
Customers' Emotions and Openness to Product Co-Creation: An Empirical Analysis Based on EEG Data

Submitted 09/04/23, 1st revision 27/04/23, 2nd revision 13/05/23, accepted 30/05/23

Konrad Biercewicz¹, Małgorzata Wiścicka-Fernando²

Abstract:

Purpose: The aim of this paper is to identify the emotions and engagement of customers versus their openness to product co-creation. The research was conducted among users of a computer game.

Design/Methodology/Approach: The study used high-tech methods EEG (electroencephalography) and a virtual environment, as well as a questionnaire. The research aims to investigate the customer emotions of the players - their engagement in testing the product and their openness to product co-creation.

Findings: The authors identified two groups of customers and proposed a simplified condition for testing openness to product co-creation. The study's sample size was small and may not represent the entire population. Only one game-type product was examined.

Practical implications: The study's findings have practical implications for practitioners in product co-creation, product development, and creating a relationship with customers. For example, the simplified condition can be used for the development of the customer group which is open to co-create the product.

Originality value: The research provided insights into the relationship between emotions and player engagement during the game and the determination of openness to product co-creation with the customer.

Keywords: Product co-creation, customer, emotion, EEG, gaming.

JEL classification: C90, D12, D83, M31.

Paper type: Research article.

Acknowledgment: The project is financed within the framework of the program of the Minister of Science and Higher Education under the name "Regional Excellence Initiative" in the years 2019 - 2023; project number RID/IZ/2022/1/70; the amount of financing PLN 10,684,000.00.

¹University of Szczecin, Institute of Management, Department of Computer Science in Management, konrad.biercewicz@usz.edu.pl;

²The same as in 1.

1. Introduction

The research aims to explore the present in customers - the players in their engagement in product testing and their openness to product co-creation. The researchers invited 30 university students to the experiment and the sampling technique was simple random sampling. In the research was used a quantitative method approach to collect and analyses data.

The study aimed to answer the following research questions: (1) What are the emotions of players during game testing? (2) What is the level of player engagement? (3) How do emotions and engagement affect decisions about product co-creation? The study will contribute to the understanding of the importance of customer emotions in the co-creation process and may provide insights into effective strategies for designing and implementing customer co-creation initiatives. The novelty of this research is to combine traditional tools like questioner with a modern tool - EEG to describe real emotions and their impact on openness to product co-creation.

2. Literature Review

2.1 The Role of Customers in the Process of Co-creation

Contemporary market is driven by increasing competition, but also by changes resulting from technological advances including the internet and social media (O'Hern and Rindfleisch, 2017; Rathore *et al.*, 2016), including the fourth industrial revolution (Schwab, 2017), but also the adoption by companies of customer orientation.

Increasing competition is causing companies to exceed each other in their sales efforts and in attracting more customers. And technological change means that companies may have a variety of modern technologies at both the product creation and sales and use levels, but the pursuit of novelty can be detrimental to a company's stability and competitiveness (The End of the Vendor?, 2016). Both activities are geared more towards active selling than strategically building long-term relationships with stakeholders.

Striving to build long-term relations requires a company to adopt a customer orientation. This means that the company places the customer at the center of its activities, a process that starts with the product design stage and continues through to the post-purchase behaviour stage (e.g., satisfaction assessment). At this point, it should be noted that the data acquired in the non-purchasing behaviour stage becomes the basis for subsequent decisions (challenges).

Customer orientation also means that the whole company adopts the philosophy - the mindset - that the customer is the source of value for the company, and that creating relationships with customers becomes a key success factor (Kiffin-Petersen and Soutar, 2020; Li Sa *et al.*, 2020; Zhao, 2022).

One important activity in building customer relationships is to invite (encourage) customers into the co-creation process. Areas of co-creation can be products and services (Bettiga and Ciccullo, 2019), but also processes and even values (Merz *et al.*, 2018; Moghadamzadeh *et al.*, 2020; Prahalad and Ramaswamy, 2004a; 2004b). More and more companies are using co-creation as a tool to build strategic competitive advantage.

Co-creation with customers can provide benefits in many areas, for example, innovative ways of working together, building customer satisfaction, increasing loyalty and greater brand loyalty, increasing willingness to pay and higher product ratings (Schnurr, 2017). Companies that are open to co-creation are those that are not afraid of dialogue with their customers and that treat the information and knowledge provided as equal to that of their employees (Prahalad and Ramaswamy, 2004a).

Companies undertake co-creation activities because they want to prevent failures and increase the quality of products, which will affect the final level of satisfaction (Agrawal and Rahman, 2015). Also, the role of customers can be divided into product conceptualiser, product designer, product tester, product support specialist, and product marketer (Nambisan and Nambisan, 2008).

It is also important to remember that inviting customers to co-creation is voluntary (Füller *et al.*, 2009), and the whole process is a dialogue between the company and the customer (Grönroos and Voima, 2013).

2.2 Product Co-creation

The process of co-creation of a product can take different forms, for example, the co-creation of an idea, co-selection, joint testing, or joint marketing (Agrawal and Rahman, 2015). An important change is a recognition that it is the customer who provides value to the company. This means that the customer becomes a source of competence (Prahalad and Ramaswamy, 2000; Sawhney and Prandelli, 2000), and the company is open to knowledge sharing, equality, and interaction (Ranjan and Read, 2016).

Due to the research problem posed, the authors focus on one aspect of co-creation, i.e. product co-creation, and more precisely on co-creating a product together with the customer, which is also referred to in the literature as co-production (Fang *et al.*, 2008; Hu and McLoughlin, 2012; Nuttavuthisit, 2010; Ranjan and Read, 2016).

The process of co-creating a product is one of the more emotionally engaging, as the customer invests their resources such as knowledge, time, skills, and experiences (Hoyer *et al.*, 2010; Koniorczyk, 2015; Mandolfo *et al.*, 2020; Misiak-Kwit *et al.*, 2021). A key part of this process is product prototyping. This is the creation of a model, a test version, and a sample. In the creation process, stakeholders have contact with the product, which builds a bond between the creator and the created product. Customer feedback obtained in this way allows the discovery of what product features should be improved.

