Emotional Analysis through EEG on In-Store Journey

Pilot Methodology for Evocation of Emotions Through Video Stimuli to Measure Performance Metrics Using EEG Emotiv EPOC+ on In-Store Experiences

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Abstract. This work presents the results of a pilot study for emotion evocation to explore the customer journey in a departmental store to detect possible friction points using biosignals and a retrospective verbalization. Our proposed methodology relies on the assumption that states how episodic memory elicits recollection of past events, thus, the previous emotional state of that specific event, providing a more efficient and vivid approach to measure their experience in a controlled environment. The present methodology is based on video-recording the participant's purchase journeys at the store, subsequently using the mentioned recording as visual stimuli to measure and report the emotional journey (as-is) based on quantitative data acquired by the use of an electroencephalograph (EEG). This data was complemented by retrospective interviews in order to build a solid comprehension of the user's journeys and their interactions with the services. The results obtained through these tests (n = 3) offer measurable genuine reactions towards their personal journey through the store, areas of friction, and key interactions during critical stages of their journey such as the payment system failures, crucial interactions, and the presence of the store employees, along with the imperative store's infrastructure to offer a homogeneous in-store experience. We present these results despite the limitations of the study (sample size) due to the potential of the methodology and expect that more researchers can expand our findings.

Keywords: UX Research · EEG · Emotional Journey · Customer Journey · Episodic Memory · Human computer interaction (HCI) · Bioinformatics · Laboratory experiments

1 Introduction

One of the main objectives of business organizations is that customers can access their value proposition. However, they can only access them through the interaction of the different spheres that conform to the offered service [21]. These spheres may include

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interactions with technological interfaces such as digital applications or web pages, and human-human interactions, with systems and operational processes to complete a certain task. The integration of all interactions in these spheres and their consequences for the individuals result in the user experience [15, 17]. Therefore, it is necessary to ensure that all of them are working properly. To achieve this, it is indispensable to know which are the key points of friction or rupture through all interactions employing research processes.

The user experience can be categorized into different levels of an individual's relationship with a company; the single interaction level reflects the experience of an individual who has used a single device to perform a specific task. The journey level captures the complete experience of a user to achieve a goal and can be made up of multiple interactions between channels or devices. The main phases of a typical journey are; the need for recognition, information search, evaluation of alternatives, purchase decision, and post-purchase behavior [21]. The last level, the relationship level, refers to the interactions between a person and the company throughout the life of the customer-company relationship [19]. To create memorable experiences and ensure that they not only meet but exceed user expectations, at any level of relationship with companies, they must be known and understood in their entirety. Understanding the experience in this way will help us to identify the needs of stakeholders and not just customers [10].

Among the methods used for this purpose, it can be found effective tools such as the so-called journey maps. This type of human-centered tool (HCT) helps to understand the interactions that users have with other stakeholders by visualizing the interrelationships of people over time between the service channels and the users. A journey map not only includes the steps where individuals interact with the services but also reveals the key steps of an experience. Journey maps help to find gaps in user experience and explore potential solutions. This tool can be used to visualize existing processes (as-is) like a sequence of events, moments, experiences, interactions, or activities. Journey Maps make intangible experiences visible and facilitate a common understanding point and offer possible solutions [21]. Nevertheless, data collection methods for these types of tools usually include interview methods and retrospective verbalization protocols, so that the information collected may be biased by the user. That is, for researchers to fully understand users' interactions with the services they offer, they rely on the user to consciously recall and acknowledge the processes they underwent. This can be difficult when talking about a journey in a physical store, where there is not a completely controlled environment for observation.

This pilot study aims to offer an alternative to end-to-end knowledge through the analysis of psychophysiological data acquired through biosensors. The advantage of these is that the psychophysiological reactions elicited by the interaction of the users in the journey offer quantitative information that does not rely on the consciousness of the actions of each individual. The methods presented are based, like the retrospective verbalization protocols, on the evocation of memories and therefore emotions for the tracking of the journey through biosensors.

