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Research Article

Method for Selecting an Engagement Index for a Specific Type of Game Using Cognitive Neuroscience

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The popularity of video games means that methods are needed to assess their content in terms of player satisfaction right from the production stage. For this purpose, the indicators used in EEG studies can be used. This publication presents a method that has been developed to determine whether a person likes an arcade game. To this end, six different indicators to measure consumer involvement in a video game using the EEG were compared, among others. The study was conducted using several different games created in Unity based on the observation ($n = 31$) of the respondents. EEG has been used to select the most suitable indices studied.

1. Introduction

Computer games can evoke many emotions in a person who likes a given type of gameplay such as excitement, competition, fun, or relaxation. Game developers are most interested in ensuring that the player reaches the level of engagement in the game to such extent that he/she is performing the current activity for as long as possible. In other words, player involvement is one of the dimensions of gaming experience and can be associated with many concepts such as [1, 2] flow [3, 4], game flow [5], presence [6, 7], immersion [8–10], pleasure [11], motivation [12–14], enjoyment [15], arousal [16], and fun [17]. Therefore, in order to unleash such a state in the recipient, it is necessary to maintain the player's involvement at a certain level, e.g., by introducing unexpected twists and turns of action, which will encourage him to further explore further areas of the game. Firstly, to assess whether a participant is not discouraged by the game, it is necessary to introduce research, among other things, into the participant's involvement in the game. In addition, the growing community of video game players is creating a demand among game developers for a better approach to indicating when and at what point the player's interest is changing. However, before you start to study what elements in the game should be improved, you should examine whether a person likes a particular type of game.

On the face of it, it may seem that evaluating a player's involvement in a video game is quite an easy task. This is not quite so, as evidenced by the methods provided by the manufacturers in the source code, which, for example, count how many blows the player took and how many times he played a particular level. It is difficult to check in real time, for example, what the player is looking at and what emotions accompany them. An example of such a module is the use of Unity Analytics if the game is created in the Unity engine. This tool helps to understand why people are playing the game or, on the contrary, why they are giving up the game. By understanding the people involved in the game and how they play, you can make improvements to the game.

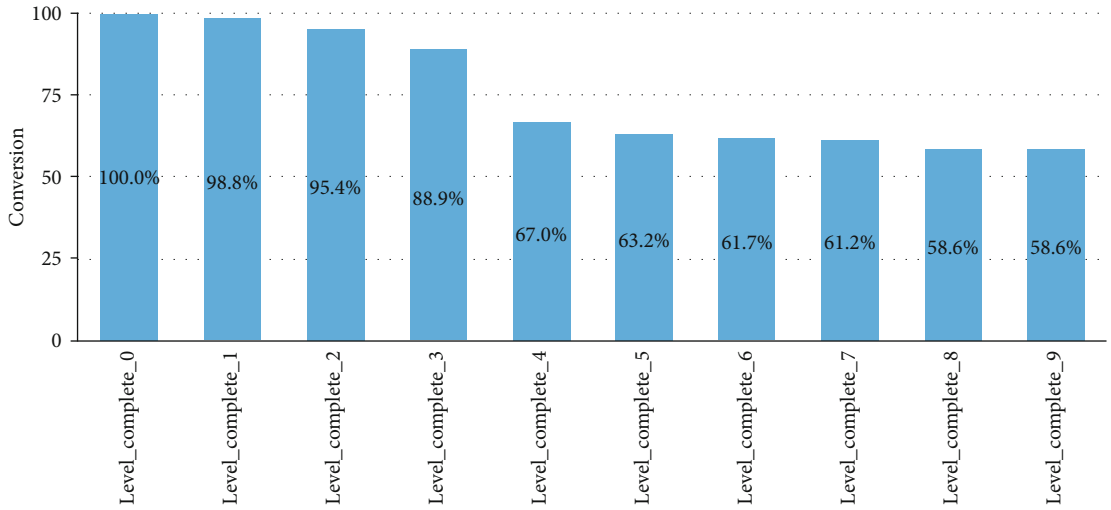

Figure 1: Level progression funnel [18].

Using Unity Analytics, you can monitor your game in the following areas [18]:

(i) *Onboarding*. Do players use mechanisms such as tutorials or starter levels?

(ii) *Progression*. Do players pass the game levels?

(iii) *Economics*. Does the game economy work as expected?

(iv) *Design Validation*. Does the game work properly?

(v) *Application Validation*. Are all application areas used as expected? Are there any items that the players ignore or do not notice?

(vi) *Earnings*. Are earning strategies optimal?

The use of the Analytics Dashboard helps analyze player behavior. The tool allows you to create paths that show how players pass through a linear step sequence. For example, you can create a tutorial sequence that shows the percentage of users that have passed the tutorial steps. Pathways are useful for identifying places in applications where we lose a player.

The sample path shown in Figure 1 shows the player's progress in a hypothetical game. Each step on the path is the completion of the game level. There is always the possibility of a decrease from level to level; too much decrease after a given level may indicate a problem at this level. The path will not give the reason—it may be due to a problem with the game, error, boredom, or level being too difficult—but it will indicate the area to be explored.

The sample path shown in Figure 1 refers to the scientific literature; several studies have used questionnaires which are not entirely a good form of investigating a player's experience [19]. The problems arise from the formulation and context of these forms [20].

The most common methods used to test a player's involvement in digital games are the following test methods [21]:

(i) *Questionnaire [6]*. By asking the appropriate questions in the survey, we can determine the degree of involvement in the individual elements of the game.

(ii) *Involvement Consisting of Focusing on Attention Using Eye Tracking (ABE) [22–26]*. The time during which the respondent looks at the elements on the monitor screen is measured. Concerning the time when the person was not looking at the monitor, it is possible to deduce how much attention the person tested gave to the game.

(iii) *Electrodermal Activity (EDA)*. This, also known as skin galvanic reaction (GSR), allows determining the emotions of the tested person based on the measurement of skin conductivity [16, 27, 28].

(iv) *Examination of Facial Expression*. The facial expressions were examined by observation [29].

(v) *Mouse Clicks and Mouse Movement [30]*. Measurements of the number and location of clicks and mouse movements allow determining the level of player involvement during the game.

The above methods are very limited. In a self-reported survey, the researcher relies on the observations of the respondent. The test person may have difficulty in remembering his or her feelings during the whole game. It is difficult to determine the exact time frame within which the growth of interest in the game begins and ends on the basis of this study. Attention-Based Engagement (ABE) depends not only on the player's engagement but also on the type of game and the situation in the game. During a fight, the player's focus on the game will be very high, because he/she has to react quickly to the opponent's actions, while in a game where the player is just wandering around the city, their focus can be lower.

Galvanic skin response (GSR) allows you to define emotions in the first place. However, it is not always that a player's involvement can be emotional. Certain elements of

the game may not generate emotions until some success or failure is achieved.

Mouse clicks and mouse movement are strongly dependent on the scenario of the game itself. They can be useful if you are able to refer to other players. You can tell from them which player is more involved and which one is less involved. For example, during a fight, the mouse movements will depend on the weapon chosen by the player and the way the opponent fights. They may, therefore, be incomparable between opponents.

It is necessary to look for such methods of engagement research that will allow determining the level of engagement at any time in the game, while not being dependent on other factors. An example of such methods is a method of cognitive neuroscience. They are becoming more and more useful because they allow us to get to know the current state of the brain. This task is facilitated by the indices calculated on the basis of the recorded signals. In the literature on the subject, numerous indices of engagement can be found, which will be presented later in this chapter. They allow us to know the level of human involvement in a given activity in a given moment.

New developments in Brain-Computer Interfaces (BCI) using wireless electroencephalographic (EEG) systems provide recordings and access to neuronal activity, enabling the computer to retrieve and analyze information from brain waves. It has been demonstrated that EEG has the ability to determine the involvement of the user [31–34]. The frequency bands are determined from the EEG signal using the spectral method. More details can be found in Section 2.5.

Using the EEG device, we can determine the preferences of the player, as well as which moment of the game is not very interesting, and we can improve it to make the player fully active in the game. New EEG devices are increasingly being used outside of medicine and are finding more and more new applications.

