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NEUROFEEDBACK IN TAILORING EMOTION-EVOKING INTERFACES

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Abstract. The interplay between visual attention, emotional reactions and neurofeedback patterns during interface interactions is investigated in this work. It shows how long visitors can stay focused on banner adverts and video replay buttons, therefore impacting their experiences. By examining the physiological foundations of emotional responses, neurofeedback theory provides a basis for developing more engaging and immersive user interfaces. The study underlines the need to create specialist design methodologies to satisfy the needs of several user groups by including neurofeedback data, self-reported emotional responses and eye movement monitoring into design. The outcomes could change the process of designing interfaces, offer new perspectives for user-centred design and ultimately improve user satisfaction. Theory of human interface design and neurofeedback theory might cooperate to enhance user experience interfaces. The findings of this research project might change the way interfaces are created, provide users something physical to hold onto, increase their enjoyment and inspire deeper investigation of user-centred design ideas. Combining neurofeedback theory with user interface design theory helps one create user interfaces that fit consumer demands and have an improved user experience.

Keywords: *Neurofeedback, emotion, user interface, user experience, eye-motion monitoring.*

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1. Introduction

Theories in neurofeedback and user interface design suggest that technology able to recognise as well as manage users' emotional reactions has become ever more crucial to provide an all-encompassing user experience. Recently, creative user interface design has attracted a lot of interest as designers strive to provide experiences that satisfy practical needs and also appeal to users' emotions. However, generating correct emotional feedback using neurofeedback theory is difficult in user interface design and necessitates taking into account several aspects. According to certain research, using neurofeedback theory may affect user interface design and elicit particular emotional reactions (Ho, 2017; Jeunet *et al*., 2019).

Given its functions on tracking brain activities and providing immediate reactions, neurofeedback has found widespread application in scientific and therapeutic settings to assist in controlling emotional changes and cognitive thinking processes (Fahrudin & Wahyudi, 2023). Based on neurofeedback theoretical concepts, more possible principles and applications of neuroscience-related designs have been developed. For example, neurofeedback technologies would be applicable to grasp certain emotional reactions. This application is vital to identify the roots of typical emotional changes. Since users' emotional states influence their cognitive thinking capacities, decision-making skills and overall satisfaction with technology were understood, it is beneficial to design scholars to explore how user interfaces generate diverse emotions. It is expected that the enhanced interface usability would boost brand recognition and promote user engagement. By swiftly analysing people's emotional reactions to a design, researchers may get valuable insights by using the ideas of neurofeedback theory. The interface's design (Ho, 2021) and the intensity of the appeal to the user to input the value (Bate & Robert, 2023) may be enhanced using the provided information.

By studying general individual feelings, designers would modify the vast aspects to improve user interfaces. Creating interactive user interfaces that take the user's emotional state into account is a potential alternative to traditional approaches that do not. Integrating neurofeedback into design challenges standard methods while bringing up new creative avenues (Nath *et al*., 2023). Moreover, it recognises that emotional responses are inherently and exhaustively complex. At the same time, we recognise the potential limitations of traditional design techniques when it comes to handling human variety and subjective emotional responses. Although user feedback is useful, it is based mostly on the process of assessing self-experience, which may only capture a portion of the emotional reaction to real-time interactions (Maszczyk *et al*., 2018). Designers may overcome the inherent limits of subjective feedback approaches by using neurofeedback to understand users' emotional experiences more directly and correctly. This study aims to address the gap in understanding how neurofeedback can be systematically applied to user interface design to evoke targeted emotional responses, thereby advancing research in affective computing and user experience.

2. Overview of neurofeedback applications in various fields

Neurofeedback is a kind of biofeedback that builds self-regulation on top of monitoring brain activity in real-time. Many different types of businesses have made use of this technology. A good example is the use of neurofeedback to enhance athletic performance. Previous research shows that neurofeedback may improve both the dynamic balance skill of judo players and the minimally invasive surgical abilities of healthy individuals (Ros *et al*., 2009; Maszczyk *et al*., 2018). Also, neurofeedback can enhance athletes' psychological capacities, as several studies have shown that it enhances the performance of athletes who fire weapons (Rostami *et al*., 2012; Cheng *et al*., 2017). However, since it improves concentration and attention, neurofeedback may be useful for athletes who want to improve their performance (Domingos *et al*., 2020; Bíró & Balogh, 2021). Among the mental health illnesses for which neurofeedback has had favourable results are attention deficit hyperactivity disorder (ADHD), anxiety, major depressive disorder (MDD) and post-traumatic stress disorder (PTSD). Many people (including young football players, individuals with tinnitus, cancer survivors and sad people) who have reported increases in their emotional health, creativity, physical performance and cognitive capacity have benefited from neurofeedback (Linden *et al*., 2012; Luctkar-Flude *et al*., 2019). In many spheres, including the decrease of symptoms, anxiety, tension and enhanced aural awareness (Zadkhosh *et al*., 2018) as well as improvements in expressiveness, attention, cognitive function and emotional processing (Maszczyk *et al*., 2020; Jensen *et al*., 2020), neurofeedback has shown promise. Though it is clear that neurofeedback helps in these areas, additional research is needed to appreciate it and its possible uses in other sectors (Rydowicz *et al*., 2023). Neurofeedback offers excellent promise in raising emotional regulation capacities in guiding principles and user interface design. Positive social-emotional networks might be susceptible to neurofeedback treatment depending on changes in resting-state brain activity.