Thanks to the evocation of emotions and interactions it could be possible not only to measure in a more reliable way the experience in a physical place, but on digital screens

by placing users in a specific context. Therefore, now we could evaluate more complex interactions and elicited emotions by the users due to cultural, social or individual contexts with the EEG. These evoked emotions could be reported robustly without the traditional worries that come with EEG signals like mobility of the equipment, travel costs, BCI Illiteracy [3] and those derived from the active interaction: user's movement, noise in the signals and artifacts, which need to be removed by the researchers; this is our main contribution to the field of HCI.

1.1 A Glimpse into Human Memory

Human memory can be divided into two main categories; short-term memory, which is defined as that memory that we can access only when we are aware of specific actions or events that have occurred within a short period, and declarative memory or long-term memory, which is that which we can access even when we are not aware of the actions performed and the period of occurrence of the events may dwell in a place far away from the present [24].

Declarative memory is categorized into three areas; semantic, which refers to the association of events with meanings, this kind of long-term memory can be abstract and are not context-dependent [4]; procedural, which has to do with that type of memory that we acquire through the constant practice of some activity [12] and episodic memory. In this case, the study was oriented toward the third area of long-term memory, episodic memory, which is defined as that type of memory that consciously elicits past events conceptualized in the first person (events personally experienced by the individual) in a specific Spatio-temporal context [18], that is, the evocation of past events conscious defined by a specific cognitive state; by temporal circumstances, by spatial circumstances, and by the affective state. The importance of the emotional state in which individuals are at the moment of memory fixation is evident when it is noted that people do not remember just any events, but those that carry an intrinsic emotion [2, 7, 24, 25].

1.2 Episodic Memory and Emotional State

Some authors show evidence of the close relationship between memory and cognition with the emotional state of individuals [2, 8, 18]. In this sense, the emotional state can be understood as the sum of complex psychophysiological patterns in the brain and body derived from the response to external events or objects perceived through sensory activity, whether this response occurs in real-time or is retrieved from memory [5, 13]. The existence of the emotional state and its change endows individuals with the ability to assign values, either positive or negative, concerning a psychosocial belief system to the events they experience, and this in turn mediates the way they interact with their environment [7].

Thus, cognitive processes, and memory, rarely occur completely independently of emotional processes. Memory and emotions are affected in both directions, in other words, cognitive processes can mediate and evoke emotions, just as an emotional response can evoke memories. In the case of episodic memory, this type of memory mediates complex emotions. Recalling past events in a specific context should evoke the emotional experiences associated with this event, which in addition would generate the

emotional state that the subject experienced from the event in question. This is because the limbic system, the one that processes emotions, is related to memory processes through two types of somatic markers [2].

Therefore, two types of somatic markers contribute to the experience of emotions, the first are those markers that are learned or are innate, the second, and the most relevant for this pilot study, are those markers that cause emotional states thanks to the retrieval of information stored as memories [5].

1.3 Evoking Emotions Through Episodic Memory

According to Ellard [8] it is not enough that an emotional state is recalled, but the environment and the context by which it is recalled influence the quality of the experience. In this sense, the evoked episodes are more vivid when the same contextual conditions are available to the individual during the memory creation process [2]. There is evidence that recall of personal experiences through stimuli that are recognized as personal evoke more complex emotions [8].

Likewise, the methods for evoking episodic memories and emotional states directly affect the quality of the information collected for study. Hu [13] divides the two types of stimuli used to evoke these, internal stimuli where there are no external stimuli to induce a memory, for example, guided recall practice, and, on the other hand, external or media-based stimulation. The second category refers to those stimuli that come from a source outside the individual, such as photographs, audio, or video [18]. When talking about the study of emotions at the laboratory level, media-based studies are usually chosen because these types of stimuli evoke responses automatically and the bias of the participants tends to be lower than in guided recall activities [8].