Using the EEG to measure the commitment of tasks is not a new concept. Pope et al. [35] built a system to control the level of automation of tasks based on whether the operator had increased or decreased his involvement. Freeman et al. [36] extended this system by evaluating the performance of each task with the use of absolute values of commitment. Berka [37] has invented a more accurate and effective method for people to interact with technology, with the ability to develop more productive work environments that increase motivation and productivity. The results suggest that the commitment measured using the EEG reflects information gathering, visual processing, and attention allocation. Smith and Gevins [38] used a flight simulator to study the reactions of the human brain to low-, medium-, and high-difficulty exercises. Studies have shown increased activity of the frontal lobe waves together with decreased activity of parietal lobe alpha waves during demanding tasks. In turn, Yamada [39] measured the activity of theta waves along with blinking of the eye and discovered that children playing video games had higher activity of theta waves during more frequent blinking. These results suggest that interesting tasks cause higher activity of theta waves, while the task inhibits the activity of blinking eyes. Kamzanova et al. [31] compared the sensitivity of a series of EEG engagement indices by examining time-pressured individuals performing tasks of varying degrees of stress to determine which one was most effective. McMahan et al. [32] investigated in the Super Meat Boy game whether there is a connection between engagement and arousal in events of death and general entertainment. The results of their research suggest that by combining engagement data with arousal data, we can establish thresholds indicating when a player has left the flow state. On the other hand, Ewing et al. [33] investigated the sensitivity of EEG power in the (front) theta and (parietal) alpha bands to changing levels of demand for play. Besides, they also conducted a study that assessed the adaptive performance of Tetris in terms of system behavior and user experience. Vourvopoulos et al.'s [34] research focuses on the impact of gaming experience on modulating brain activity, as an attempt to systematically identify elements that contribute to high BCI control and that can be used in the design of a neurogame.

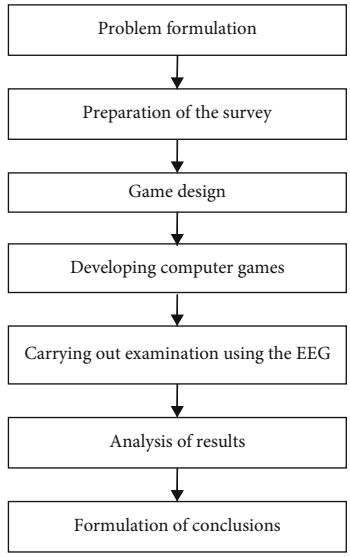

Figure 2: Proposal for a test procedure.

The above author's research studies [32–34] examine player engagement but focus on topics related to dependencies or BCI. There is no prior research that will show what approach to take in order to determine whether a person likes a particular type of gameplay. In such a case, the relationship between engagement and arousal may prove to be more accurate, because we will be able to present the results as they were presented in people who like or dislike the given type of game.

This article presents the results of the research, which was aimed at developing a method of researching the involvement of a player during an arcade game. Therefore, we can determine which index should be used to determine whether a participant likes this type of gameplay.

2. Materials and Methods

The test procedure is shown in Figure 2. The first step of the test procedure is to formulate the problem. It is presented in

Figure 3: The screenshot shows a 2D shooter computer game platform.

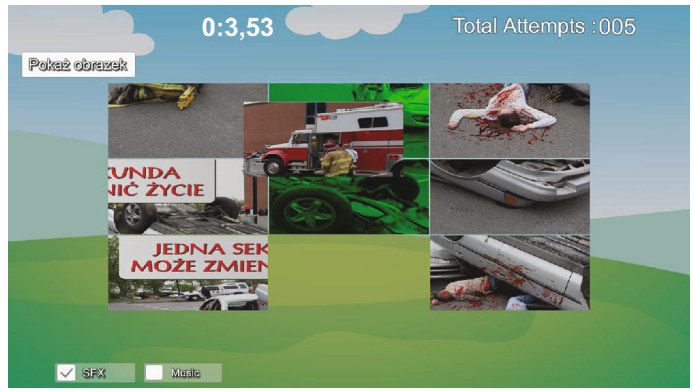

Figure 4: Screenshot showing a computer game of puzzling jigsaw puzzles.

Introduction. The second stage of the research procedure is the preparation of a questionnaire. The survey is aimed at learning about the preferences of players—their expectations as to the content of the game, their favorite type of gameplay, and the activities performed in the game. The results of the survey will be the basis for determining the player's profile.

It took several games to find out what kind of game the player was involved in. The games were created in the Unity engine in the C# language. They were made in such a way that it is possible to record in-game events in order to synchronize them with the registered EEG signals. EEG signals were recorded in a group of 31 people. First, a pilot study was carried out on several persons to verify the correctness of registration.. After the pilot study and the correction of all errors, an appropriate study was carried out.

The recorded signals were used to calculate the EEG indices. Based on the received involvement of the respondent and the respondent's answer, a comparison was made between the responses and the engagement indices. Based on this selection, it was determined which index should be used for a given type of game.

2.1. Questionnaire. EEG data were collected from 31 healthy subjects (5 = women, 26 = men), and the average age was 23. The subjects were informed about the course of the study. They then signed consent to participate in the study and seated on a comfortable chair with access to a keyboard and mouse. The next step was to put on a cap and connect the electrodes to the skin of the participant's head and to a device that recorded data from the participant's brain. After performing the above activities, the study was started. Before each game, there was information about what the game was going to be about, what goal to achieve, and how to move around in it. Immediately after the end of the survey, each participant was interviewed about their experience with computer games and which type of game is the most popular. During the game, the players were asked to organize the games in terms of their involvement.

The game of each participant was saved in the resolution of 1360×768 using the programmed registration in the game. Each shot on the screen generated a timestamp for EEG data to determine the position of the beginning and end of each section. The screenshots were saved for later reference during the data analysis phase. In addition to EEG, an eye tracker ("The Eye Tribe") was used in the study to track what was particularly important to the respondent.

2.2. Description of the Games. The games were downloaded from the Unity Asset Store and adapted to the needs of this research in the Unity engine. Before the start of the game,

Figure 5: Screenshot of a hexlogic computer game.

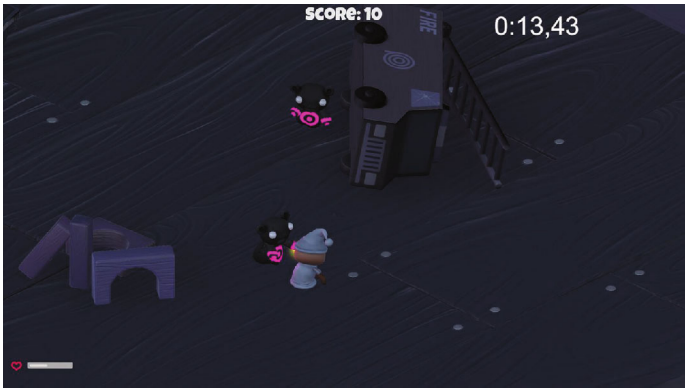

Figure 6: Screenshot of a 3D shooter computer game.

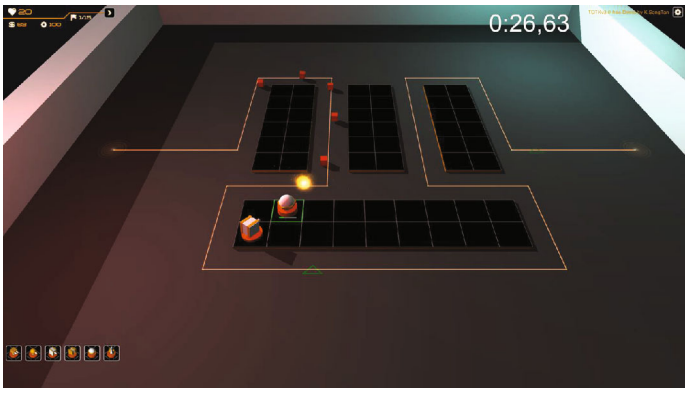

Figure 7: Screenshot of a tower defense computer game.

there was a short instruction on how to move and the purpose of the game.

The following games have been created:

(i) *2D Shooter [40]*. The game was about achieving the best possible result by killing monsters (Figure 3).

(ii) *Puzzle [41]*. The game consisted of arranging a large picture from small fragments with characteristic shapes (Figure 4).

(iii) *Hexlogic [42]*. The task was to indicate the excess number of figures (Figure 5).

(iv) *3D Shooter [43]*. Just like in the 2D shooter game, the game consisted of achieving the best possible result by killing creatures (Figure 6).

(v) *Tower Defense [44]*. The task was to stop further waves of enemies by building defense towers (Figure 7).

Figure 8: Screenshot of a flying mushroom computer game.