The product development process is iterative and can involve multiple rounds of refinement. If customers participate all the time in the prototyping process, they establish a more lasting relationship not only with the created product but also with the company. There are six stages of prototyping: conceptualization, design, prototype creation, testing and evaluation, refinement, and production (Fullerton *et al.*, 2004; J. Russell and Barrett, 1999).

Also, different forms of prototypes can be created, physical models, virtual simulations, digital mock-ups, or a basic version of the product. The choice of form depends on the objectives and features of the product and the capabilities of the company. Each form has its appropriate testing methods. And encouraging the cooperation of users will make them feel that they are co-creating the product together with the company.

According to research, games are the most frequently co-created product with the customer, which is due to the specific nature of these products and their environment (El Afi and Smail, 2021; Hussain *et al.*, 2023). According to Elizabeth (Sanders, 2002) product testing is mainly related to the user experience and their attitudes which are revealed, among other things, by what people say or do. Consequently, there are many methods for testing a game prototype, among the most popular are (Sagi, 2016), internal playtest, user testing, focus groups, analyse data, bug testing, and iterating.

Internally playtest involves bringing together people from different backgrounds and skill levels to play a game and give their feedback. This provides an opportunity to gather important information about the game and what needs improvement. User testing is based on users seeing the game for the first time. This is the moment to observe the players' interactions and collect their feedback.

Focus groups this method is based on gathering a fairly small group of people to whom the game will be presented and people will give their opinion on what they like and don't like about the game. It should be emphasised that data analysis is important in each of the aforementioned methods. It is based on tracking player behaviour through embedded code that collects data. This makes it possible to identify very accurately various player behaviours during the game, such as where

they spent the most time, what difficulties they had, and whether they moved smoothly to different tasks and stages.

Another method of testing the game prototype is bug testing, which allows you to identify and fix any technical issues that affect the satisfaction of the game. Another tool is Iterate, which is based on three steps, receiving feedback, making a fix to the game, and testing it. The testing process is repeated until full satisfaction with the final product is established. In the research presented here, the authors used the following testing methods: internal playtest, analyse data, and bug testing.

Co-creation with the player-customer can be carried out on many levels and with varying intensity. However, the most important feature of co-creation is the willingness to cooperate and be involved in the process. This is a sine qua non-condition. It also implies that the client has the knowledge and skills in using this type of product. Customers with 'uninvolving' personality traits or without motivation should not be considered for co-creation (Camoiras-Rodriguez and Varela, 2020; Mandolfo *et al.*, 2020).

2.3 Emotions and Engagement as a Condition for Product Co-creation with the Customer

People tend to react emotionally to products and become attached to products. As a result of active participation in the creation of a product, a relationship is formed between the person and the object. Belk defines it as an integrated self that is created as a result of the effort expended and engagement (Belk, 1988; Csikszentmihalyi and Halton, 1981). It is the effect of transferring one's own self onto the product. The co-created product is an expression of our emotions, value expectations, and identity.

As a result, an emotional bond is formed between the co-creator and the product, which is referred to as affective commitment or if they compare their identities then a process of identification takes place.

In a study by Atakan, Bagozzi, and Yoon, it was shown that affective (emotional) engagement and identification with a product are two separate concepts, but closely related. They influence the consumer's evaluation of the product. The affective involvement of the customer will occur when the customer is involved in the product development stage.

Thus, the design stage builds a cognitive bond (identification with), which will build affective involvement, and this will influence his identification with the product (Atakan *et al.*, 2014). An important factor is also the customers' search for fun (Hirschman and Holbrook, 1982), which is particularly important for playability products. The effect of feeling strong emotions during product development is engagement.

Customer engagement is a multidimensional concept, consisting of cognitive, behavioural, and emotional dimensions. Berka *et al.* (2007) on the other hand, considers these to be information gathering, visual attention, and attentional allocation.

Important advantages of involving the customer in the co-creation process will be: having a positive impact on product evaluation, prolonged product life, and increased product care. If the product is physically co-created with the customer, the customer's identification with the product may increase, and there may be greater involvement in promoting the product. (Atakan *et al.*, 2014).

Customer engagement is a multi-stage process, but one that depends on the individual characteristics of the customer and the type of product. There are five basic stages: awareness, interest, trial, repeat purchase, and loyalty (Kotler and Keller, 2016). It should be noted, however, that some clients may not proceed to the next stage and others may skip some stages. Furthermore, the duration of the process of moving through these stages can differ significantly, depending on the particular product and the individual involved.

The affective engagement of co-creation occurs when the product is self-created by the customer and they begin to endow it with positive emotions. Reasons for wanting to participate in co-creation include playfulness, curiosity, self-efficacy, skill development, information seeking, recognition, community support, making friends, personal needs, and monetary compensation (Füller, 2010).

In marketing, both cognitive and emotional bonding approaches are adopted in the study of engagement with, for example, a brand. They most often refer to five psychological theories, these are the technology acceptance model, self-determination theory, social influence theory, flow theory, and theory of planned behaviour (Tobon *et al.*, 2020). This demonstrates the key role of psychology in assessing customer behaviour and creating experience value. Mainstream focuses on the relationship with the brand rather than the customer (Dulabh *et al.*, 2018).

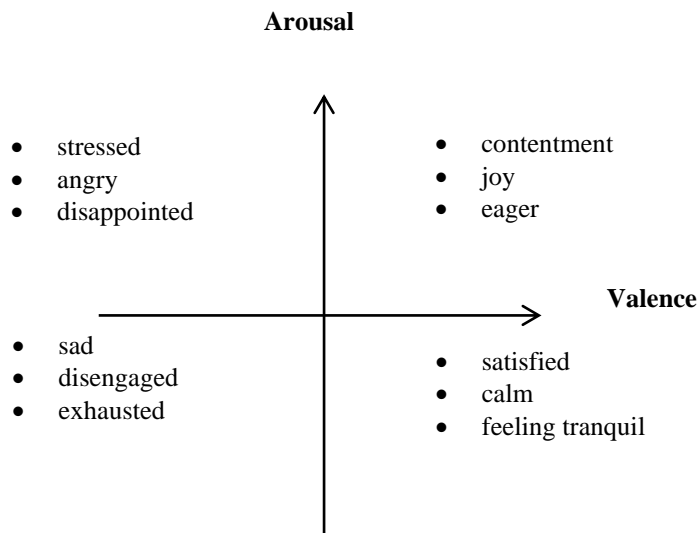
An important component of involvement in product co-creation is motivation. According to Fuller, motivation is one of the main drivers of customer involvement in product co-creation (Füller, 2010). Motivation has two dimensions that can be divided into intrinsic and extrinsic. Intrinsic refers to the intrinsic desire to engage in an activity or behaviour because it is inherently interesting, enjoyable, or rewarding.