Therefore, if it is desired to elicit memories and emotions as closely as possible to the moment in which the event was experienced, it is important to achieve an ecological environment that emulates as closely as possible the environment experienced by the individuals. Several authors have suggested that the best source to recall emotions is video, since this creates environments of high intensity and emotional complexity, offering greater stimulation in a more efficient manner and with a much more vivid approach in a laboratory environment; where participants have a greater sense of substitution of the environment and a faster response to the materials presented [8, 13, 18]. In addition, the video material can be complemented with meaningful audio, congruent with the recording, to increase the effectiveness of the evocation, creating a conducive, ecological and familiar environment for the participant to recall these events with the emotional states involved.

1.4 Methods for Emotion Quantification

The method by which emotional information is obtained also plays an important role in ensuring the quality of the data. Usually, the analysis of the emotional state of individuals is based on self-reported information that gives researchers an idea of what is happening as long as the user is aware of this.

In addition to the self-reported emotional state, there is another way to obtain information about the emotional state of individuals, which refers to the measurement and

analysis of physiological indices through biosensors. In general, biosensors are used to measure spontaneous physiological changes due to the psychophysiological change of individuals in reaction to external stimuli, and these measurements have the advantage of greater consistency between individuals [13].

Finally, some of the most commonly used physiological parameters for the quantification of psychophysiological and emotional states refer to the change in cardiac variability (HRV), the change in respiratory rate (RFV), or the change in electrodermal skin response (EDA). Spontaneous physiological changes in these indices are often related to cognitive and emotional responses [1, 6, 16]. However, from a neurophysiological perspective, electroencephalography (EEG), a method mediated by a non-invasive device, can provide information about electrical changes in the brain more accurately and in real-time, without being mediated by some other type of limbic system mechanism by measuring the electrical activity of the cerebral cortex under different emotional states [16]. The information retrieved from the EEG can provide information about the mental and emotional processes that lead to certain behaviors.

1.5 Similar Studies Measuring Emotions

An emerging need for product and service evaluations has been measuring emotions in real time, with short times being the most accurate because of the difficulty involved in measuring them beyond a few hours [20]. The Emotiv EPOC+, biosensor used in this pilot, has been used in different studies: such as the one by Zabcikova in 2018 [28] to measure the performance metrics, using the software company, in relation to visual and auditory stimuli; in addition to the use in measuring stress in architectural virtual environments [9].

Other EEGs have also been used to localize frontal brain regions during the memory development process, as well as to explore other important factors related to long-term memory and its remembering [11]. Also using these devices, it has been found that there is a greater effect on user experience when combining sounds and video, compared to using only one type of stimulus [26].

2 Materials and Methodology

2.1 Participants

The sampling method used for this pilot study was non-probabilistic, by convenience. This study was open to any individual who was a customer of the evaluated department store, in this case being residents of the city of Puebla, Mexico, in an age range between 18 to 60 years old; it was also required that they had the availability to attend the different stages of the study in person. The exclusion criteria for the study were that participants must not have any self-reported neurological condition or be under any medical treatment that would interfere with the acquisition of electroencephalographic signals and that they should not present BCI Illiteracy [3]. From this sampling method and due to the pilot characteristics of the study the sample size consisted of two females and one male ($n = 3$, avg 31.4 years old) in which an in-store test and a biometric test were applied.

2.2 Procedure

Recording of Stimuli. Prior to the in-store trial, a technical test was carried out. It was verified that each one of the participants did not present BCI Illiteracy [3], meaning they were not part of the 20% of the population whose neurological signals could not be recorded by an EEG. This was performed in order to avoid complications of readings in the second part of the trial and ensure reliable signals during the interviews. In case of having valid readings, the test was continued, in case of not having readings, the participants could not be considered within the sample, since there would be no EEG readings.