Figure 9: Screenshot of a computer game of time racing.

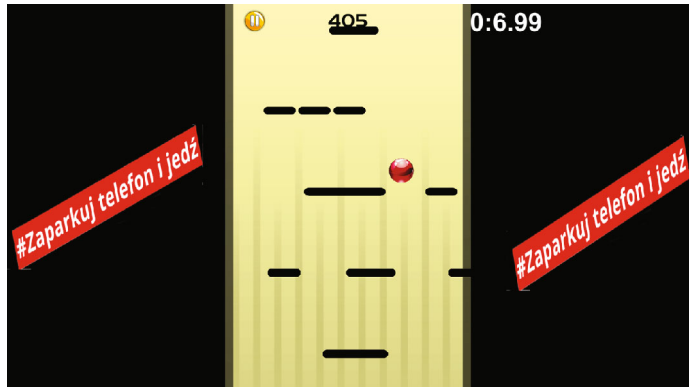

Figure 10: Screenshot showing a computer game of ball control with advertisement #Zaparkuj telefon i jedź ("#Park the phone and go").

(vi) *Flying Mushroom [45]*. The task was to fly the mushroom to the indicated location (Figure 8).

(vii) *Racing Game*. The game consisted of driving as many meters as possible avoiding obstacles (Figure 9).

(viii) *Ball Control [46]*. The task was to avoid obstacles and achieve the highest possible result (Figure 10).

Each game lasted a minute. During each game, the start and end time of the game was recorded and then saved to an Excel file.

2.3. Electrodes Used in the Examination. The cap with 21 electrodes placed in AF3, AF4, F3, F4, F7, F8, FC5, FC6, P7, P8, T7, T8, O1, O2, P3, C3, Pz, Fz, Cz, FPz, and P4 was used (see Figure 11). The channels have been distributed

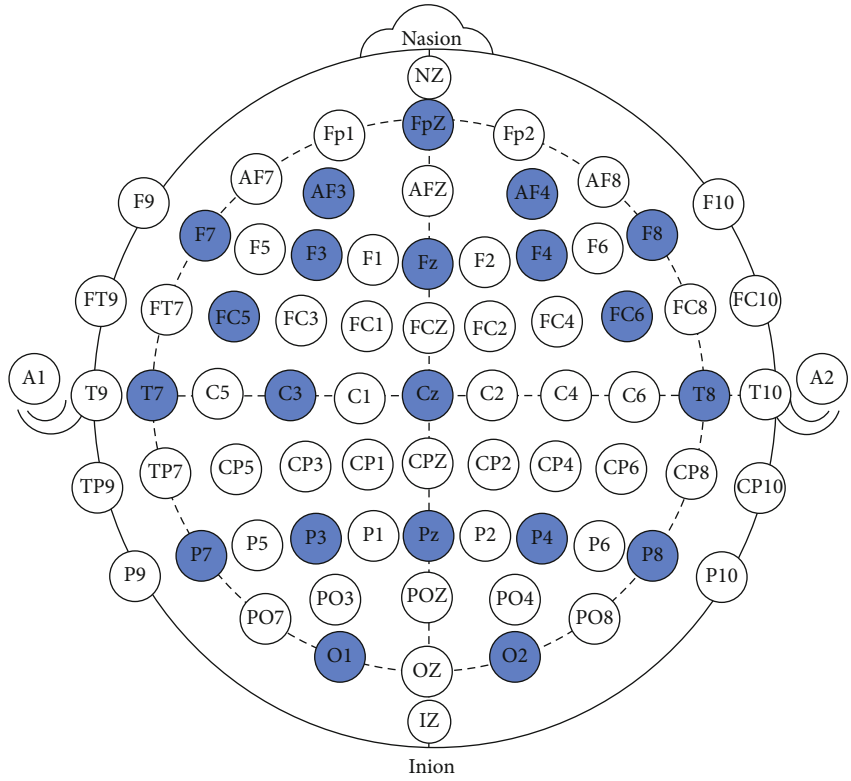

Figure 11: Sensor location on a headset.

according to the 10-10 system, the international EEG electrode distribution system [47]. The electrodes required a dampened socket to improve conductivity. The sampling frequency was 500 Hz.

2.4. Game Survey. The participants answered a series of questions evaluating previous experiences with video games and other personal characteristics. The participants were asked to submit their favorite type of game: arcade (27 people) and logical (4 people). The participants were also asked if they would qualify as "recreational players"; the answer was positive.

The last questions concerned the game itself and, more specifically, which elements of the game should be improved according to them, as well as in which situations they believe that their involvement grew and decreased.

2.5. Analysis of Data. All data were analyzed using MATLAB R2019a and Statistica. Events such as blinking of the eyes, head movements, or body movements may cause undesired EEG registration data. Most EEG analyses require the removal of such events in order to identify medical problems. However, this is not a problem to analyze the gameplay. Such events are common in everyday play [48].

The EEG measured on the scalp corresponds to a recording at frequencies of 0.5 to 30 Hz. Four basic bands are recognized in this range [49]:

(i) *Delta (0.5-4 Hz).* The brain waves of the delta are generated in the deepest meditation and sleep. Delta waves suspend external consciousness and are a source of empathy. In this state, treatment is stimulated and regeneration, which is why deep restorative sleep is so important for the healing process.

Table 1: Representation of frequency bands (alpha, beta, and theta).

Bandwidth	Frequency (Hz)
Theta	4-7.9
Alpha2	7-13
Alpha3	8-13
Alpha4	8-10.9
Alpha5	11-13.9
Beta3	13-25
Beta4	13-22
Beta5	14-19.9
Beta6	20-29.9

(ii) *Theta (4-8 Hz).* Theta waves occur most frequently in sleep but are also dominant in deep meditation. Theta waves are noticed during learning or remembering.

(iii) *Alpha (8-12 Hz).* Alpha activity is best seen in the back regions of the brain and is typical for relaxation. It occurs when closing the eyes.

(iv) *Beta (12-30 Hz).* Beta activity can be divided into low-activity waves (12-15 Hz), medium-activity waves (15-20 Hz), and high-activity waves (18-

Table 2: Description of the indices used in the test.

Index number	Formula	Counting method
Index 1	Beta3/(alpha2 + theta)	Average registration value of all electrodes on the head
Index 2	Theta/alpha2	Average registration value from electrodes placed on the frontal lobe of theta and parietal lobe of alpha
Index 3	Theta	The average value of registration from electrodes placed on the frontal lobe of theta
Index 4	Beta4/(alpha3 + theta)	Average registration value from electrodes: F3, F4, F7, F8, Cz, P3, Pz, and P4
Index 5	Beta5/(alpha4 + theta)	Average registration value from electrodes: F3, F4, F7, F8, Cz, P3, Pz, and P4
Index 6	Beta6/(alpha5 + theta)	Average registration value from electrodes: P3, C3, Pz, Fz, Cz, and FPz

Table 3: Respondent's opinion on which game he/she thinks is the best.

Examining the number	1st place	2nd place	3rd place
1	Flying mushroom	3D shooter	Ball control
2	Puzzle	Tower defense	Other
3	Racing game	Other	
4	Tower defense	3D shooter	2D shooter
5	3D shooter	Ball control	2D shooter
6	Puzzle	Hexlogic	Ball control
7	Flying mushroom	Other	
8	2D shooter	Ball control	3D shooter
9	Racing game	Flying mushroom	Ball control
10	I was not interested in anything		
11	Ball control	Tower defense	2D shooter
12	Flying mushroom	Other	
13	Flying mushroom	Other	
14	Flying mushroom	Other	
15	Racing game	Puzzle	Hexlogic
16	3D shooter	Flying mushroom	Other
17	Flying mushroom	3D shooter	Racing game
18	Flying mushroom	Tower defense	Racing game
19	3D shooter	Puzzle	Other
20	3D shooter	Puzzle	Other
21	3D shooter	2D shooter	Puzzle
22	3D shooter	2D shooter	Puzzle
23	Racing game	Tower defense	Puzzle
24	Racing game	3D shooter	2D shooter
25	3D shooter	Flying mushroom	Racing game
26	3D shooter	Racing game	Puzzle
27	3D shooter	Hexlogic	Flying mushroom
28	Tower defense	3D shooter	Puzzle
29	Flying mushroom	2D shooter	Racing game
30	3D shooter	2D shooter	Other
31	Flying mushroom	Tower defense	Puzzle

30 Hz). The average range of beta activity is associated with increased energy, anxiety, performance, and concentration. The most visible is in the leading regions.