People who are intrinsically motivated are driven by the satisfaction of the activity itself, rather than by external reward or recognition. Extrinsic motivation is a type of motivation that comes from external factors such as rewards, punishment, or recognition from others (Solomon, Russell-Bennett, and Previte, 2012).

The product-game area studied by the authors is characterised by the described features of engagement and motivation, e.g., to achieve the highest score in a computer game. Such behaviours may represent the first stage of creating an emotional bond between the player and the product. To perform a more accurate analysis can be applied EEG (electroencephalography) to assess the emotional state of a research participant.

Two studies, conducted by McMahan *et al.* (2015) and Petrantonakis and Hadjileontiadis (2010), used the Index of Arousal-Valence to measure emotional states. This method involves identifying a plane where emotions occur, with Arousal as one axis and Valence as another. Arousal refers to the intensity of emotions, while Valence is used to determine if emotions are positive or negative (Russell and Barrett, 1999), as presented in Figure 1.

Figure 1. Presenting Arousal and Valence on a plane



Source: Russell and Barrett, 1999.

Emotions are a significant factor in providing useful implicit or explicit information for making quick and effective decisions (Bechara and Damasio, 2005). Moreover, as one of the types of influence, emotions have the ability to have a short but powerful impact on an individual (Frijda, 1994). The impact of impacts on clients depends on individual psycho-physical predispositions. The ability to take data using modern tools that show a person's emotional state is one of the most objective methods of research.

With the Arousal and Valence indices, emotions can be defined more precisely by assigning values and meaning to them. The identification of emotional state and

intensity paves the way for further analyses of emotions and customer involvement, e.g., in the process of developing a product together with the company.

3. Materials and Methods

3.1 Research Methods

The research aim of this study is to determine the relationship between emotions and the level of engagement to determine the willingness to product co-creation. The described pilot study aimed to gather primary data and analyse them following the research objectives to conclude:

- What are the emotions of the players during the game testing?
- What is the level of player engagement?
- How do emotions and engagement influence decisions to co-create a product?

Additionally, the following hypothesis was assumed, the average engagement in the group of people who declared openness to co-creation is the same as in the group who did not declare such openness.

In the study were used the following variables: emotions, engagement, and openness. The researchers used a quantitative approach. Data were collected from 30 students who were selected from different majors and with different levels of playing ability to achieve randomisation of the research sample. To collect data researcher utilized modern tools like EEG, a questionnaire survey, and a virtual environment.

The data were analysed using methods such as descriptive statistics, T-student test, Pearson correlation, task engagement, Index of Arousal and Valence, and inductive approach.

3.2 Experimental design

The research procedure is shown in Figure 2.

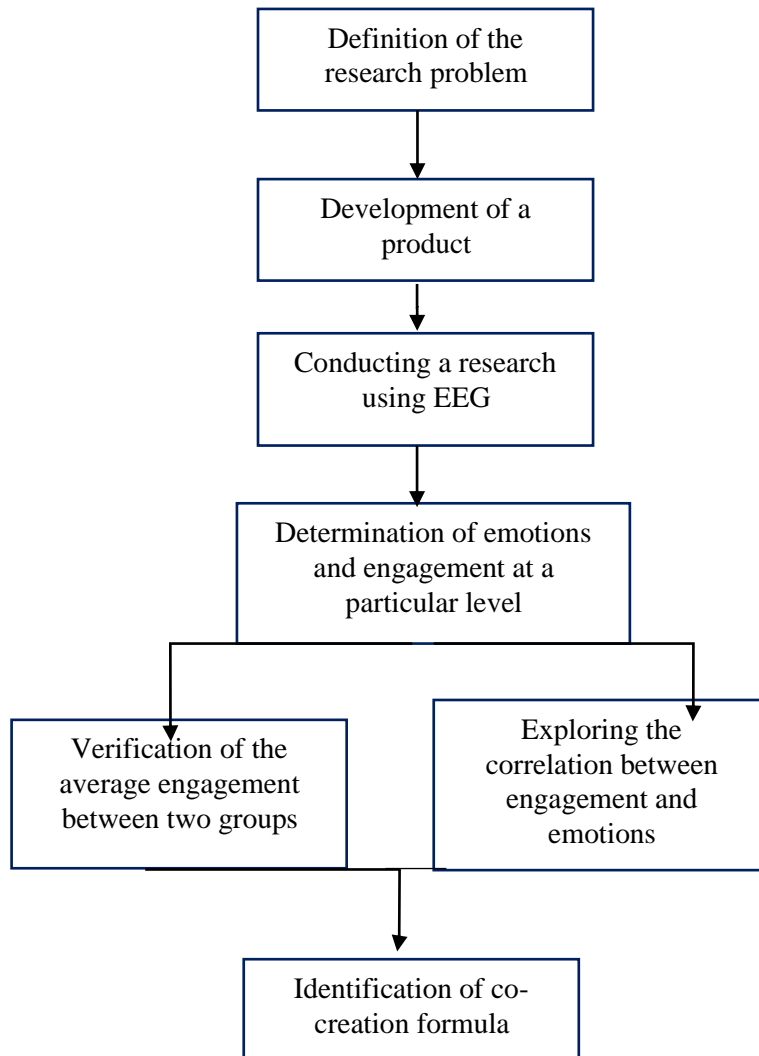
The first step was to define the research problem, which was presented in Figure 2 in this section. The product was then created in the form of a computer game. The game was written in C# in the Unity engine. Eight levels were created, which will be discussed later in this article.