Once the technical test with EEG was performed and the signals obtained were validated, their experience in the store was recorded using a GoPro HERO9 Black with a harness on the chest, as evidence of their journey through the store, which would be used the next day to evaluate their journey biometrically. The participants' journey consisted of typical journey that many clients do on a regular basis, which consisted of the following activities:

- Need recognition: The participants looked around the store for products they wanted without exceeding 500 Mexican pesos.
- Information search: During their search, they were allowed to interact with every information point, including the store employees.
- Evaluation alternatives and Purchase decision (user's choice): The participants indicated when they were ready to pay for the items selected through the product search.
- Product Payment: The participants pay their items by interacting with the store employees and ended when the articles were given to them.
- Post-purchase behavior: the participants interacted with the systems and employees after the purchase.

The participant's journey could be summarized in three broad moments which include the before-paying phase (Need recognition, Information search, Evaluating alternatives, and Purchase decision), the payment phase (Product payment), and the after-payment phase (post-purchase behaviors).

After the observation test in the department store, the videos of the three participants were transferred to a computer, to be used in the next phase of the study. The second phase of the study was conducted at the offices of Sperientia: [Studio + Lab]® a day after the in-store trial, where the participants were fitted with the EEG headset model EPOC+ of the EMOTIV brand, where they watched the aforementioned videos, to measure performance metrics obtained through the EEG. In addition, retrospective interviews were also conducted to complement the information retrieved from the readings obtained by the biometric device in order to understand the complete customer journey of the participant.

Retrospective Interview with EEG about the Store Experience. Interviews were conducted along with the observation test with EEG model EPOC+ by Emotiv. The observation test used as stimuli the video recordings of each participant along their purchase journey. The EEG was used to observe the emotional reactions of their journey.

The data obtained was stored at an internal server from Emotiv, for future processing, lecture, and interpretation.

To ensure the reliability of the signals, participants were asked to go to the test without hair products, not wearing any metal accessories on their ears or neck; keep the cell phone and any electronic device in airplane mode, or turned off, as far away as possible from the EEG. Participants were also asked to limit their head movements to reduce and/or eliminate noise in the signals caused by electronic devices or movement of the participant, respectively.

A baseline was used in the study, as a reference, to measure the relative changes in emotional states concerning the participant's baseline. During the baseline, participants were asked to try to relax as much as possible for 60 s with their eyes open and to repeat this process with their eyes closed for the same period.

The main analysis tool was the performance metrics graphs associated with emotional states, especially those related to task stress. These are provided by EmotivPRO software; the emotional spectrum obtained is explained below:

- Stress (ST) is a metric of comfort with the current task. High stress can result in the inability to complete a difficult task, feeling overwhelmed, and fearing the negative consequences of failing to meet task requirements.
- Engagement (ENG) is perceived as awareness and conscious attention to task-related stimuli. It measures the level of immersion at the moment and is a mixture of attention, and concentration that contrasts with boredom.
- Interest (VAL) is the degree of attraction or aversion to the current stimulus, environment, or activity and is commonly referred to as valence.
- Excitement (EXC) is a feeling with a positive value. It is characterized by activation of the sympathetic nervous system which results in a range of physiological responses including pupil dilation, eye-opening, sweat gland stimulation, heart rate, increased muscle tension, blood redirection, and digestive inhibition.
- Concentration (FOC) is a measure of attention to a specific task. It measures the level of depth of attention, as well as the frequencies at which attention shifts between tasks.
- Relaxation (MED) also known as meditation, is a measure of the ability to shift concentration and recover from intense concentration.

3 EEG Data Interpretation

The data collected by the EMOTIV PRO software is represented in a simplified scale with a range of 0 to 100 points. There is also the baseline, which refers to the lack of stimulation or conscious rest of an individual, to be compared with situations by measuring the change between the signal at the desired time for the initial normal values marked by the baseline for each human being.