Patients with obsessive-compulsive disorder may find neurofeedback and metacognitive therapy useful for several problems, like cognitive attention impairment and emotional control. These results provide credence to the idea that applications of neurofeedback theory are essential for emotion management and UI design. Moreover, the comparison between non-immersive and immersive extended reality in the context of motor imagery neurofeedback inside brain-computer interfaces has implications for emotion regulation and user experience.

However, there's a risk of misinterpreting neurofeedback data, leading to incorrect conclusions about an individual's emotional or cognitive states. Challenges may arise from the reliability and consistency of neurofeedback technology, impacting the accuracy of the data collected. Also, privacy and ethical concerns about collecting and using sensitive brainwave data can pose risks without appropriate data protection measures. In some cases, continuous monitoring of brain activity could lead to psychological discomfort or undue stress in users. The capacity of neurofeedback is demonstrated to enhance the control of emotions and its suitability for addressing cognitive and emotional issues in many therapeutic contexts.

3. Existing research on emotional design and user experience

The importance of considering and designing for users' emotional experiences to generate meaningful and engaging interactions is highlighted by vibrant design, which substantially impacts user experience across many domains. Regarding human-computer interaction, the mysterious and crucial user experience (Hassenzahl & Tractinsky, 2006). They bring attention to the criticism of user experience (UX) for being nebulous and evasive, which shows how difficult it is to comprehend and create emotional experiences. Inspiring design can improve user experience by making people feel something when they use a product. The interdependence of usability, aesthetics and emotions in determining the whole user experience. These factors draw attention to the impact of aesthetics and emotional experiences on human-technology interaction. When designing interactive packaging, it is crucial to keep the user's emotional state in mind. There is a rising focus on dynamic elements in user experience design. One of these aspects is the analysis of user psychological characteristics, including feelings and emotions, while building web-based UX (Yusa *et al*., 2023). Highlighting the significance of emotional experiences in the design of mobile applications (Isa *et al*., 2023), positive feelings and recollections are robust indicators of product design success. A growing number of users are looking for products and services that cater to their emotional needs and augmented reality designs should consider this to improve UX. Andersen et al. (2017) made it known that user experience design techniques centred on people have the potential to create an enormous emotional effect via the use of technology.

4. The connection between emotional responses and user interface design

If examining the subject from the perspective of nerve feedback and user interface design, we recognise that the interface's design determines much of the user's emotional response. Based on previous research studies, aesthetic characteristics such as symmetry, complexity, as well as shape could influence the user's emotional response (Wang & Hsu, 2020). Alterations to the UI change the system's availability and may affect the user's emotional response. Using dynamic design to enhance visual communication and design is a widely utilised strategy to improve the user experience (Thüring & Mahlke, 2007). As a bonus, incorporating emotional engineering into user interfaces might enhance the bond between goods and their purchasers (Chang, 2005). Providing a satisfying dynamic experience to consumers is Dynamic Structure's principal goal. Since both practical contact and emotional reaction are important to computer systems, it is essential to include emotional aspects in the design of user interfaces (Gasah & Baharum, 2018).

When designing interactive objects, it is crucial to think about the user's journey from start to finish. One tactic used by designers to elicit the intended response is creating an emotional atmosphere (Gasah & Baharum, 2018). By integrating current dynamic features and visual presentation with new standards for user interface design, it might enhance psychological research tools (Betella & Verschure, 2016). Emotional engineering and the incorporation of new technologies into service and product design may influence how customers perceive a product's value and quality. 'Emotional Design' was defined as the processes put in place to ensure that a service or product meets the needs of its intended audience (Ho & Siu, 2012). As more and more emotional detection technologies are being used in UX design, the importance of emotion in UI design is growing.

5. Concurrently monitoring users' emotional reactions

Monitoring users' emotional states while interacting with a product or interface in real time is essential to collecting emotional response data during interface engagement. This procedure unfolds in phases and makes use of many approaches and technologies, as shown in Figure 1. Physiological reactions associated with emotional states are identified using biometric sensors (Nicholson *et al*., 2016). Electrodermal activity sensors, heart rate monitors and facial expression analysis tools provide real-time data on facial expression changes, skin conductance and heart rate. These measures, therefore, let one evaluate users' emotional arousal degrees in real time (Huang *et al*., 2023). The second phase is emotional recognition. Recently put in use, the emotionally sensitive system may identify user feelings during interactive participation (Filippi *et al*., 2022). This difficult approach calls for extensive inspection of the speaker's body language, facial expressions and voice intonation. It lets the system react to users' mood swings in real time. This considerably increases the availability of a meaningful view of their emotional condition throughout the conversation. Following this process, self-reported approaches include the use of mood assessment questionnaires and intermediate mood rating scales help to define its development (Linden *et al*., 2012). Employing this capability, users may interact with the user interface (Persiani *et al*., 2021) more effectively transmit their feelings. This approach guides the stage of data integration. Different data acquired from many sources - including biometric sensors, self-reported data and emotion-detecting software - must be combined in instrumentation. After the research is over, a comprehensive picture of the user's always shifting emotional states across the user interface is created (Zhou *et al*., 2014). The combined approach is a major tool for practitioners as it fully reflects the emotional profile of the user when interacting with the system. This kind of thinking enables individuals to gain a deeper understanding of the relationship between user attitudes and their interaction with the user interface (Lottridge *et al*., 2011). While prior studies have explored the use of neurofeedback in clinical and performance settings, a notable gap remains in applying these insights to the systematic design of emotion-evoking user interfaces. This research addresses this gap by triangulating neurofeedback, self-reported emotion and eye-tracking data to inform interface design strategies that are empirically grounded.