The game was created in such a way that it was possible to record events, which were then synchronised with the recorded EEG (electroencephalography) signal. Before the study, a prior verification took place. This consisted of checking whether something needed to be corrected in the game, or whether the EEG signal was registering correctly. After completing this step, the study was conducted on a group

of 30 people (n=30). After each survey, a questionnaire consisting of three questions was administered.

Appropriate calculations were carried out based on the recorded EEG signal, and these included calculating the mean engagement at each level for each group, verifying with Student's T-test whether the averages in both groups were statistically significant. Arousal and Valence indices for each subject were used to determine emotion, and the Pearson correlation coefficient was also calculated.

Figure 2. The proposed research procedure.



Source: Own collaboration.

In the end, the data were combined, allowing the condition to be set for the co-creation of a computer game product.

3.3 Description of the Game

A platform game consisting of 8 different levels was created in the Unity engine. Each level contained an intermediate goal (green point), which the player had to reach first, to then travel to a teleport (purple point), which took the player to the next level. In addition, each level was time-limited. If a person did not complete a level they were automatically moved to the next level. There were difficulties at each level:

- Level 1 - moving the blocks
- Level 2 - the appropriate movement of a block and a rotating element to cover two lasers
- Level 3 - appropriately move three blocks to cover three lasers
- Level 4 - appropriately move two blocks to cover the lasers whose beam passes through the cross
- Level 5 - introducing a new element with instructions for its operation, moving the blocks to cover the lasers
- Level 6 - introducing a new element with instructions for its operation, moving the blocks to cover the lasers
- Level 7 - avoiding the flashing lasers and avoiding the multiplying object on the map
- Level 8 - avoiding moving objects

3.4 Description of the Research

The person signed a form declaring voluntary participation in the study before taking part. An important activity of the study in a virtual environment and using the EEG tool is the preparation of the test site. This has a significant impact on the quality of the acquired data from the measuring device (EEG). The most important steps include, quieting the room, a comfortable place to sit, easy access to peripheral devices (in the study described here it was a mouse and keyboard and a monitor), and removal of any interfering devices from the study area.

This procedure was performed with each survey participant. The next step was to prepare the respondent for the study by wearing a cap (Enobio 20, Neuroelectronics) and connecting the electrodes to the scalp. The cap with 20 electrodes was placed on the points of the P7, P4, Cz, Pz, P3, P8, O1, O2, T8, F8, C4, F4, Fp2, Fz, C3, Fp1, T7, F7, and Fpz and was used to record the testing session.

The electrodes were placed according to the 10-20 system, an international EEG electrode placement system. The electrodes required wetting of the cap to ensure proper conductivity between the scalp and the electrode. To verify that the EEG

electrodes were in good contact with the scalp, the impedance value was measured using the software Neuroelectrics® Instrument Controller (NIC2) v2.0.11.1. The sampling frequency was 500 Hz.

Following the above steps, the test was started. A black screen was displayed for 60 seconds before the game screen appeared. The purpose of this step was to calm the emotions and brain waves of the study participants. The game was then initiated. During this, the respondent's completion of each level was recorded. The data were recorded in an Excel file, which was later used to analyse the.

3.5 Measures

The first step involved calculating indices of task engagement, which was related to answering the research question What is the level of player engagement? The next step was to examine the Arousal and Valence indices, in order to answer the question: what are the emotions of players during game testing? By using the respective indices (Table 1), this was possible. On the other hand, in the final stage of the study, the two variables' emotions and engagement were combined to determine how do emotions and engagement affect decisions about product co-creation the product?

Table 1. Description of indices used in the examination.

Name of the index	Formula	Counting Method
The task of Engagement (Kamzanova et al., 2011)	Fz_Theta / Pz_Alpha	Mean electrode registrations on frontal lobe theta and parietal lobe alpha. Band of Theta (4-8 Hz), Alpha (7-13 Hz)
Arousal	$(F3_Beta + F4_Beta) / (F3_Alpha + F4_Alpha)$	Registration value from electrodes F3 and F4. Band of Alpha (7-13 Hz), Beta (13-25 Hz).
Valence	$(F4_Alpha / F4_Beta) - (F3_Alpha / F3_Beta)$	Registration value from electrodes F3 and F4. Band of Alpha (7-13 Hz), Beta (13-25 Hz).

Source: Own collaboration.

The reason for choosing these particular indices for analysis was that they can be used to study engagement as well as emotion in computer games (Kamzanova *et al.*, 2011; McMahan *et al.*, 2015). Challenges posed to the player in the form of obstacles such as time pressure or overcoming levels will build excitement and engagement.

Then, using the Student's T-statistic test, the equality of mean engagement was examined for the group of people who indicated in the questionnaire that the game

needed to improve elements with the group who did not. In a further step, the Pearson correlation between engagement and emotion (Arousal and Valence) was examined for the aforementioned groups.

In the final step, a simplified precondition was defined by which it is possible to determine whether the respondent wants to co-create the product.

4. Results

The collected survey data were analysed using Excel. The results are presented in Table 2.

Table 2. Results of the questionnaire survey

Survey question topics	Summary of responses
Number of people who said that the game needs to be improved (Group I)	15
Number of people who stated that the game does not need to be improved (Group II)	15
Average engagement in Group I	3.85
Average engagement in Group II	4.23
Difficult obstacles	Lasers, control, movable

Source: Own collaboration.

Each respondent had to answer the following three questions:

- What obstacles caused you the most difficulty?
- Is there anything you would improve about the game? If yes, describe it.
- Rate your engagement (scale from 1 to 5).