Each individual presents different performance metrics, either by their mental state on that day, or session, up to the moment of obtaining data, so the baseline allows an understanding of the current resting state of each participant and a comparison. Therefore, due to the different metrics in each individual, it is not possible to have a

standardization of performance metrics. However, it is possible to measure the change in these metrics over time when different stimuli are presented, then a comparison is made between the baseline and some other relevant event to observe the change in the metrics.

4 Results

Applying the emotion evocation pilot methodology, the customer experience at the store could be measured by the aggregation of Emotiv's performance metrics through the shopping journey. Since these results only use information from 3 participants, it allowed the researchers to identify problems on the customer journey experience on the retail store on one of its locations. The results are depicted like radar charts, which are formed by 6 axes. Each axis represents a performance metric variable, and each set of data is represented by a color. These figures are used for a better lecture.

4.1 Payment System Importance for the Customer Experience

It was observed that while the participants recalled their payment journey, the three observed their problems when they tried to pay by credit card. The performance metrics showed a stress increase after the store staff stated the issue with their payment system (yellow color and squares in Figs. 1 and 2).

Additionally, relaxation, which represents the ability to change focus and switch between tasks; all the participants upon completion of the payment journey (green color and circles) had a low level of this metric compared to the point of the statement of the crash pay system. This could indicate that the experience of this failure generates stress that remains after the payment journey is completed (Figs. 1 and 2). Without this methodology, it would have been difficult to find this reaction to the error or crash in the payment system.

On the other hand, the three participants showed an increase in their interest levels while the payment task in the journey was recalled. This metric can note aversion or attraction to a stimulus. In this case, it could be taken on aversion, as indicated by the aforementioned metrics.

As shown in Figs. 1 and 2, it is possible to observe an increase in stress along all three (3) participants. This increase was observed during the payment procedure, where in all three participants, the system failed and didn't allow them to pay with anything except cash (yellow color and squares).

Furthermore, the performance metrics observed in Fig. 3, excitement, interest, and relaxation (green color and circles) increased compared with the start levels before the payment of the items (blue color and triangles). This could mean that the participant had a conscious positive emotion at the time of the purchase, even though they had to pay for the items in different store departments. This positive emotion can be related to a decrease in the excitement level at the moment before and over the purchase. It's possible meaning, regardless of the outcome, the excitement still increased, even with the payment failure.

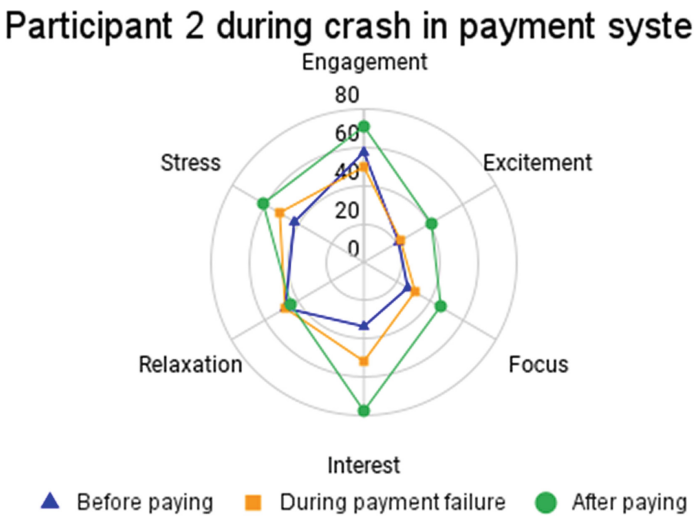

Fig. 1. Performance metrics along the payment journey, with system failures on participant 2. Showing an increase in stress and interest; with stress levels from 38 to 39 points and interest levels from 47 to 48 points.