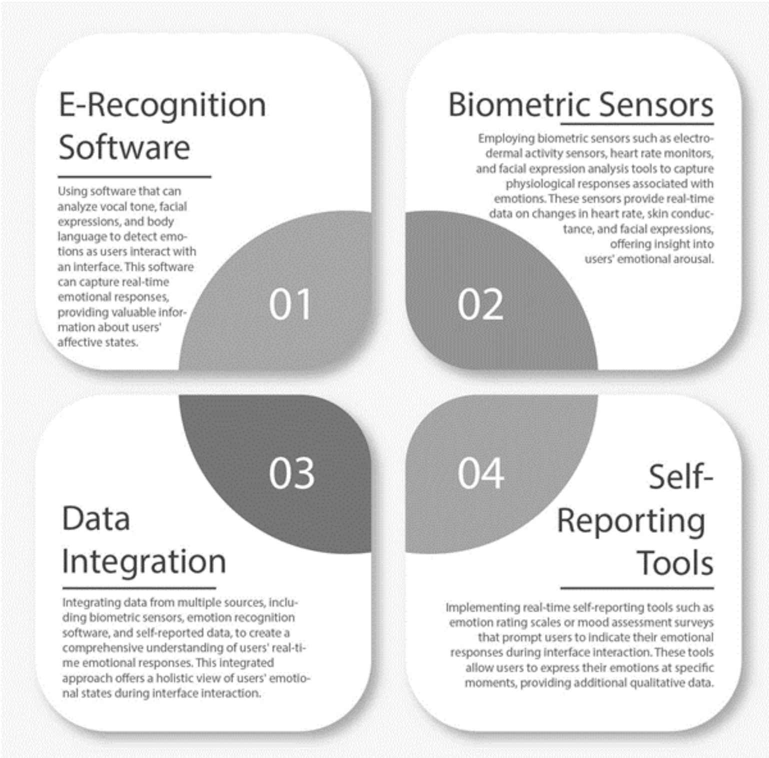

Figure 1. The figure shows the method for observing consumers' emotional condition

6. Addressing emotional states in interface design

Selecting appropriate emotional states is absolutely essential when developing a neurofeedback treatment interface. Neurofeedback-based interface designers have to fully grasp the ideas of emotional control in order to enhance the emotional reactions the components of the interface cause (Marcos-Martínez *et al*., 2023). The main emphasis of many studies has been on how people see neurofeedback. One area of specific inquiry that interests me is the use of neurofeedback to reduce PTSD symptoms. Emphasising this specific region, functional magnetic resonance imaging (fMRI) has been shown in trials to help reduce PTSD symptoms (Zadkhosh *et al*., 2018; Jensen *et al*., 2020). Focusing on the emotional control of symptom reactions, the recommended method may interact in a certain emotional state. Thus, the electroencephalography (EEG) data of a person might provide reliable signals of whether they experience happiness, sadness or neutrality, thereby augmenting the assessment of emotional states. Patients suffering from mental health issues might benefit from electroencephalographic neurofeedback devices. As a result of the current level of EEG technology, neurofeedback therapy to treat troubling emotions may be begun immediately away utilising EEG data. Neurofeedback and functional magnetic resonance imaging (fMRI) together provide hope for the treatment of depression and the real-time management of certain emotional states. The results provide information on the effects of neurofeedback on emotional states and pave the way for novel interfaces to aid in the treatment of diseases such as depression, post-traumatic stress disorder (PTSD) and complex emotion regulation. As far as neurofeedback theory and user interface design are concerned, these findings pave the way for neurofeedback technology to find many uses in the control of emotions.

7. Design Procedure

A variety of design techniques are necessary for the comprehensive and effective use of eye-motion tracking in studies evaluating neurofeedback of emotional changes induced by interfaces. Listed below are the processes that comprise these procedures. To adequately brief participants for the assessment phase, an overview of the study's objectives, methodologies and the intended utilisation of the eye-motion monitoring apparatus is provided. Proceed with the necessary preparations, such as calibrating the eye-tracking apparatus, after obtaining informed consent. Choosing the stimuli or interfaces evaluated requires much consideration; these should represent different emotional triggers and elicit a spectrum of reactions. Examples of this include applications, websites or multimedia interfaces meant to evoke particular feelings in the user. Before interface interaction, a baseline neurofeedback measurement of their brain activity is acquired to give participants' emotional states a starting point. This change permits one to examine the subsequent emotional responses to the interface. The eye-tracking device is positioned and calibrated so that it records the eye motions and gaze patterns of the users as they interact with the interface. This arrangement guarantees accurate data collection for subsequent neurofeedback analysis. Participants are asked to describe their emotional responses during the interface interaction or emotional stimulation. Pictures, videos or interactive elements designed to evoke a certain feeling might be the emotional stimuli found in the interfaces. In addition to detecting eye movement, neurofeedback data is gathered by employing eye-motion tracking to record brainwave patterns linked to emotional states. Because this data collection happens in real time, we can immediately correlate eye movements with emotional reactions. After interacting with an interface, individuals may be asked to share their feelings via surveys or interviews to have their thoughts and feelings recorded. The results on quantitative neurofeedback and eye-motion monitoring are supplemented by these findings. Correlations between participants' gaze patterns and emotional states are identified via the integration and analysis of recorded data from eye-motion tracking and neurofeedback. The purpose of this investigation is to show how various interface visual aspects affect users' emotional reactions. The results are examined within the framework of user experience research and emotive design principles to provide an interpretation of the results.