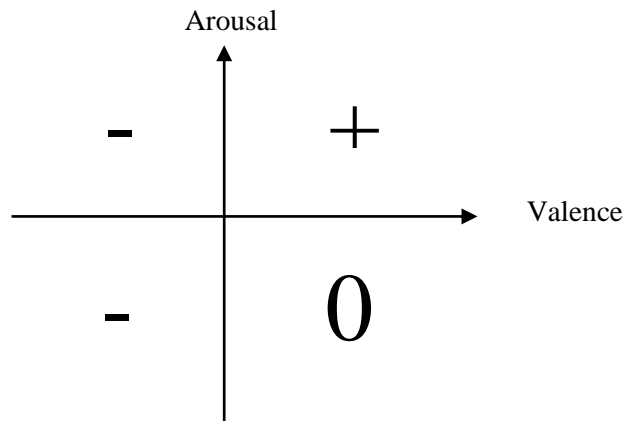
Among the participants, half (15 people) said that the game needed improvement. Among this group, the average engagement was 3.85, while in the other group, it was 4.23. The most common difficulties players encountered were lasers at different levels, controls, or moving obstacles.

The EEG signal data were analysed using Matlab R2022a. The analysis of the EEG signal started with bandpass filtering and the removal of power grid interference (frequencies above 50 Hz). In addition, the signal was detrended and filtered using the Fieldtrip library. The EEG spectral signal was then analysed using a Morse wavelet, which calculated the average peak frequency of half a second in a frame (Lilly and Olhede, 2010; Lilly and Olhede, 2012; Wachowiak *et al.*, 2018).

On the other hand, in order to calculate Alpha, Beta, and Theta frequencies, the signal was divided into the corresponding bands - Alpha 7-13 Hz, Beta 13-25 Hz,

and Theta 4-8 Hz. In the study presented here, these indices were used to determine the emotions that occurred in the players at a particular level and the type (positive, negative) of emotion. In this respect, four groups of emotions were distinguished (Figure 3) – positive, two negative, and neutral (0).

Figure 3. *The emotional state of the product*



Source: *Own collaboration.*

A positive value of the Arousal and Valence indices indicates positive emotions (contentment, satisfaction) about the product (plus), a positive value of the Arousal index and a negative value of the Valence index speak of negative emotions (upset, anger) about the product (minus), while negative values of the Arousal and Valence indices touch on negative emotions (boredom) about the product (minus). In the case of a negative value of the Arousal index and a positive value of the Valence index, one can speak of emotions signifying indifference (impartiality, neutrality) towards the product (0).

After conducting a study using cognitive neuroscience methods on 30 people, an engagement index was calculated for each person based on the data collected. And for each level, a hypothesis was tested: is the average engagement in both groups equal (Table 1).

Table 1. *The p-value of the Student's T-statistic for the average engagement.*

Level	Mean of group 1	Mean of group 2	Value of p
Level1	0,003	0,089	0,198
Level2	0,043	0,028	0,787
Level3	0,005	0,044	0,473
Level4	-0,017	0,042	0,245
Level5	-0,007	0,059	0,225

Level	Mean of group 1	Mean of group 2	Value of p
Level6	0,010	0,081	0,149
Level7	-0,009	0,077	0,100
Level8	0,001	0,049	0,371

Source: Own collaboration.

For all levels, the statistic is greater than 0.05. Therefore, the average level of engagement in group1 is not statistically significantly different from those in group 2. In addition to this, Table 3 identifies the average level of engagement at each level, which answers the research question: what is the level of player engagement? It can be seen that, apart from level 2, the average level of engagement in group 2 is higher than those in group 1.

The next step was to examine the correlation between Arousal and Valence and engagement using Pearson's coefficient (Table 2).

Table 2. *Pearson correlation coefficient between Arousal and Valence, and engagement.*

Level	Index	Engagement group 1	Engagement group 2
Level1	Arousal	-0,020680	0,580205
	Valence	-0,396765	-0,535400
Level2	Arousal	0,161174	0,251119
	Valence	0,074702	-0,684893
Level3	Arousal	0,020162	-0,159291
	Valence	-0,021632	0,433415
Level4	Arousal	-0,130790	-0,503693
	Valence	-0,010346	-0,352410
Level5	Arousal	-0,190448	0,602080
	Valence	-0,363068	-0,251246
Level6	Arousal	0,634030	0,276227
	Valence	0,132963	0,504609
Level7	Arousal	-0,342666	-0,401571
	Valence	0,049755	-0,060918
Level8	Arousal	0,021117	0,207342
	Valence	-0,496375	-0,265118

Source: Own collaboration.

From the calculated Pearson correlation coefficient, it can be seen that for Group 1 the relationship between Arousal and Engagement is at a low to moderate level. The only exception is Level 6, where the correlation coefficient between Arousal, and Engagement was $r=0.63$. This high result may be due to the features of Level 6, where players had to familiarise themselves with how a new element in the game worked.

This generated strong excitement about overcoming the challenge while engaging in the task. Since we are dealing with group 1, i.e. people declaring themselves open to cooperation, the low scores may indicate a weakness in the game that they will want to improve.

The Pearson correlation coefficient calculated for this group is also low or moderate between Valence and engagement. In the main, a negative correlation is apparent, indicating a decrease in commitment. It is not clear whether this means that the levels are easy or that making changes would not appeal to players.

In the second group, it can be observed that the correlation between Arousal and engagement is strong ($r=0.58$) and takes lower values with each level. The reason for this could be boredom with the repetitive elements in the game and the repetitive nature of the tasks. A change occurs at level 5 ($r=0.60$). It is possible that this is an effect of increased task difficulty. Additionally, the low completion rate of this level - less than 10% - may be indicative of this. A continuation of the decrease in correlation is evident in the subsequent stages. This means that the remaining levels of the game no longer evoked such excitement.

However, in the case of the correlation between Valence and engagement, the correlation is negative, i.e., as the Valence index increases, the player's engagement in the game decreases. The levels where we have a negative and strong correlation are levels 1 and 2. The exception is level 6, where the correlation is positively strong, i.e., as the Valence index increases, the player's commitment also increases.

The results obtained from the study of the relationship between the Arousal and Valence indices are difficult to clearly identify the relationship between emotions and engagement. Therefore, the researchers attempted to write down a necessary condition to facilitate the recognition of how emotions and engagement affect decisions about product co-creation. The condition was written as follows:

*IF (Emotion in (+, -) AND Engagement > Mean (Engagement))
THEN Co - Creation of Product,*

where Emotion in (+,-) means that the emotion should be in quadrant I, II, or III, Engagement - is the involvement of the respondent at the level, Mean (Engagement), where it means the average involvement of all participants at the given level.