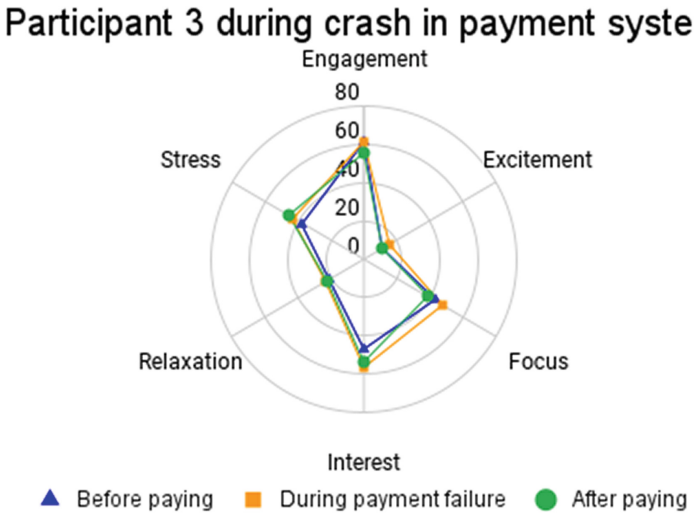

Fig. 2. Performance metrics along the payment journey, with system failures on participant 3. Showing an increase in stress and interest among the participant 3, showing stress levels from 37 to 45 points and interest levels from 47 to 56 points.

Therefore, by using the emotion evocation methodology it was possible to observe the psychological effects along the journey in the product payment. For this instance, the negative effects of a payment system failure lead to an increase in stress. This allows

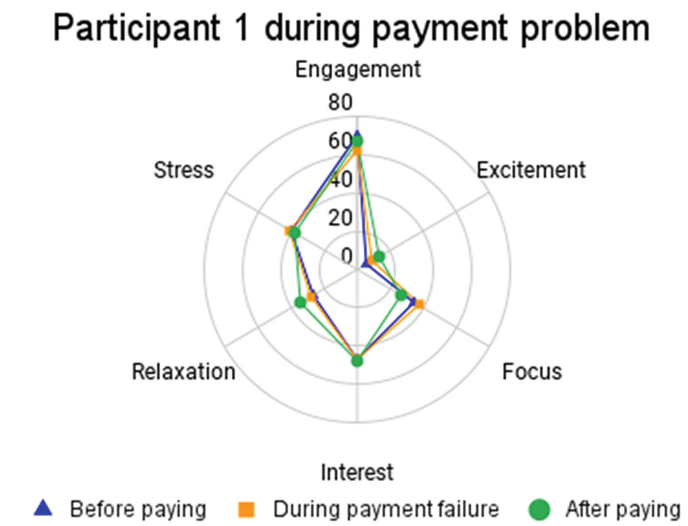

Fig. 3. Performance metrics along the payment journey, with system failures on participant 1. Showing an increase in stress and interest among the participant 3, showing stress levels from 37 to 45 points and interest levels from 47 to 56 points.

us to find a possible problem that the chain store can fix and prevent further instances of bad payment experience for their customers.

4.2 Shortage of Staff Affects Customer Experience

On top of that, it was also possible to observe how the performance metrics change with the staff presence and their help through the shopping journey. This change in the performance metrics was seen when the staff attendant brought assistance to a participant (Fig. 4, blue color and triangles).

Also, it was noted in the data how the presence of staff affected the participants at an emotional level; a decrease could be observed when activities were carried out without collaborators (Fig. 4, color yellow and square), and an increase when there was the opportunity to interact with them (Fig. 5, color yellow and square).

Firstly, in Fig. 4, we can see the journey of participant 1, where the performance metrics of her sensory reactions to being lost in the store without having a specific goal (blue color and triangle) were observed. It is possible to see how the lack of store personnel affects the values of the performance metrics by not observing a collaborator and reacting to her journey in the store.