8. Findings

Thirty participants from various areas of the research provided actual information. The information of each participant generated a substantial corpus. Through these data, one discovered an increase in the staring habit, self-reported emotional reactions and neurofeedback data of the research group. solid statistical analysis made possible by this aggregated data expanded the comprehension of the emotional reactions induced by interfaces.

8.1. Interface Interaction Timeline

The results of neurofeedback research and eye-motion monitoring provide perceptive study of how various interface components influence emotional responses. Participants engaged with many interface components (including augmented reality (AR), testimonial sections, homepage banners, navigation menus and interactive galleries), having emotional states and gaze patterns recorded throughout a 30-individual sample. Interaction times varied from five seconds (Participant 26 in AR) to as much as 57 seconds (Participants 4, 8 and 12) interacting with webpage banners or testimonial sections. Shorter durations of interaction often correlated with strong positive emotional responses, such as excitement (Participant 26) or trust (Participant 1 and 13), while prolonged interactions often produced more complex or negative reactions, such as frustration (Participant 7 and 11) or awe (Participant 3 and 4).

Certain interface components exhibited distinct emotional responses. With short interaction periods between 5 and 14 seconds, augmented reality consistently aroused enthusiasm (Participants 21 and 26) and curiosity (Participant 27). Homepage banners produced mixed responses; some participants experienced irritation (Participant 24), while others claimed amazement (Participants 3 and 4) or trust (Participant 23). Contact forms produced varied results, indicating usability issues. They caused dissatisfaction (Participant 7) in some circumstances and astonishment (Participant 9). Navigation menus suggested that good engagement is supported by their primarily inducing interest (Participant 10) and trust (Participant 19). Primarily, video playback buttons were linked to trust (Participant 13) and irritation (Participant 11), reflecting variation in user experience depending on implementation in Figures 2 and 3.

Figure 2. Emotional response distribution among gaze areas

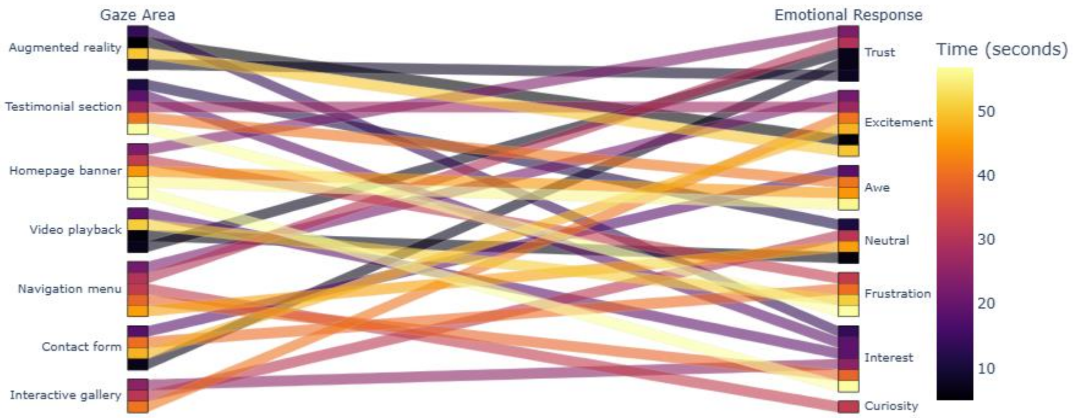

Figure 3. Flow Between gaze areas and emotional responses

A robust investigation of the link between visual attention and emotional states was made possible by combining neurofeedback data with gaze tracking. For instance, testimonial sections underscored the necessity of information relevance and presentation clarity by eliciting irritation (Participant 12) and attention (Participant 14). Post-interaction investigations provided these quantitative trends with a qualitative context and further insight into the subjective experiences of the participant. The method of the study (including baseline neurofeedback calibration, real-time eye-tracking during interaction and post-session feedback) helped to offer a complete correlation analysis. The importance of iterative testing to optimise interfaces for the intended emotional consequences is underscored by expert substantiation of these results within the context of emotive design concepts. These findings underscore the importance of utilising features such as AR to enhance user experiences and ensuring that the duration of engagement is balanced to prevent potentially disagreeable emotional tipping points.

8.2. Eye-Motion Tracking Data

Participants' attentional patterns and interaction dynamics are thoroughly revealed by the eye-motion tracking data collected in this study, which provides a comprehensive understanding of their visual interaction with interface components. The dataset consists of thirty individuals whose interactions' key metrics (including gaze positions, timestamps and interaction lengths) are recorded. With an average duration of 201.27 ms ± 56.61, interaction times ranged from a low of 102 milliseconds (Participants 7 and 27) to a maximum of 297 milliseconds (Participant 12). Participants' visual attention was usually focused within the centre areas of the interface; the horizontal gaze locations (X-coordinates) averaged 441.87 (±31.54), while the vertical gaze positions (Y-coordinates) averaged 359.5 (±29.26), as shown in Table 1 and visualised in Figure 4.