The EEG spectral signal was analyzed using a Fast Fourier Transform (FFT) and an overlapping 3-second time frame with a 1-second jump at the relevant alpha, beta, and theta frequencies listed in Table 1.

Table 4: The table shows the distinguished games in which the involvement index was highest.

Examining number	Index 1 Game	Index 2 Game	Index 3 Game	Index 4 Game	Index 5 Game	Index 6 Game
1	prof1_0	prof4	prof1_1	prof5	prof5	prof1_1
2	prof1_1	prof3	prof4	prof3	prof1_1	prof4
3	prof1_1	prof5	prof4	prof6	prof4	prof2
4	prof1_1	prof1_1	prof1_1	prof1_1	prof4	prof1_1
5	prof1_1	prof2	prof5	prof1_2	prof1_1	prof6
6	prof2	prof1_1	prof1_1	prof4	prof5	prof2
7	prof6	prof4	prof4	prof6	prof6	prof4
8	prof1_1	prof1_0	prof3	prof1_1	prof1_1	prof5
9	prof4	prof5	prof5	prof6	prof4	prof4
10	prof1_1	prof1_1	prof5	prof1_1	prof4	prof1_2
11	prof5	prof4	prof4	prof5	prof2	prof3
12	prof1_2	prof4	prof4	prof1_2	prof1_1	prof1_2
13	prof1_0	prof4	prof1_1	prof5	prof5	prof1_1
14	prof3	prof4	prof4	prof3	prof1_2	prof1_1
15	prof4	prof5	prof2	prof1_2	prof4	prof4
16	prof1_1	prof2	prof3	prof1_1	prof4	prof4
17	prof5	prof5	prof5	prof1_2	prof6	prof1_2
18	prof1_2	prof1_0	prof4	prof1_2	prof1_1	prof5
19	prof1_1	prof2	prof6	prof6	prof4	prof6
20	prof4	prof5	prof5	prof4	prof1_1	prof1_2
21	prof4	prof2	prof2	prof5	prof1_1	prof5
22	prof1_1	prof2	prof4	prof6	prof6	prof6
23	prof1_2	prof5	prof4	prof3	prof1_2	prof1_2
24	prof6	prof5	prof5	prof5	prof1_2	prof1_1
25	prof1_2	prof1_1	prof4	prof5	prof5	prof5
26	prof1_1	prof2	prof2	prof6	prof6	prof5
27	prof1_2	prof1_1	prof1_1	prof5	prof1_2	prof1_2
28	prof1_1	prof1_1	prof1_1	prof5	prof5	prof1_1
29	prof1_2	prof4	prof4	prof5	prof1_2	prof1_1
30	prof1_1	prof1_1	prof3	prof1_1	prof1_1	prof5
31	prof6	prof4	prof4	prof1_2	prof5	prof1_2

prof1_0: 2D shooter; prof1_1: puzzle; prof1_2: hexlogic; prof2: 3D shooter; prof3: tower defense; prof4: flying mushroom; prof5: racing game; prof6: ball control.

Measurement of the level of engagement is one of the elements determining the player's experience while playing a computer game. In particular, it can be used to determine the player's preferences for the same type of game.

For this purpose, the exposure indices used to calculate the exposure level are those presented in Table 2.

(i) *Index 1 [32]*. Beta/(alpha + theta) has been calculated for each participant using the following electrodes: AF3, AF4, F3, F4, F7, F8, FC5, FC6, P7, P8, T7, T8, O1, and O2.

(ii) *Index 2 [32]*. Theta/alpha was calculated using the average registration value from electrodes placed on the frontal lobe of theta (F3, F4, FC5, and FC6) and divided by the average registration value from electrodes placed on the parietal lobe of alpha (P7, P8).

(iii) *Index 3 [32]*. Theta was calculated using the average registration value from the electrodes placed on the frontal lobe of theta: AF3, AF4, F3, F4, F7, F8, FC5, and FC6.

(iv) *Indices 4 and 5 [31]*. Beta/(alpha + theta) was calculated using the average registration value of the following electrodes: F3, F4, F7, F8, Cz, P3, Pz, and P4.

(v) *Index 6 [50]*. Beta/(alpha + theta) was calculated using the average registration value from the following electrodes: P3, C3, Pz, Fz, Cz, and FPz.

Table 5: The table shows at which game the engagement index was highest.

Examining number	Place	Index 1 Mean	Index 1 Std	Index 1 Game	Index 2 Mean	Index 2 Std	Index 2 Game	Index 3 Mean	Index 3 Std	Index 3 Game
	1	1.3939	0.1108	prof1_0	0.5771	0.1089	prof4	4.8238	0.3323	prof1_1
1	2	1.3915	0.1170	prof3	0.5446	0.1079	prof1_1	4.7891	0.3452	prof4
	3	1.3910	0.1169	prof6	0.5367	0.1114	prof5	4.7650	0.3531	prof1_0
	1	1.2741	0.0974	prof1_1	0.5506	0.1264	prof3	4.8002	0.4985	prof4
2	2	1.2736	0.1005	prof3	0.5497	0.1337	prof4	4.7719	0.5057	prof1_1
	3	1.2736	0.0988	prof1_2	0.5491	0.1253	prof6	4.7669	0.5051	prof1_2
	1	1.2984	0.1060	prof1_1	0.5875	0.1109	prof5	5.0370	0.5387	prof4
3	2	1.2984	0.1060	prof1_1	0.5810	0.1127	prof2	4.9798	0.5069	prof5
	3	1.2983	0.1059	prof6	0.5793	0.1130	prof1_0	4.9580	0.4984	prof2
	1	1.3223	0.1204	prof1_1	0.5577	0.0748	prof1_1	4.5023	0.3074	prof1_1
4	2	1.3086	0.0754	prof4	0.5550	0.0719	prof3	4.4917	0.2896	prof2
	3	1.3058	0.1413	prof5	0.5542	0.0715	prof1_2	4.4904	0.2912	prof1_0
	1	1.2725	0.1256	prof1_1	0.5711	0.0951	prof2	4.9084	0.5123	prof5
5	2	1.2569	0.1164	prof1_2	0.5692	0.0934	prof1_0	4.9022	0.5264	prof2
	3	1.2541	0.1176	prof6	0.5678	0.0928	prof3	4.8939	0.5219	prof1_0
	1	1.3830	0.1039	prof2	0.4907	0.1151	prof1_1	4.7602	0.4777	prof1_1
6	2	1.3777	0.1244	prof5	0.4882	0.1160	prof4	4.7254	0.4585	prof1_0
	3	1.3730	0.1178	prof1_2	0.4847	0.1110	prof1_0	4.7203	0.4542	prof3
	1	1.3725	0.1253	prof6	0.5299	0.1003	prof4	4.9861	0.5093	prof4
7	2	1.3716	0.1249	prof1_2	0.5071	0.1052	prof2	4.7367	0.4541	prof1_1
	3	1.3712	0.1289	prof3	0.5061	0.1046	prof3	4.6896	0.4708	prof5
	1	1.3415	0.1052	prof1_1	0.5070	0.0959	prof1_0	4.8350	0.4741	prof3
8	2	1.3411	0.1056	prof1_2	0.5068	0.0947	prof3	4.8346	0.4803	prof2
	3	1.3407	0.1064	prof6	0.5061	0.1002	prof2	4.8306	0.4764	prof1_0
	1	1.2701	0.1022	prof4	0.6678	0.1249	prof5	5.3371	0.6738	prof5
9	2	1.2669	0.1080	prof6	0.6661	0.1276	prof2	5.3148	0.6838	prof2
	3	1.2663	0.1066	prof1_1	0.6661	0.1290	prof1_1	5.2975	0.6811	prof1_1
	1	1.2778	0.0893	prof1_1	0.4622	0.0878	prof1_1	4.5582	0.3510	prof5
10	2	1.2674	0.0934	prof4	0.4557	0.0810	prof1_0	4.5532	0.3909	prof1_1
	3	1.2671	0.0863	prof3	0.4551	0.0793	prof3	4.5172	0.3086	prof1_0
	1	1.3664	0.1249	prof5	0.6665	0.1264	prof4	6.0602	0.7416	prof4
11	2	1.3628	0.1273	prof1_2	0.6448	0.1395	prof1_1	5.9635	0.7834	prof1_1
	3	1.3613	0.1277	prof6	0.6270	0.1393	prof5	5.7526	0.8399	prof5
	1	1.2783	0.1185	prof1_2	0.5877	0.0938	prof4	5.1959	0.5158	prof4
12	2	1.2777	0.1196	prof6	0.5664	0.1066	prof5	4.9896	0.5499	prof5
	3	1.2763	0.1211	prof3	0.5614	0.1046	prof1_1	4.9659	0.5589	prof1_1
	1	1.3939	0.0612	prof1_0	0.5771	0.0685	prof4	4.8238	0.2783	prof1_1
13	2	1.3915	0.0629	prof3	0.5446	0.0663	prof1_1	4.7891	0.2776	prof4
	3	1.3910	0.0613	prof6	0.5367	0.0750	prof5	4.7650	0.2943	prof1_0
	1	1.2853	0.1046	prof3	0.5631	0.0927	prof4	4.7660	0.4829	prof4
14	2	1.2849	0.1020	prof6	0.5596	0.1057	prof2	4.6753	0.4275	prof2
	3	1.2835	0.0989	prof1_2	0.5593	0.1055	prof1_0	4.6739	0.4335	prof1_2
	1	1.3021	0.1322	prof4	0.5203	0.0996	prof5	4.7767	0.5267	prof2
15	2	1.2380	0.1566	prof5	0.5167	0.0990	prof2	4.7546	0.5224	prof5
	3	1.2258	0.1421	prof1_2	0.5107	0.0888	prof1_1	4.7519	0.5167	prof1_0
	1	1.2423	0.1070	prof1_1	0.5739	0.0971	prof2	4.7264	0.4814	prof3
16	2	1.2423	0.1070	prof1_2	0.5737	0.0970	prof5	4.7236	0.4813	prof2
	3	1.2422	0.1143	prof4	0.5695	0.0934	prof3	4.7213	0.4813	prof1_0