Referring to the condition formulated regarding the willingness to co-create the product. Positive emotions (+) located in quadrant I of the Cartesian coordinate system and negative emotions (-) from quadrants II and III of the Cartesian coordinate system were selected.

According to the authors, this means that people, despite having positive emotions (e.g., satisfaction), want to improve the product they use. In the case of negative

emotions, people who are annoyed or angry at the product may also seek to improve it. The 4th quadrant (0) of the Cartesian coordinate system is deliberately omitted because they show emotions of indifference which causes the respondent to feel indifferent towards the product, and this affects the lack of openness to co-create the product.

Table 3 shows the results of how many people want to co-create a level in the game after using the simplified condition.

Table 3. Number of people who want to contribute to a level in the game

Level	Number of people
Level1	6
Level 2	9
Level 3	9
Level 4	7
Level 5	10
Level 6	10
Level7	9
Level 8	7

Source: Own collaboration.

The highest number of people, which is 10, was achieved for levels 5 and 6, while the lowest number was achieved for levels 1, 4, and 8. Without the use of the condition, it would appear that half of the people surveyed are ready to develop the product, which would not be entirely true when the simplified condition is used.

5. Discussion

The results show that those declaring their willingness to co-create the product were less committed than those who did not. In addition, the Arousal and Valence indices in group 1 (declared willingness to co-create) did not show a strong correlation between emotions and involvement. In contrast, emotions could be categorised as negative (anger) in the majority of people in this group.

According to Velinga *et al.* (2012) anger is an emotion that motivates people to make a change in a product, which was confirmed in the study. These people were willing to provide support and point out what needs to be modified in the game to make it even better. This is particularly evident at level 5 of the game, which players felt was the hardest of all in terms of difficulty.

On the other hand, a group was identified that did not declare a change in the game. For these people, the level of engagement is higher than for group 1. In addition to this, the correlation showed a strong relationship between emotions and engagement. The Arousal and Valence scores in group 2 (non-cooperative) show a dominance of

negative emotions (boredom). According to the authors, the emotion of boredom found in this group means that the respondents are not interested in further product development.

In addition to the emotion variable, the condition depends on the level of commitment. The requirement is that a person's commitment is higher than the average commitment of other people. Thus, we are able to select individuals who are above the average level. The research shows that these individuals are more committed than others and therefore it is likely that they pay attention to more details and put more effort into the task at hand. According to the authors, this is a prerequisite for the willingness to co-create a product to occur.

It should therefore be emphasised that the whole process of openness to co-creation is influenced by the intensity and direction of the emotions (positive or negative) and the degree of involvement.

According to the authors, the lack of engagement may also be due to the psycho-physical characteristics of the player, specifically the level of emotional intelligence. It can have a positive impact on the participant's engagement in co-creation by improving communication, enhancing cooperation, and increasing creativity and ease of problem-solving (Delpechitre *et al.*, 2018; Tong *et al.*, 2022). This set of skills makes individuals more engaged in the co-creation process, as it can help them build relationships, generate new ideas as well as perform better.

However, the research conducted did not assess players' levels of emotional intelligence. This is an area of research that the authors would like to undertake in the future. The researchers succeeded in identifying the emotions of the respondents and determining engagement. Also, it was shown that there is a correlation between emotions, regardless of their type, and engagement.

The results obtained provided an inconclusive answer to the research questions of what emotions occur among the subjects. Emotions in the study group were highly variable and changed at different levels of the game. The Arousal and Valence indices helped mark emotions. This also had an impact on the assessment of engagement, here too the results were not conclusive to determine the level of engagement of the players.

From the knowledge available to the authors, such measurement scales have not yet been developed and this article did not attempt to do so, as this was not the purpose of this article.

Openness to co-creation depends on positive or negative emotions and involvement, which should be higher than the group average.

6. Conclusion

The authors of the study believe that determining willingness to co-create is dependent on emotion and commitment. It was helpful for this finding to examine the correlation between emotion and commitment in a group of people who expressed willingness to co-create a game and a group where willingness was negative.

Once the necessary data had been obtained, using the Engagement Index, the average degree of engagement was calculated for individual respondents for the respective levels and the whole collective; in addition, using the Arousal and Valence indices, the emotions at a given level were determined.

Then, using the Student's T-test, it was verified whether the mean engagement was statistically significant between the aforementioned groups. On the other hand, to formulate a condition depicting openness to co-creation, the relationship between involvement and emotion was examined.

It should be taken into account that the results obtained are based on a study in which only one specific product was used, i.e., a computer game. To obtain a general condition, it is necessary to extend the study to other products. Nevertheless, the results obtained support the view that product co-creation depends on emotion and involvement.

The use of EEG, despite being labour-intensive, provides results that are independent of the respondent's declaration and the precondition created facilitates the interpretation of the data. The authors of the study plan to extend their research with an eye-tracking analysis and an index related to emotional intelligence.

References:

- Agrawal, A.K., Rahman, Z. 2015. Roles and Resource Contributions of Customers in Value Co-creation. *International Strategic Management Review*, 3(1), 144-160. <https://doi.org/10.1016/j.ism.2015.03.001>.
- Anderman, E.M. 2020. Achievement motivation theory: Balancing precision and utility. *Contemporary Educational Psychology*, 61, 101864. <https://doi.org/10.1016/j.cedpsych.2020.101864>.
- Atakan, S.S., Bagozzi, R.P., Yoon, C. 2014. Consumer participation in the design and realization stages of production: How self-production shapes consumer evaluations and relationships to products. *International Journal of Research in Marketing*, 31(4), 395-408. <https://doi.org/10.1016/j.ijresmar.2014.05.003>.
- Bechara, A., Damasio, A.R. 2005. The somatic marker hypothesis: A neural theory of economic decision. *Special Issue on Neuroeconomics*, 52(2), 336-372. <https://doi.org/10.1016/j.geb.2004.06.010>.
- Belk, R.W. 1988. Possessions and the Extended Self. *Journal of Consumer Research*, 15(2), 139. <https://doi.org/10.1086/209154>.