The data exposes different trends in variability and gaze dispersion. Greater dispersion (407-495) shown by horizontal gaze positions suggested higher lateral scanning activity across the interface than by vertical positions (301-397). Higher X-coordinates (e.g., Participants 1 and 21: 495) were linked, for instance, with longer durations (174 ms), most likely reflecting continuous interaction with visually rich features such as augmented reality components. On the other hand, mid-range Y-coordinates (344-476) dominated the sample by interface designs stressing concentrated material, such as navigation menus or homepage banners. Additionally, there are clear tendencies in the durations of interactions. Longer times, such as the 297-meter involvement of Participant 12, matched targeted Y-coordinates (387), suggesting continuous attention on difficult or content-heavy parts like interactive galleries. More compact intervals were noted for lower Y-values (e.g., Participant 7: 352), perhaps suggesting distant or less attractive interface zones. These results highlight the need for exact eye-motion monitoring for comprehension of user activity. The study's high-resolution data collection enabled the identification of micro-interactions that were essential for the assessment of brief affective responses, such as astonishment or annoyance. The observed variations in gaze patterns indicate that interface designs could enhance user enjoyment by harmonising the duration of engagement and the position of spatial elements, thereby reducing cognitive burden. These findings could be combined with neurofeedback data in future research to investigate causal relationships between gaze behaviour and emotional states, thereby enhancing emotive design principles.

8.3. Self-Reported Emotional Responses

The subjective experiences of interaction with various elements on the interface were multifaceted in the affective reports that were the result. This dataset exhibits a wide range of emotional responses, including neutral, curiosity, trust, astonishment, displeasure, exhilaration and confusion. These responses fluctuate significantly along an interface component. These findings offer a more comprehensive comprehension of the affective consequences of interfaces, as they are founded on objective (quantitative) eye-tracking and neurofeedback data in Figure 2.

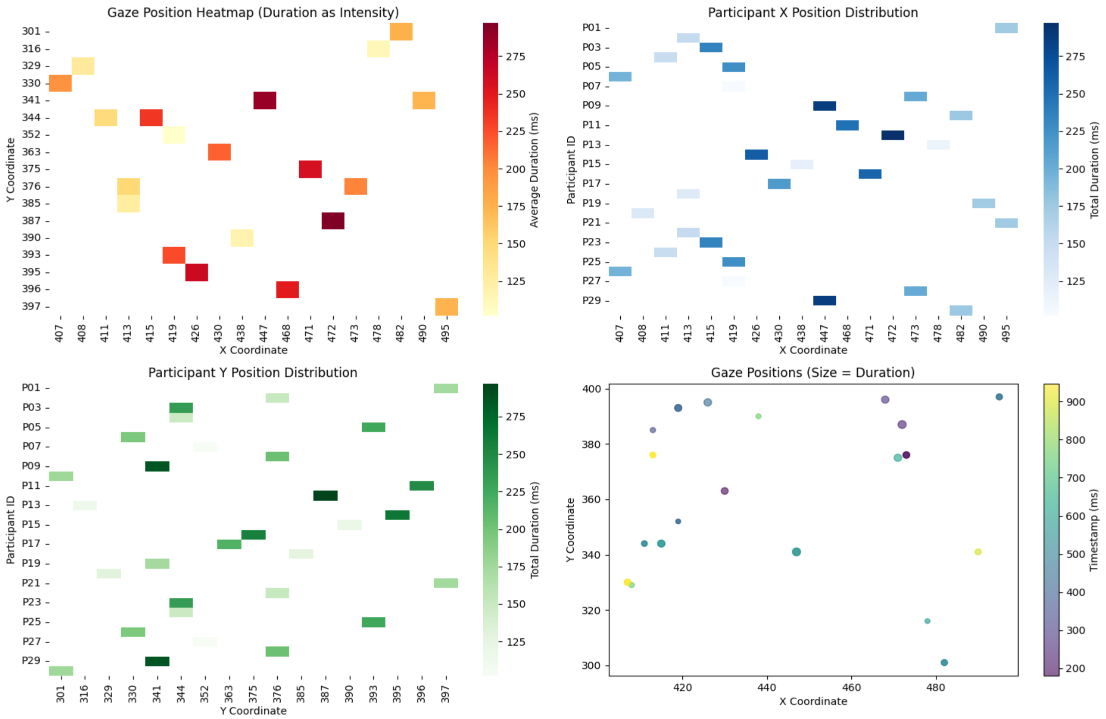

Figure 4. Heatmap Visualisation for Eye-Motion Tracking Data

Table 1. Eye-motion tracking data

Participant ID	Timestamp (in milliseconds)	Gaze X-coordinate	Gaze Y-coordinate	Fixation duration (in milliseconds)
P01	100	450	320	150
P02	200	480	310	200
...	...	...	...	...
P29	500	490	330	210
P30	700	460	340	190

8.4. Emotional Trends Across Interfaces

As evidenced by trust (P09) and fascination felt (P02), AR frequently elicited favourable emotions in the individual. This appears to suggest that the reason AR is so engaging and persistent for individuals is that it creates the social anticipation of entering virtual environments. The testimonial sections elicited a variety of responses, with some individuals being puzzled (P17) or intrigued (P22; P30), while others were astonished (15; 31) and excited in Figure 6. These contradictory responses may indicate that there are deficiencies in the validity of the content or the clarity of the presentation, underscoring the necessity of strategies to enhance these aspects to ignite interest and confidence. Conversely, homepage banners elicit unpredictable reactions, including astonishment (P12), revulsion (P06, P19) and neutrality (P15). Therefore, there was a discord across the stakes. The unpredictability of user gratification may be attributed to factors such as image saturation or sluggish loading times in Figures 7 and 8. Joy (P16), interest (P24 and P28) and neutrality (P07 and P29) emotions were received by the video playing buttons. The subject was momentarily shocked by negative emotions, such as confusion and attempted to push a button on top of the written default text, which was a plain orange colour and lacked a description string. The previously disbelief/awe emotion was initially pushed or touched from below at the left-side bottom edge. This may suggest the need for additional development or usability issues to ascertain the relevance of the content. In contrast, navigation menus typically elicited neutral emotions (P01 and P20) or moderate interest (P21, P25 and P27), suggesting that they were functionally appropriate but did not elicit emotional resonance. The use of contact forms received negative feedback from some participants (P10), while others responded with awe (P14). This may be attributed to the differences in the design of the usability aspects.