Table 5: Continued.

Examining number	Place	Index 1			Index 2			Index 3		
		Mean	Std	Game	Mean	Std	Game	Mean	Std	Game
	1	1.2430	0.0921	prof5	0.5288	0.0852	prof5	4.7155	0.4200	prof5
17	2	1.2429	0.0899	prof1_2	0.5179	0.0823	prof2	4.6865	0.4163	prof2
	3	1.2424	0.0898	prof6	0.5125	0.0778	prof1_2	4.6715	0.4113	prof1_0
	1	1.4281	0.1378	prof1_2	0.5532	0.0980	prof1_0	4.7321	0.3417	prof4
18	2	1.4270	0.1378	prof1_1	0.5527	0.0983	prof1_2	4.6583	0.4871	prof1_0
	3	1.4270	0.1378	prof6	0.5526	0.0977	prof3	4.6561	0.4875	prof1_2
	1	1.1832	0.0925	prof1_1	0.4885	0.0951	prof2	4.4860	0.3320	prof6
19	2	1.1832	0.0925	prof1_2	0.4875	0.0964	prof1_0	4.4857	0.3305	prof1_0
	3	1.1826	0.0929	prof6	0.4874	0.0970	prof6	4.4847	0.3329	prof3
	1	1.3625	0.1730	prof4	0.5214	0.1405	prof5	4.9589	0.7446	prof5
20	2	1.3621	0.1750	prof1_1	0.5137	0.1275	prof1_1	4.9212	0.7097	prof4
	3	1.3284	0.1486	prof1_2	0.5135	0.1262	prof4	4.9134	0.7149	prof1_1
	1	1.3028	0.0927	prof4	0.5638	0.1199	prof2	4.7399	0.5710	prof2
21	2	1.2918	0.0904	prof1_1	0.5604	0.1154	prof1_0	4.7392	0.5607	prof3
	3	1.2911	0.0899	prof1_2	0.5599	0.1198	prof5	4.7372	0.5556	prof1_1
	1	1.2583	0.1075	prof1_1	0.5481	0.1066	prof2	4.8554	0.4468	prof4
22	2	1.2583	0.1075	prof1_2	0.5466	0.1022	prof1_0	4.8347	0.5118	prof1_0
	3	1.2580	0.1072	prof6	0.5454	0.1005	prof3	4.8323	0.5126	prof3
	1	1.1481	0.1034	prof1_2	0.4769	0.0936	prof5	5.0241	0.4799	prof4
23	2	1.1468	0.1040	prof6	0.4752	0.0786	prof4	4.8410	0.5040	prof1_1
	3	1.1461	0.1053	prof3	0.4640	0.0928	prof2	4.8364	0.5332	prof5
	1	1.2417	0.0796	prof6	0.5838	0.1269	prof5	4.9556	0.5460	prof5
24	2	1.2415	0.0781	prof1_2	0.5607	0.1139	prof2	4.9414	0.5930	prof4
	3	1.2400	0.0809	prof3	0.5590	0.1135	prof1_0	4.9362	0.5417	prof1_1
	1	1.4218	0.1146	prof1_2	0.5910	0.0991	prof1_1	5.0299	0.4832	prof4
25	2	1.4198	0.1170	prof6	0.5884	0.0994	prof4	5.0196	0.4496	prof1_1
	3	1.4187	0.1237	prof3	0.5757	0.0975	prof3	4.9003	0.4604	prof3
	1	1.3732	0.1040	prof1_1	0.5623	0.1315	prof2	4.7500	0.4765	prof2
26	2	1.3732	0.1040	prof1_2	0.5576	0.1238	prof1_0	4.7404	0.4582	prof1_0
	3	1.3717	0.1249	prof5	0.5553	0.1297	prof5	4.7322	0.4507	prof3
	1	1.3557	0.1023	prof1_2	0.6389	0.0874	prof1_1	4.6823	0.4899	prof1_1
27	2	1.3546	0.1055	prof3	0.6196	0.0713	prof4	4.6518	0.4172	prof5
	3	1.3546	0.1053	prof1_0	0.6166	0.0939	prof5	4.6159	0.4044	prof2
	1	1.3015	0.1300	prof1_1	0.5502	0.1066	prof1_1	4.8910	0.5148	prof1_1
28	2	1.2848	0.1277	prof1_2	0.5491	0.1066	prof5	4.8438	0.5042	prof2
	3	1.2827	0.1295	prof3	0.5444	0.1123	prof2	4.8410	0.4996	prof1_0
	1	1.3764	0.1139	prof1_2	0.6071	0.0777	prof4	5.1324	0.5021	prof4
29	2	1.3759	0.1135	prof1_1	0.5606	0.0928	prof1_2	4.9583	0.5014	prof5
	3	1.3741	0.1169	prof6	0.5602	0.0929	prof1_0	4.9030	0.4791	prof2
	1	1.1402	0.0762	prof1_1	0.5803	0.0934	prof1_1	4.8808	0.4266	prof3
30	2	1.1293	0.0743	prof4	0.5650	0.1013	prof4	4.8769	0.4203	prof6
	3	1.1116	0.0833	prof1_2	0.5637	0.0979	prof2	4.8741	0.4160	prof1_2
	1	1.3262	0.1255	prof6	0.6185	0.1855	prof4	5.2500	0.7078	prof4
31	2	1.3256	0.1346	prof1_1	0.5956	0.1418	prof2	5.1171	0.5887	prof1_1
	3	1.3253	0.1255	prof1_2	0.5938	0.1362	prof1_0	5.0460	0.6261	prof1_0
	1	1.3939	0.1107	prof1_0	0.5771	0.0820	prof4	4.8238	0.0985	prof1_1
1	2	1.3915	0.1130	prof3	0.5446	0.0799	prof1_1	4.7891	0.0862	prof4
	3	1.3910	0.1174	prof6	0.5367	0.0830	prof5	4.7650	0.0858	prof1_0

Table 5: Continued.