- Berka, C., Levendowski, D.J., Lumicao, M.N., Yau, A., Davis, G., Zivkovic, V.T., Olmstead, R.E., Tremoulet, P.D., Craven, P.L. 2007. EEG correlates of task engagement and mental workload in vigilance, learning, and memory tasks. *Aviation, space, and environmental medicine*, 78(5), B231-B244.
- Camoiras-Rodriguez, Z., Varela, C. 2020. The influence of consumer personality traits on mobile shopping intention. *Spanish Journal of Marketing - ESIC*.
- Csikszentmihalyi, M., Halton, E. 1981. *The Meaning of Things: Domestic Symbols and the Self*. Cambridge University Press. <https://doi.org/10.1017/CBO9781139167611>.
- Delpechitre, D., Beeler-Connelly, L.L., Chaker, N.N. 2018. Customer value co-creation behavior: A dyadic exploration of the influence of salesperson emotional intelligence on customer participation and citizenship behavior. *Journal of Business Research*, 92, 9-24. <https://doi.org/10.1016/j.jbusres.2018.05.007>.
- Dulabh, M., Vazquez, D., Ryding, D., Casson, A. 2018. Measuring Consumer Engagement in the Brain to Online Interactive Shopping Environments. W T. Jung, M.C. Dieck (Red.), *Augmented Reality and Virtual Reality: Empowering Human, Place and Business*, 145-165. Springer International Publishing. <https://doi.org/10.1007/978-3-319-64027-3>.
- El Afi, F., Smail, O. 2021. Consumer engagement in value co-creation within virtual video game communities. *Management and Marketing: Challenges for the Knowledge Society*, 16, 370-386. <https://doi.org/10.2478/mmcks-2021-0022>.
- Fang, E., Palmatier, R.W., Evans, K.R. 2008. Influence of customer participation on creating and sharing of new product value. *Journal of the Academy of Marketing Science*, 36(3), 322-336. <https://doi.org/10.1007/s11747-007-0082-9>.
- Frijda, N.H. 1994. Varieties of affect: Emotions and episodes, moods, and sentiments. In: P. Ekman and R. Davidson (Eds.), *The nature of emotions: Fundamental questions*, 59-67. New York, Oxford University Press.
- Füller, J. 2010. Refining Virtual Co-Creation from a Consumer Perspective. *California Management Review*, 52(2), 98-122. <https://doi.org/10.1525/cm.2010.52.2.98>.
- Füller, J., Mühlbacher, H., Matzler, K., Jawecki, G. 2009. Consumer Empowerment Through Internet-Based Co-creation. *Journal of Management Information Systems*, 26, 71-102. <https://doi.org/10.2753/MIS0742-1222260303>.
- Fullerton, T., Swain, C., Hoffman, S. 2004. *Game Design Workshop: Designing, Prototyping, and Playtesting Games*. CMP Books.
- Grönroos, C., Voima, P. 2013. Critical Service Logic: Making Sense of Value Creation and Co-Creation. *Journal of the Academy of Marketing Science*, 41, 133-150. <https://doi.org/10.1007/s11747-012-0308-3>.
- Hirschman, E.C., Holbrook, M.B. 1982. Hedonic Consumption: Emerging Concepts, Methods and Propositions. *Journal of Marketing*, 46(3), 92-101. <https://doi.org/10.1177/002224298204600314>.
- Hoyer, W., Chandy, R., Dorotic, M., Krafft, M., Singh, S. 2010. Consumer Cocreation in New Product Development. *Journal of Service Research - J SERV RES*, 13. <https://doi.org/10.1177/1094670510375604>.
- Hu, Y., McLoughlin, D. 2012. Creating new market for industrial services in nascent fields. *Journal of Services Marketing*, 26(5), 322-331. <https://doi.org/10.1108/08876041211245218>.
- Hussain, A., Abid, M.F., Shamim, A., Ting, D.H., Toha, M.A. 2023. Videogames-as-a-service: How does in-game value co-creation enhance premium gaming co-creation experience for players? *Journal of Retailing and Consumer Services*, 70, 103128. <https://doi.org/10.1016/j.jretconser.2022.103128>.