8.5. Implications for Interface Design

Adapting various interface components to receive emotional reactivity accurately is necessitated by the self-reported data. Positive emotions of astonishment and trust were elicited by good or entertaining AR and testimonial elements, both of which are associated with the potentiation effect. These elements have a significant capacity to increase participation. On the other hand, site advertising and video play buttons should be turned down as much as feasible to maximise user experience and reduce annoyance and confusion. A window for introducing engaging design elements, such as animated visual signals or customized messages, is suggested by the frequency of lackluster responses within navigation menus. These self-reported insights could be combined with eye-tracking or neurofeedback data to create more emotionally intelligent interfaces that align with users' expectations and desires.

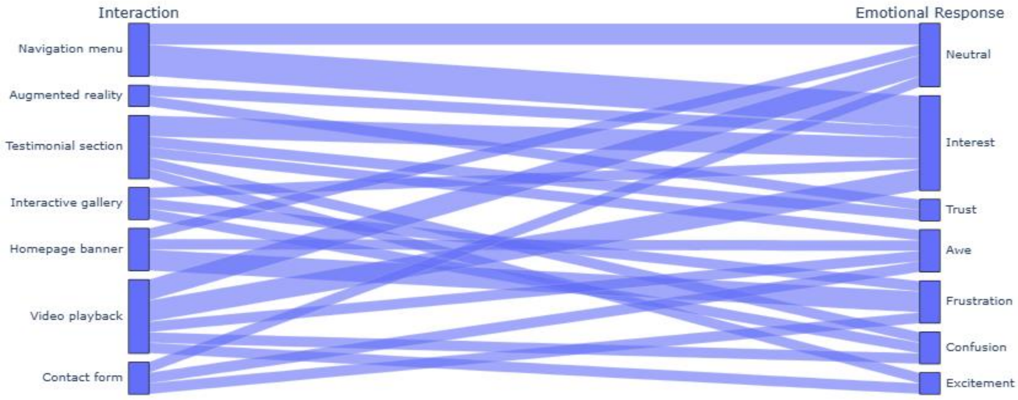

Figure 5. Connection between interactions and emotional responses

Figure 6. Emotional response distribution among interactions

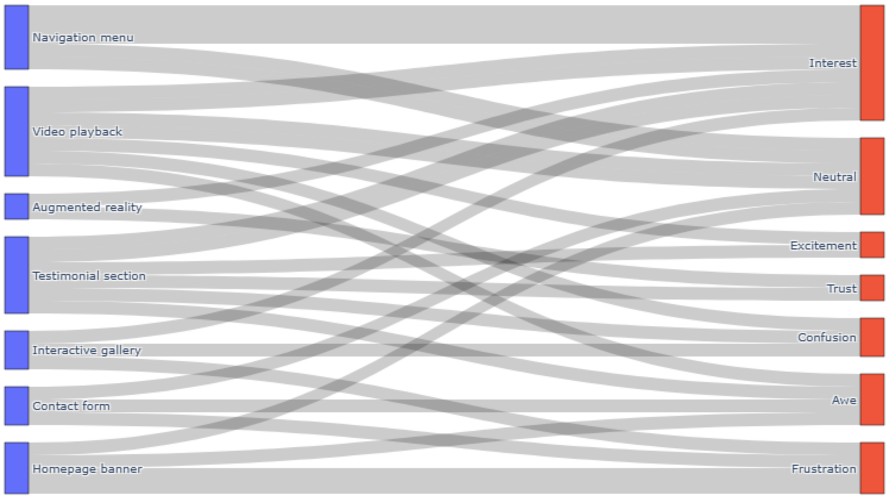

Figure 7. Emotional response flow

8.6. Neurofeedback Data

The psychophysiological database (Table 2) provides information on human brain activity during the interaction with interfaces and whose interpretation points to a relationship between which patterns of wave rides stem from emotional states. Apart from contact durations, the dataset comprised measurements of alpha, beta and theta wave amplitudes acquired among thirty participants (Figures 8-12). This multifarious approach clarifies how certain design elements influence cognitive and emotional reactions. The average length of engagement was 64.4 seconds (±38.9), ranging from 1 second (Participants 6 and 20) to 116 seconds (Participants 13, 14, 27 and 29) (Figure 8). In Figures 9-12, reflecting variation in relaxation and focused concentration, alpha wave amplitudes varied from 11 μV (Participant 14) to 20 μV (Participants 8, 11 and 15). Varying degrees of active cognition and attentiveness, beta wave amplitudes varied from 8 μV (Participants 8 and 10) to 15 μV (Participants 13, 19 and 29).