Examining number	Place	Index 1			Index 2			Index 3		
		Mean	Std	Game	Mean	Std	Game	Mean	Std	Game
	1	1.2741	0.1163	prof1_1	0.5506	0.0912	prof3	4.8002	0.1021	prof4
2	2	1.2736	0.1192	prof3	0.5497	0.0917	prof4	4.7719	0.0987	prof1_1
	3	1.2736	0.1140	prof1_2	0.5491	0.0914	prof6	4.7669	0.0986	prof1_2
	1	1.2984	0.1090	prof1_1	0.5875	0.0784	prof5	5.0370	0.0860	prof4
3	2	1.2984	0.1097	prof1_1	0.5810	0.0767	prof2	4.9798	0.0833	prof5
	3	1.2983	0.1097	prof6	0.5793	0.0775	prof1_0	4.9580	0.0854	prof2
	1	1.3223	0.1006	prof1_1	0.5577	0.0790	prof1_1	4.5023	0.1067	prof1_1
4	2	1.3086	0.1174	prof4	0.5550	0.0804	prof3	4.4917	0.1082	prof2
	3	1.3058	0.1174	prof5	0.5542	0.0843	prof1_2	4.4904	0.1082	prof1_0
	1	1.2725	0.1127	prof1_1	0.5711	0.0855	prof2	4.9084	0.0849	prof5
5	2	1.2569	0.1125	prof1_2	0.5692	0.0769	prof1_0	4.9022	0.0846	prof2
	3	1.2541	0.1135	prof6	0.5678	0.0807	prof3	4.8939	0.0860	prof1_0
	1	1.3830	0.1117	prof2	0.4907	0.0915	prof1_1	4.7602	0.1070	prof1_1
6	2	1.3777	0.1123	prof5	0.4882	0.0845	prof4	4.7254	0.1227	prof1_0
	3	1.3730	0.1033	prof1_2	0.4847	0.0836	prof1_0	4.7203	0.1187	prof3
	1	1.3725	0.1253	prof6	0.5299	0.0734	prof4	4.9861	0.1368	prof4
7	2	1.3716	0.1264	prof1_2	0.5071	0.0740	prof2	4.7367	0.1099	prof1_1
	3	1.3712	0.1246	prof3	0.5061	0.0769	prof3	4.6896	0.0991	prof5
	1	1.3415	0.1132	prof1_1	0.5070	0.0799	prof1_0	4.8350	0.1143	prof3
8	2	1.3411	0.1136	prof1_2	0.5068	0.0797	prof3	4.8346	0.1087	prof2
	3	1.3407	0.1135	prof6	0.5061	0.0805	prof2	4.8306	0.1011	prof1_0
	1	1.2701	0.0971	prof4	0.6678	0.0721	prof5	5.3371	0.1272	prof5
9	2	1.2669	0.0974	prof6	0.6661	0.0676	prof2	5.3148	0.1096	prof2
	3	1.2663	0.0980	prof1_1	0.6661	0.0676	prof1_1	5.2975	0.1047	prof1_1
	1	1.2778	0.0897	prof1_1	0.4622	0.0749	prof1_1	4.5582	0.0951	prof5
10	2	1.2674	0.0925	prof4	0.4557	0.0681	prof1_0	4.5532	0.0971	prof1_1
	3	1.2671	0.0926	prof3	0.4551	0.0672	prof3	4.5172	0.0959	prof1_0
	1	1.3664	0.0833	prof5	0.6665	0.0714	prof4	6.0602	0.0884	prof4
11	2	1.3628	0.0693	prof1_2	0.6448	0.0724	prof1_1	5.9635	0.0868	prof1_1
	3	1.3613	0.0660	prof6	0.6270	0.0735	prof5	5.7526	0.0867	prof5
	1	1.2783	0.1047	prof1_2	0.5877	0.0759	prof4	5.1959	0.0980	prof4
12	2	1.2777	0.1050	prof6	0.5664	0.0771	prof5	4.9896	0.0975	prof5
	3	1.2763	0.1049	prof3	0.5614	0.0766	prof1_1	4.9659	0.0981	prof1_1
	1	1.3939	0.1067	prof1_0	0.5771	0.0602	prof4	4.8238	0.0724	prof1_1
13	2	1.3915	0.0950	prof3	0.5446	0.0544	prof1_1	4.7891	0.0731	prof4
	3	1.3910	0.0957	prof6	0.5367	0.0537	prof5	4.7650	0.0721	prof1_0
	1	1.2853	0.0864	prof3	0.5631	0.0672	prof4	4.7660	0.0900	prof4
14	2	1.2849	0.0864	prof6	0.5596	0.0671	prof2	4.6753	0.0945	prof2
	3	1.2835	0.0867	prof1_2	0.5593	0.0673	prof1_0	4.6739	0.0892	prof1_2
	1	1.3021	0.1018	prof4	0.5203	0.0838	prof5	4.7767	0.0837	prof2
15	2	1.2380	0.1039	prof5	0.5167	0.0762	prof2	4.7546	0.0838	prof5
	3	1.2258	0.1023	prof1_2	0.5107	0.0711	prof1_1	4.7519	0.0837	prof1_0
	1	1.2423	0.0913	prof1_1	0.5739	0.0835	prof2	4.7264	0.1004	prof3
16	2	1.2423	0.0913	prof1_2	0.5737	0.0696	prof5	4.7236	0.0987	prof2
	3	1.2422	0.0903	prof4	0.5695	0.0689	prof3	4.7213	0.0987	prof1_0
	1	1.2430	0.0994	prof5	0.5288	0.0703	prof5	4.7155	0.0912	prof5
17	2	1.2429	0.0991	prof1_2	0.5179	0.0703	prof2	4.6865	0.0909	prof2
	3	1.2424	0.0989	prof6	0.5125	0.0716	prof1_2	4.6715	0.0922	prof1_0

Table 5: Continued.

Examining number	Place	Index 1			Index 2			Index 3		
		Mean	Std	Game	Mean	Std	Game	Mean	Std	Game
	1	1.4281	0.1102	prof1_2	0.5532	0.0719	prof1_0	4.7321	0.0689	prof4
18	2	1.4270	0.1099	prof1_1	0.5527	0.0719	prof1_2	4.6583	0.0674	prof1_0
	3	1.4270	0.1099	prof6	0.5526	0.0722	prof3	4.6561	0.0674	prof1_2
	1	1.1832	0.1020	prof1_1	0.4885	0.0831	prof2	4.4860	0.1017	prof6
19	2	1.1832	0.1018	prof1_2	0.4875	0.0768	prof1_0	4.4857	0.1014	prof1_0
	3	1.1826	0.1022	prof6	0.4874	0.0768	prof6	4.4847	0.1014	prof3
	1	1.3625	0.1248	prof4	0.5214	0.1091	prof5	4.9589	0.0990	prof5
20	2	1.3621	0.1154	prof1_1	0.5137	0.1080	prof1_1	4.9212	0.0995	prof4
	3	1.3284	0.1148	prof1_2	0.5135	0.1057	prof4	4.9134	0.1005	prof1_1
	1	1.3028	0.1010	prof4	0.5638	0.0704	prof2	4.7399	0.0914	prof2
21	2	1.2918	0.0986	prof1_1	0.5604	0.0708	prof1_0	4.7392	0.0869	prof3
	3	1.2911	0.0929	prof1_2	0.5599	0.0709	prof5	4.7372	0.0868	prof1_1
	1	1.2583	0.0930	prof1_1	0.5481	0.0615	prof2	4.8554	0.0914	prof4
22	2	1.2583	0.0926	prof1_2	0.5466	0.0617	prof1_0	4.8347	0.0915	prof1_0
	3	1.2580	0.0926	prof6	0.5454	0.0617	prof3	4.8323	0.0915	prof3
	1	1.1481	0.0768	prof1_2	0.4769	0.0846	prof5	5.0241	0.1184	prof4
23	2	1.1468	0.0774	prof6	0.4752	0.0847	prof4	4.8410	0.1193	prof1_1
	3	1.1461	0.0772	prof3	0.4640	0.0846	prof2	4.8364	0.1208	prof5
	1	1.2417	0.1043	prof6	0.5838	0.0775	prof5	4.9556	0.0917	prof5
24	2	1.2415	0.1008	prof1_2	0.5607	0.0776	prof2	4.9414	0.0925	prof4
	3	1.2400	0.0935	prof3	0.5590	0.0824	prof1_0	4.9362	0.0974	prof1_1
	1	1.4218	0.1487	prof1_2	0.5910	0.0857	prof1_1	5.0299	0.1155	prof4
25	2	1.4198	0.1326	prof6	0.5884	0.0799	prof4	5.0196	0.1057	prof1_1
	3	1.4187	0.1333	prof3	0.5757	0.0805	prof3	4.9003	0.1098	prof3
	1	1.3732	0.1331	prof1_1	0.5623	0.0805	prof2	4.7500	0.1093	prof2
26	2	1.3732	0.1339	prof1_2	0.5576	0.0810	prof1_0	4.7404	0.1044	prof1_0
	3	1.3717	0.1339	prof5	0.5553	0.0802	prof5	4.7322	0.1044	prof3
	1	1.3557	0.0958	prof1_2	0.6389	0.0752	prof1_1	4.6823	0.0814	prof1_1
27	2	1.3546	0.0996	prof3	0.6196	0.0764	prof4	4.6518	0.0828	prof5
	3	1.3546	0.0998	prof1_0	0.6166	0.0762	prof5	4.6159	0.0826	prof2
	1	1.3015	0.0969	prof1_1	0.5502	0.0958	prof1_1	4.8910	0.0929	prof1_1
28	2	1.2848	0.0930	prof1_2	0.5491	0.0845	prof5	4.8438	0.0901	prof2
	3	1.2827	0.0954	prof3	0.5444	0.0809	prof2	4.8410	0.0907	prof1_0
	1	1.3764	0.1202	prof1_2	0.6071	0.0818	prof4	5.1324	0.0909	prof4
29	2	1.3759	0.1155	prof1_1	0.5606	0.0816	prof1_2	4.9583	0.0912	prof5
	3	1.3741	0.1151	prof6	0.5602	0.0822	prof1_0	4.9030	0.0917	prof2
	1	1.1402	0.0659	prof1_1	0.5803	0.0581	prof1_1	4.8808	0.0976	prof3
30	2	1.1293	0.0674	prof4	0.5650	0.0573	prof4	4.8769	0.0954	prof6
	3	1.1116	0.0668	prof1_2	0.5637	0.0591	prof2	4.8741	0.0955	prof1_2
	1	1.3262	0.1232	prof6	0.6185	0.1117	prof4	5.2500	0.0766	prof4
31	2	1.3256	0.1227	prof1_1	0.5956	0.1014	prof2	5.1171	0.0763	prof1_1
	3	1.3253	0.1240	prof1_2	0.5938	0.1014	prof1_0	5.0460	0.0780	prof1_0

