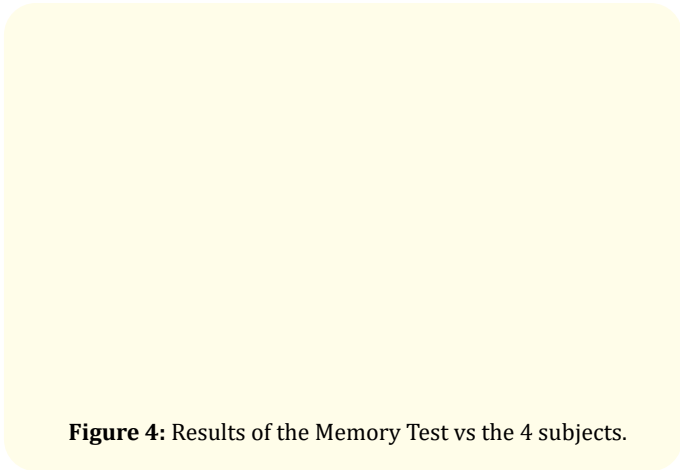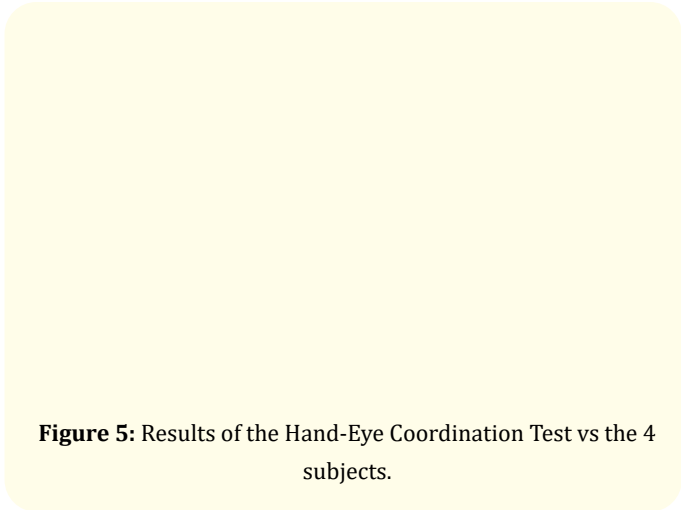e of playing computer games and is a regular player. The two lowest scorers are male, one in the age range 60-65 with no previous experience of playing computer games and is not a regular player and the other is male in the age range 18-25 with previous experience of playing computer games and is a regular player.

Figure 5: Results of the Hand-Eye Coordination Test vs the 4 subjects.

Conclusion

We presented the preparation of 3 different experimental setting where subjects were tested vs their performance in terms

of reaction time, short term memory and hand-eye coordination. Results of these testing suggest that playing computer games even over a short period of time can improve short term memory and reaction time from minimally to moderately and may slightly improve hand eye co-ordination although further studies and tests would be needed to reach a more definitive result, as the results for this test were split. Some key factors that could have had an impact on the results of this study are the ages of the candidates because memory naturally declines with age, lack of computer game experience made the candidates slower at playing the computer games and lose interest more quickly [27].

Previous computer game experience could be a key factor to take into account when carrying out further studies as this could affect results if a candidate has played the computer game before or a similar type of game this could give an inaccurate result. A way to counter this point would be to split the candidates into two groups based on their past computer game experience as done in the University of Wisconsin study [10].

Another factor that could be taken into account when carrying out future studies is different methods of testing especially hand eye-co-ordination tests to gain a more definitive result on whether computer games can improve hand eye co-ordination.

Finally, this study used computer games focused on the specific skills being tested such as reaction games for reaction testing, memory games for memory testing and games that require hand eye co-ordination for hand eye co-ordination testing. It is unclear whether this has any effect on of the results achieved but this could be something to consider when carrying out future tests/studies as well as with other type of interactions [28-31].

Acknowledgements

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