8.7. Emotional Correlations with Brainwave Patterns

The calm but engaged attitude is indicated by higher alpha amplitudes that are associated with positive emotions, such as trust [(18 μV) (Participants 9)] and amazement [17 μV (Participants 4)]. In contrast, lower alpha values are indicative of negative emotions (displeasure), as demonstrated by Participant 6, whose value of approximately 11 μV suggests cognitive excess or tension. Higher beta-band amplitudes were indicative of increased mental engagement when participants interacted with dynamic elements, such as participant 19's interest/excitement during augmented reality components (15 μV). Frequently linked to impartial responses, low beta values suggest passive interactions. Theta is typically produced in distressed individuals or a negative mood [-4.93 μV (Participants 7)]. Conversely, the amplitudes of this frequency are higher in all subjects who are experiencing cognitive stress and any confrontational emotions, such as confusion, unhappiness with their job or family. This was attributed to the local brain circuitry world versus the distant/discomfort way of location identification. Similarly, the centrally post-vibrating mode results in less expressive pressures at the cortices, which is in opposition to the general balance against affect norms of hearing. In contrast, low values of theta were negatively correlated with positive emotional climaxes, such as astonishment (Participants 11) in Figure 11.

8.8. Interaction Duration Patterns

Longer interactions were characterised by more stable alpha activity and low beta amplitudes associated with sustained attention in the absence of cognitive demand. For instance, participant 13 demonstrated continuous engagement of 115 seconds (correlated with alpha waves at 17 μV, β=15 μV and theta wave A =8), indicating that there was a balanced brain activity after extensive exposure to hard design features. Shorter interactions tended to expose more beta activity and reduced theta levels, reflecting the speedy processing of intuitive interface components in Figure 12.

8.9. Implications for Emotive Design

The neurofeedback findings highlight the importance of creating interfaces that maximise brain activity for desired emotional effects. Like augmented reality, higher alpha and moderate beta amplitude elements should be given first importance to foster calm yet engaging user experiences. On the other hand, elements connected to high theta activity, such as contact forms, may need revision to reduce cognitive load. Anomalies such as Participant 30's negative theta reading underscore the need for methodological refinement in future studies. By integrating neurofeedback data with self-reported emotional responses and eye-motion tracking insights, this study provides a holistic framework for emotive interface design. Future research could further investigate demographic influences on brainwave patterns or explore the longitudinal effects of interface interactions on neural activity to enhance user experience strategies.

Table 2. Self-reported emotional response

Participant ID	Interaction	Self-Reported Emotional Response
P01	Video	4
P02	Form	2
...	...	...
P29	Gallery	5
P30	Testimonial	3