The variance is then analyzed to see if there is a material significant difference between the calculated exposure indices. For this purpose, the ANOVA statistical test was used. Before comparing population averages, the Shapiro-Wilk statistical test was used to check whether the examined features have a similar distribution to normal. The study of degradability normality can de facto be disregarded because, with sufficiently large samples ($n > 40$), a breach of the normality assumption should not cause serious problems; this means that parametric procedures can be used even if the data are not normally distributed [51]. The number of samples in the tests performed is greater than 100, so that the data

Table 6: The table shows the indices between which there are no significant differences in a particular game.

	prof1_0	prof1_1	prof1_2	prof2_0	prof3_0	prof4_0	prof5_0	prof6_0
1	1.6	1.6, 4.5	1.6	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6	1.6
2	4.5	4.5	4.5	5.4	5.4	5.1, 5.4	4.5	4.5
3	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5
4	None	None	None	None	None	None	None	None
5	4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.5, 1.6, 4.5, 5.6	1.6, 4.5	4.5
6	None	None	None	None	4.5	1.6, 4.5	None	None
7	1.6	1.6	1.6	1.6	1.6	1.4, 1.5, 1.6, 4.5	1.6	1.6
8	1.6	1.6	1.6	1.6, 4.5	1.6, 4.5	1.6, 4.5	None	1.6
9	None	None	4.5	1.6, 4.5	1.5, 1.6, 4.5	1.5, 1.6, 4.5	1.6, 4.5	None
10	None	None	None	None	None	None	None	None
11	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5
12	None	1.6, 1.5	1.6	1.6, 1.5, 4.5	1.6, 1.5, 4.5	1.6, 1.5, 1.4, 4.5	1.6	1.6
13	None	None	None	None	None	None	None	None
14	None	None	None	None	None	1.6, 4.5	None	None
15	4.5	4.5	4.5	1.5, 4.5	1.5, 4.5	1.5, 1.6, 4.5	1.5, 4.5	4.5
16	None	None	None	1.5	1.5	1.5, 4.5	1.5	None
17	None	None	None	4.5	4.5	1.5	4.5	None
18	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.5, 1.5, 4.5	1.6, 4.5	1.6, 4.5
19	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
20	4.5	1.6, 4.5	4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	4.5
21	4.5	4.5	4.5	4.5	4.5	1.6, 4.5	4.5	4.5
22	4.5	4.5	4.5	4.5	4.5	1.5, 4.5	4.5	4.5
23	1.5	1.5	1.5	1.5	1.5	1.5, 4.5	1.5	1.5
24	4.5	4.5	4.5	4.5	4.5	1.4, 1.5, 1.6, 4.5	4.5	4.5
25	1.6, 4.5	None	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5
26	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
27	None	1.6, 4.5	None	1.6, 4.5	1.6	1.6, 4.5	1.6, 4.5	None
28	None	4.5	None	4.5	4.5	1.5, 4.5	4.5	None
29	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5
30	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
31	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 4.5	1.6, 1.5, 1.4, 4.5, 4.6, 5.6	1.6, 4.5	1.6, 4.5

distribution can be ignored [51]. If any differences were detected, the post hoc (postfact) HSD Tukey test was used. The post hoc tests are carried out as a further step in the analysis of variance since the analysis of variance itself only tells whether differences in the compared averages exist or not. We do not know which groups have these differences. A significant F-factor only indicates the validity (or otherwise) of rejecting a zero hypothesis. If we reject it, we have to find out whether all the averages are different or just some.

After selecting which groups differ from each other, the average of the whole game was calculated. This allowed each index to select three games for the time when the average commitment was highest. After comparing the first positions with the opinion of the respondent, the index that corresponded most closely to the opinion of the respondent was selected. Where two different indices indicated the same game, the results of a post hoc analysis were considered. Where they did not appear in the table, the second or third position to compare with the opinion of the respondents was taken into account.

3. Results

Favorite games, which were mentioned by the respondents, are listed in Table 3. Indices with the greatest commitment were assigned to each researched person and to which game this occurred (Table 4). More detailed data can be found in Table 5.

In Table 6, there are presented averages of indices between which there are no significant differences. The post hoc HSD Tukey test had to be applied to each patient because the ANOVA test (Table 7; for other subjects, the results were very similar) had to be rejected. This is because the average square of error (error) is the variance we expect and the average square (MS) is the variance in our dataset. We can see that the variance is much greater than the one we would

Table 7: The results of the ANOVA test for the first person tested are presented.

(a)

		prof1_0			prof1_1			prof1_2		
		MS	F	p	MS	F	p	MS	F	p
1	Result	595.07	20466.41	0.00	240.56	9215.93	0.00	547.85	18081.51	0.00
	Error	0.03			0.03			0.03		

(b)

	prof2			prof3			prof4			prof5		
	MS	F	p	MS	F	p	MS	F	p	MS	F	p
Result	293.44	9887.26	0.00	280.22	9308.00	0.00	76.98	2915.87	0.00	375.33	13666.71	0.00
Error	0.03			0.03			0.03			0.03		

(c)

	prof6		
	MS	F	p
Result	556.23	18491.81	0.00
Error	0.03		

expect, so the value of p, the probability, is very low. In this case, as well as for other respondents, the value of $p < 0.05$ indicates that the alternative hypothesis H1 should be assumed; i.e., there are differences between exposure indices. When two indices are in Table 6, choosing an engagement index is practically meaningless because there are no significant differences between their averages.

Before the ANOVA test, normal distribution was tested (Figure 12). An example is shown because the results are similar to the other games and the people surveyed. $p < 0.05$ was obtained in all cases (Table 8), which indicates the lack of normality of degradation. Nevertheless, parametric procedures can be used because the sample count is more than 100 [51]. In all tests, a materiality level of $\alpha = 0.05$ was established.

Analysis has shown that index 2 best reflects a player's commitment, which translates into a player's preferences. The number of situations which differed from the opinion of the examined person was 9, of which 1 opinion should be rejected because the examined person (no. 10) was not interested in the game at all; for 5 opinions, the game differed, but the type of game itself was accepted, and the remaining 3 opinions did not agree either with the game which was liked or with the type of game.