The increase in the levels of engagement can be attributed to the concentration on remembering the task of his trip the day before as the participant observes on the screen, making him aware of his behavior in the recorded video. Likewise, should also be emphasized the metrics of their concentration and interest when browsing the store; they have values that correspond to the interaction with a collaborator (blue color and triangle), the search for items without a collaborator (yellow color), and the continuation of their search without a collaborator (green color and circle), respectively. There it's

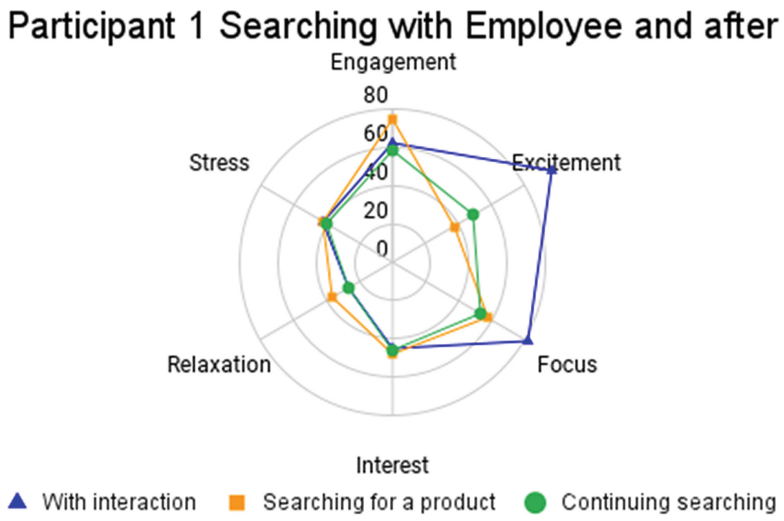

Fig. 4. Performance metrics along the searching journey, with contributor assistance and after the assistance on participant 1. It is possible to observe an increase in engagement by 13 points compared to their initial level during their search in the store; a decrease in excitement from 96 to 37 points and in concentration from 82 to 53 points.

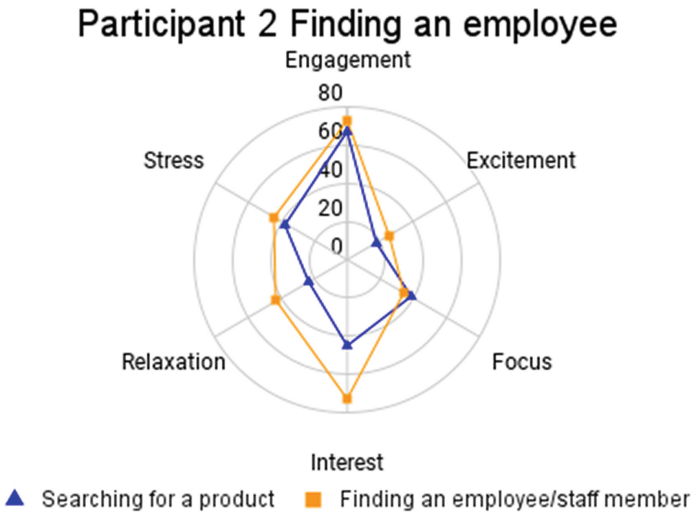

Fig. 5. Performance metrics along the searching journey, with contributor assistance and after the assistance on participant 2. Showing an increase in excitement, from 18 to 25 points; interest from 45 to 73 points; relaxation from 23 to 43 points.

noted how excitement and focus decrease, having a peak value when the participant interacts with a staff member and decreasing for the rest of the journey.

The changes in excitement and concentration allow us to infer how the lack of personnel caused a loss of excitement and concentration in their search for products, which could be the cause of a potential purchase at risk of not being completed. The participants (P1 and P2) commented on the possibility of having help but not receiving it due either to the lack of presence of collaborators or available personnel. On the other hand, excitement measures the levels of emotion that physiologically show high attention to a task, generalizing along with the exponential loss of concentration, where we can observe that P1 had a decrease in attention in the search for products when he started a part of his journey without attention to the customer or showing interest in his present needs.