- Kamzanova, A.T., Matthews, G., Kustubayeva, A.M., Jakupov, S.M. 2011. EEG indices to time-on-task effects and to a workload manipulation (Cueing). *World Academy of Science, Engineering and Technology*, 80, 19-22.
- Kiffin-Petersen, S.A., Soutar, G.N. 2020. Service employees' personality, customer orientation and customer incivility. *International Journal of Quality and Service Sciences*, 12(3), 281-296. <https://doi.org/10.1108/IJQSS-12-2018-0104>.
- Koniorczyk, G. 2015. Customer knowledge in (co)creation of product. A case study of IKEA. *Journal of Economics and Management*, 22(4), 107-120.
- Kotler, P., Keller, K.L. 2016. *Marketing management* (15th wyd.). Pearson Education.
- Li Sa, M.L., Choon-Yin, S., Chai, Y.K., Aik Joo, J.H. 2020. Knowledge creation process, customer orientation and firm performance: Evidence from small hotels in Malaysia. *Asia Pacific Management Review*, 25(2), 65-74. <https://doi.org/10.1016/j.apmr.2019.07.002>.
- Lilly, M.J., Olhede, C.S. 2012. Generalized Morse Wavelets as a Superfamily of Analytic Wavelets. *IEEE Transactions on Signal Processing*, 60. <https://doi.org/10.1109/TSP.2012.2210890>.
- Lilly, M.J., Olhede, C.S. 2010. On the Analytic Wavelet Transform. *IEEE Transactions on Information Theory*, 56(8), 4135-4156. <https://doi.org/10.1109/TIT.2010.2050935>.
- Mandolfo, M., Chen, S., Noci, G. 2020. Co-creation in new product development: Which drivers of consumer participation? *International Journal of Engineering Business Management*, 12, 1847979020913764. <https://doi.org/10.1177/1847979020913764>.
- McMahan, T., Parberry, I., Parsons, T.D. 2015. Evaluating Player Task Engagement and Arousal Using Electroencephalography. *Procedia Manufacturing*, 3, 2303-2310. <https://doi.org/10.1016/j.promfg.2015.07.376>.
- Merz, M.A., Zarantonello, L., Grappi, S. 2018. How valuable are your customers in the brand value co-creation process? The development of a Customer Co-Creation Value (CCCV) scale. *Journal of Business Research*, 82, 79-89. <https://doi.org/10.1016/j.jbusres.2017.08.018>.
- Misiak-Kwit, S., Wiścicka-Fernando, M., Fernando, K.S.D. 2021. The Symbiotic Mutualism between Co-Creation and Entrepreneurship. *Sustainability*, 13(11), Article 11. <https://doi.org/10.3390/su13116285>.
- Moghadamzadeh, A., Ebrahimi, P., Radfard, S., Salamzadeh, A., Khajeheian, D. 2020. Investigating the Role of Customer Co-Creation Behavior on Social Media Platforms in Rendering Innovative Services. *Sustainability*, 12(17), Article 17. <https://doi.org/10.3390/su12176926>.
- Nambisan, S., Nambisan, P. 2008. How to profit from a better virtual customer environment. *MIT Sloan management review*, 49(3), 53.
- Nuttavuthisit, K. 2010. If you can't beat them, let them join: The development of strategies to foster consumers' co-creative practices. *Business Horizons*, 53(3), 315-324. <https://doi.org/10.1016/j.bushor.2010.01.005>.
- O'Hern, M.S., Rindfleisch, A. 2017. Customer co-creation: A typology and research agenda. *Review of marketing research*, 84-106.
- Petrantonakis, P., Hadjileontiadis, L. 2010. Emotion Recognition from Brain Signals Using Hybrid Adaptive Filtering and Higher Order Crossings Analysis. *Affective Computing, IEEE Transactions on*, 1, 81-97. <https://doi.org/10.1109/T-AFFC.2010.7>.
- Prahalad, C.K., Ramaswamy, V. 2000. Co-opting Customer Competence. *Harvard Business Review*. <https://hbr.org/2000/01/co-opting-customer-competence>.
- Prahalad, C.K., Ramaswamy, V. 2004a. The future of competition: Co-creating unique value

- with customers. Harvard Business Press.
- Prahalad, C.K., Ramaswamy, V. 2004b. Co-creation experiences: The next practice in value creation. *Journal of Interactive Marketing*, 18(3), 5-14.
<https://doi.org/10.1002/dir.20015>.
- Ranjan, K.R., Read, S. 2016. Value co-creation: Concept and measurement. *Journal of the Academy of Marketing Science*, 44(3), 290-315. <https://doi.org/10.1007/s11747-014-0397-2>.
- Rathore, A.K., Ilavarasan, P.V., Dwivedi, Y.K. 2016. Social media content and product co-creation: An emerging paradigm. *Journal of Enterprise Information Management*, 29(1), 7-18. <https://doi.org/10.1108/JEIM-06-2015-0047>.
- Russell, J.A., Barrett, L.F. 1999. Core affect, prototypical emotional episodes, and other things called emotion: Dissecting the elephant. *Journal of Personality and Social Psychology*, 76(5), 805-819. <https://doi.org/10.1037/0022-3514.76.5.805>.
- Russell, J., Barrett, L. 1999. Core affect, prototypical emotional episodes, and other things called emotion: Dissecting the elephant. *Journal of personality and social psychology*, 76, 805-819. <https://doi.org/10.1037//0022-3514.76.5.805>.
- Sagi, B.R. 2016. *Experimental Design in Game Testing*.
<https://scholarworks.rit.edu/cgi/viewcontent.cgi?article=10170&context=theses>.
- Sanders, E. 2002. From user-centered to participatory design approaches. *Design and the Social Sciences: Making Connections*, 1-7.
<https://doi.org/10.1201/9780203301302.ch1>.
- Sawhney, M., Prandelli, E. 2000. Communities of Creation: Managing Distributed Innovation in Turbulent Markets. *California Management Review*, 42(4), 24-54.
<https://doi.org/10.2307/41166052>.
- Schnurr, B. 2017. How my product works and how it looks: Effects of functional and aesthetic co-creation and the role of product expertise. *Creativity and Innovation Management*, 26(2), 152-159. <https://doi.org/10.1111/caim.12212>.
- Schwab, K. 2017. *The Fourth Industrial Revolution*. Crown.
- The end of the vendor? Co-creation as a strategy for product development. 2016. *Strategic Direction*, 32(10), 13-15. <https://doi.org/10.1108/SD-07-2016-0111>.
- Tobon, S., Ruiz-Alba, J.L., García-Madariaga, J. 2020. Gamification and online consumer decisions: Is the game over? *Decision Support Systems*, 128, 113167.
<https://doi.org/10.1016/j.dss.2019.113167>.
- Tong, D., Kang, H., Li, M., Yang, J., Lu, P., Xie, X. 2022. The Impact of Emotional Intelligence on Domain-Specific Creativity: The Mediating Role of Resilience and the Moderating Effects of Gratitude. *Journal of Intelligence*, 10(4).
<https://doi.org/10.3390/jintelligence10040115>.
- Veling, H., Ruys, K., Aarts, H. 2012. Anger as a Hidden Motivator Associating Attainable Products With Anger Turns Them Into Rewards. *Social Psychological and Personality Science*, 3, 438-445. <https://doi.org/10.1177/1948550611425425>.
- Wachowiak, M., Smolikova-Wachowiak, R., Johnson, M., Hay, D., Power, K., Williams-Bell, F. 2018. Quantitative feature analysis of continuous analytic wavelet transforms of electrocardiography and electromyography. *Philosophical Transactions of The Royal Society A Mathematical Physical and Engineering Sciences*, 376, 20170250.
<https://doi.org/10.1098/rsta.2017.0250>.
- Zhao, X. 2022. Customer Orientation: A Literature Review Based on Bibliometric Analysis. *SAGE Open*, 12(1), 21582440221079804.
<https://doi.org/10.1177/21582440221079804>.