4. Discussion

The main objective of the study was to develop a method that would allow determining player preferences based on engagement. It was helpful to evaluate the different indices of engagement when playing different types of computer games, which had a time of 1 minute. As a result, it was determined which index most closely reflects the correct engagement in the game. MATLAB software and survey data were used for the analysis. Among the most important results, we can mention the following:

(1) Table 9 shows the number of opinions for skill games that matched the index

(2) Table 10 shows the persons in whom index 2 indicated another game, but it was still an arcade game

(3) Among the respondents, there were people whose favorite game was a puzzle or tower defense (Table 11). Index 2, in this case, did not show arcade games. Therefore, we can presume that it is also able to detect cases where players do not like arcade games. We cannot state this clearly, because the attempt is too small for a bolder statement

In order to carry out a test that will allow us to determine whether a person likes arcade games, we should use the test procedure included in Figure 13. The first stage of the test procedure is the preparation of 3 different types of games. The second stage is to conduct the EEG test using the appropriate electrode configuration, i.e., F3, F4, FC5, FC6, P7, and P8, to calculate the exposure index. The test must last at least 1 minute. The last step is to analyze the data obtained. Calculate the average engagement during the whole duration of a particular game, and then sort the received values from the highest to the lowest. If the highest value is of an arcade game, it means that the player likes this type of game.

In order to carry out a test that will allow us to determine whether a person likes arcade games, we should use the test procedure included in Figure 13. These conclusions should be understood in the context of certain restrictions. First of all, in the study, most people like arcade games; only 5 people

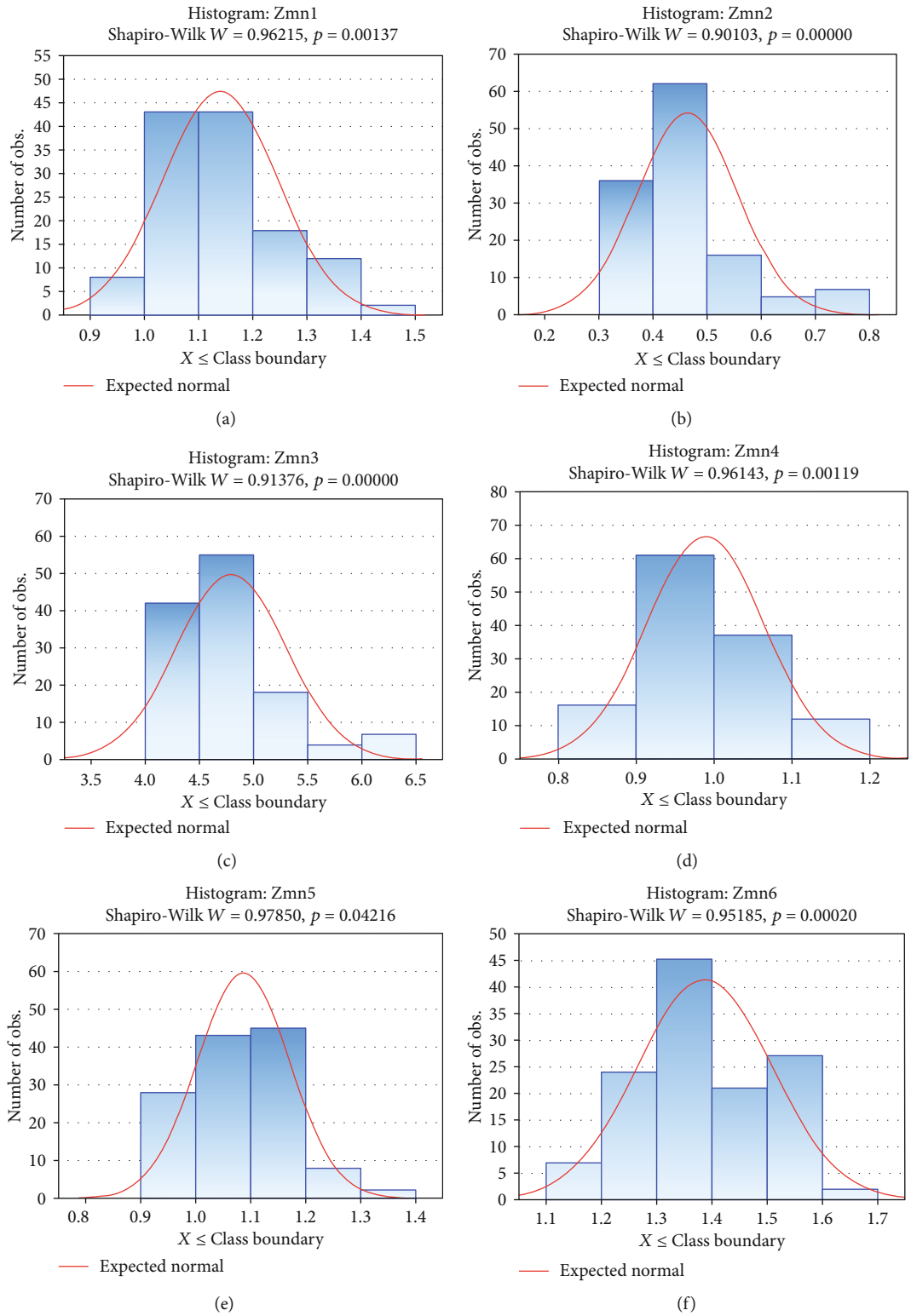

Figure 12: (a–f) The results of the Shapiro-Wilk test of decomposition normality. Table 8 presents the results obtained for the specified game.

said they liked a different type of game. As a result, we cannot fully determine whether there will be any conflict in the case of other types of games. At this moment, it was examined which index we should use for arcade games. The next step will be to prepare other types of games in order to establish the credibility of the selected index to ensure that the current scores have no anomaly due to the current number of people who do not like arcade games.

Table 8: The results of the study of normality of the Shapiro-Wilk test distribution for one tested game and one specific game are presented.

	Zmn1 (Figure 12(a))	Zmn2 (Figure 12(b))	Zmn3 (Figure 12(c))	Zmn4 (Figure 12(d))	Zmn5 (Figure 12(e))	Zmn6 (Figure 12(f))
W	0.96215	0.90103	0.91376	0.96143	0.97850	0.95185
p	0.00137	0.00000	0.00000	0.00119	0.04216	0.00020

Zmn1: index 1; Zmn2: index 2; Zmn3: index 3; Zmn4: index 4; Zmn5: index 5; Zmn6: index 6.

Table 9: The number of opinions that matched the index on the most engaging arcade game.

	Index 1	Index 2	Index 3	Index 4	Index 5	Index 6
Number of persons	0	18	9	1	0	0

Table 10: The number of the respondents, in which index 2 indicated an arcade game different from the respondent's opinion in the 1st place.

Person no.	Index
7	prof4
11	prof4
17	prof5
18	prof1_0
20	prof5

prof1_0: 2D shooter; prof4: flying mushroom; prof5: racing game.

Table 11: Comparison of games that were indicated by the respondent and by index 2.

Person no.	Game	Index 2
2	Puzzle	Tower defense
4	Tower defense	Puzzle
6	Puzzle	Puzzle
28	Tower defense	Puzzle

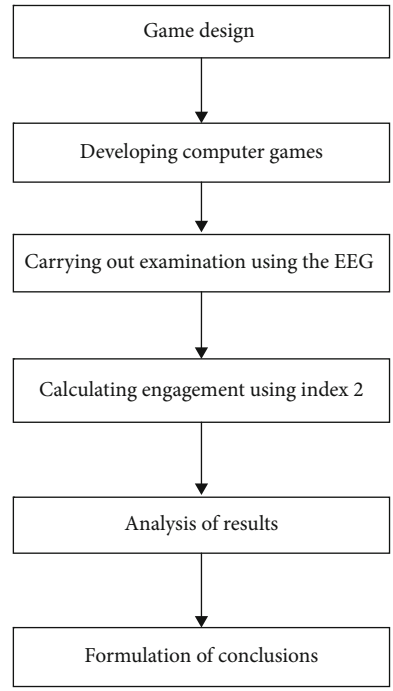

Figure 13: Test procedure to determine if a person likes to play arcade games.

5. Conclusion

The results of research aimed at selecting the appropriate index of engagement using EEG to determine whether a person likes arcade games are presented. In this achievement, it was decided to define the profile of the player on the basis of the order from the most engaging to the least engaging game. Based on their opinions, the optimal indicator is index 2 (theta/alpha), because it best represents the opinion of the respondents.

It should be taken into account that these findings are based on a single type of game and that further research will be needed in order to extend the results of the methodological approach to assessing which type of game is of greatest interest not only by analyzing the player's involvement but also by adding further indices from other categories such as concentration. Nevertheless, these results confirm the view that index 2 is a strong indicator of enjoyment for some type of games, and this shows real promise for future research with a larger more diverse set of participants and possibly a different set of games.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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