In addition, another important sensory metric is the increase in relaxation of more than half, increasing compared to the baseline when initiating a search for your products. If possible, the user witnessed an event where their cognitive load was low by not having something that caught their attention. This could be processed as a positive metric, but the emphasis should also be given to the timely cognitive load for decision-making explained by Victor Yocco [27] in his book Design for the Mind: Seven Psychological Principles of Persuasive Design; in this case, the selection of items with control reasoning and normative beliefs could lead them to make a decision which is supported by the context of being assisted by a collaborator previously knowledgeable in the area of children.

Secondly, Fig. 5 shows how participant 2 was performing tasks 1 and 2, needing recognition and information search, for about ~40 min, during which no staff interacted with him. As the participant was passing through several departmental areas and observed several employees, who were seen to be available but not interacting with him. These conditions give rise to the episodic memory reactions when showing the video to participant 2, where the values of when he goes through the shoe department (blue color and triangle) and when he observes a collaborator (yellow color and square).

These increased values of excitement, interest, and relaxation could show that the cause of these increments is due to the possibility of help being present in the area; causing the participant to feel more excited or interested in interacting with a staff member. This may be due to a person's tendency to have an idea of what they are looking for, allowing the employee to inquire and present options or recommendations as they see fit. During this event described and seen in Fig. 5, participant 2 appears to have an increase in their interest, meaning attention focused on the employee, accompanied by a relaxation regarding possible confidence in having a person available for his or her search. The potential of offering options from an experienced or knowledgeable store employee could allow the customer a short and concise trip.

To conclude, the described results have the potential found with the emotional evocation methodology, offer new ways to explore the customer experience, to find significant insights into critical points of the journey, and help to show some emotions difficult to express to the participants in the cultural or educational context. In the pilot study, it was possible to observe the emotional reaction to the crash of the payment system during task 4, product payment, and on tasks 1 and 2, need for recognition and information search, how the employees play an important part in the experience with their presence and aid to the customers.

5 Discussion

First, it was observed that the participants had common friction points throughout the shopping journey. The inability to pay by credit card, possibly derivatives in increases of stress and aversion to the experience. This could mean a possible negative emotion, that would result in an unpleasant experience and a potential dropout of the purchase or loss of loyalty from regular customers.

Another observation was the possible effect of the presence and companionship of the store staff throughout the shopping journey. The absence and lack of aid from them, generate a general decrease in the performance metrics, while the opposite stimuli increase them. Highlighting the importance of the store staff for the customer journey is vital for a better shopping experience.

The implementation of performance metrics with EEG (Emotiv EPOC+) had a positive impact on the analysis, as it was complemented with more usual methods to measure customer experience. This is a major element of change because it doesn't rely only on the self-report of experience of the participants [13]. The information collected by the proposed research method is relevant to building a journey map as described by Stickdorn, Hormess, Lawrence, and Schneider [21], specifically to know precisely all the stages and steps of the journey as well as the construction of an emotional journey and a quantitative dramatic arc and to observe and identify the channels and stakeholders involved in order to achieve a thoroughly understanding of the user experience. This information allowed us to conclude how the in-person shopping experience is still critical for department store customers.

Finally, it is important to note that although the results obtained are not generalizable, due to the sample size and the contextual specificity of the present pilot, they are relevant because the proposed methodology allows the detection of possible friction areas to explore different scenarios, thanks to the combination of different research methods; usual verbalization, video analysis and analysis of biosignals. Through which issues could be identified, without the presence of EEG would have been hard or even impossible to find, since the information obtained couldn't be expressed through conventional methods like interviews or surveys. This kind of approach could help the difficult population externalize their thoughts and feelings with service and products; being an inversion to customer experience research, making room for the improvement of the store experience. Furthermore, the methods used to identify the population with BCI Illiteracy [3] before starting a participants' journeys benefiting from the Emotiv EPOC+'s portability, could save time and efforts on research expenses.

We assume that the combination of the aforementioned methods and the implementation of biosignal analysis provide the study with a greater capacity for discoverability of critical points on the journey, making this method a viable and useful alternative for the task of user experience research.

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