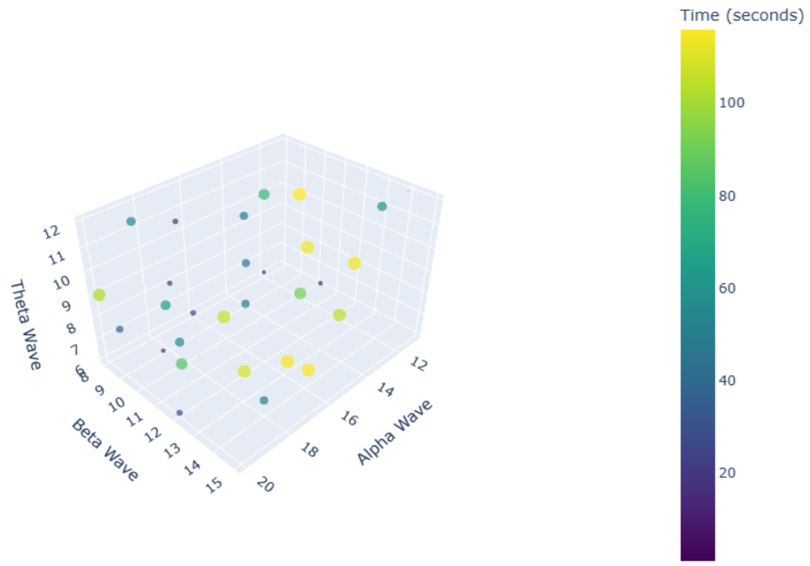

Figure 8. Brain wave amplitude relationships

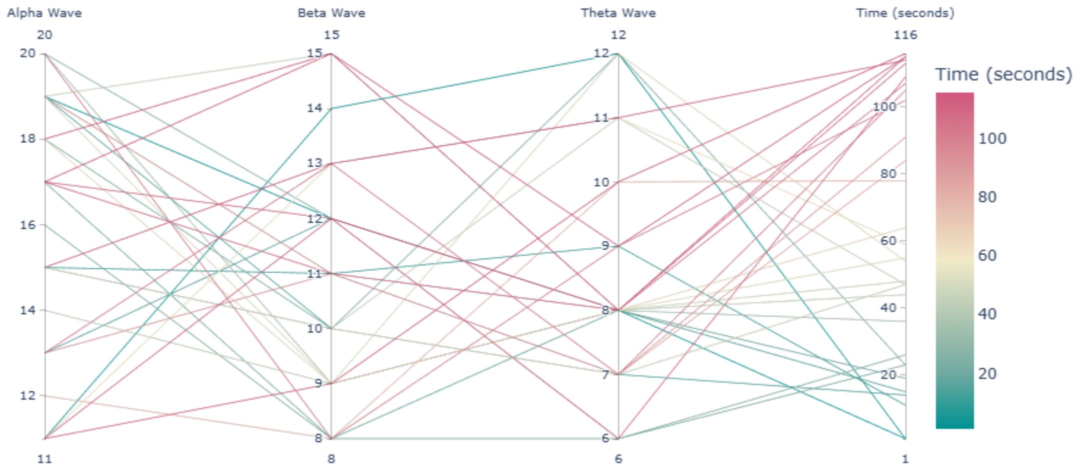

Figure 9. Brain wave patterns across participants

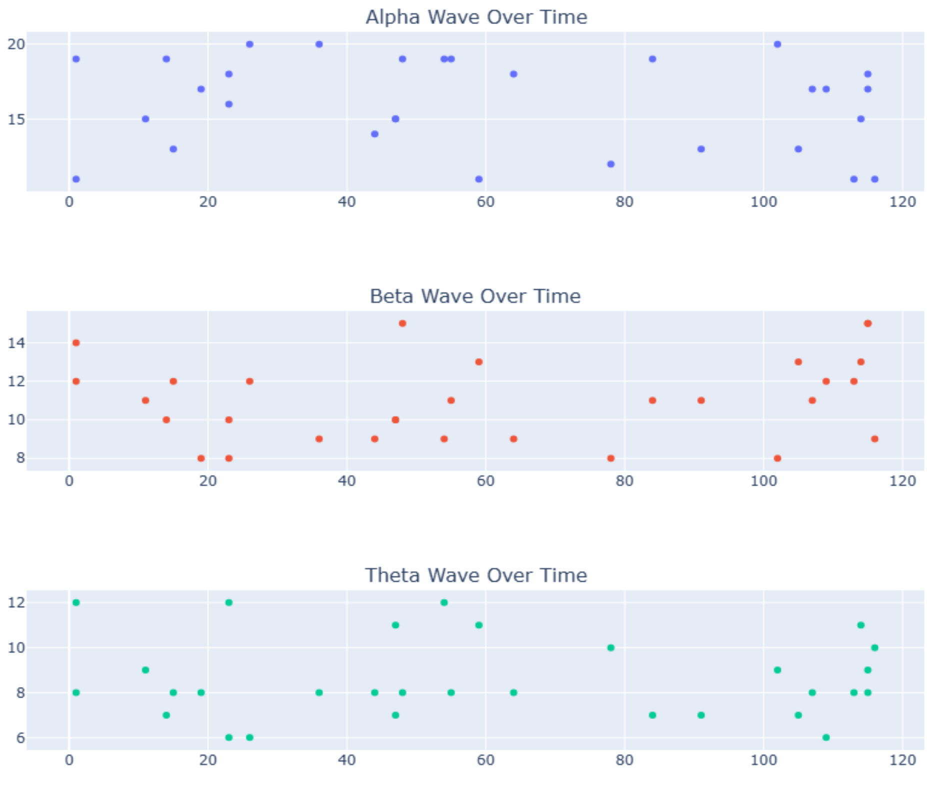

Figure 10. Brain Wave Amplitude in different Timeslots

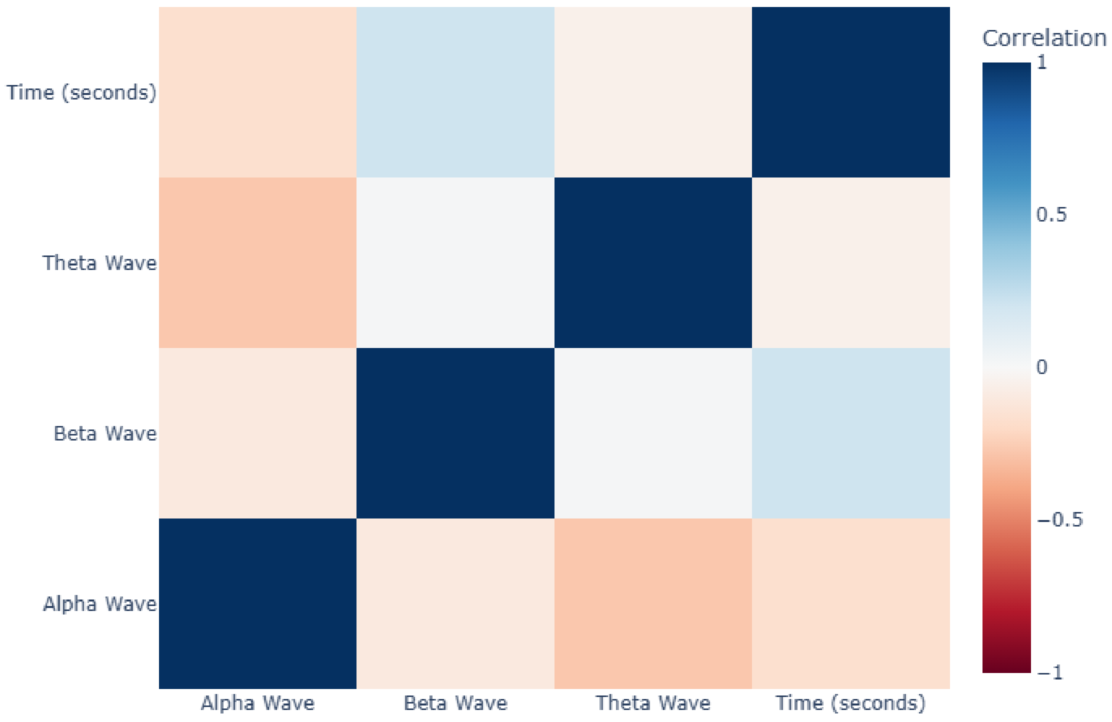

Figure 11. Brain Wave Correlations

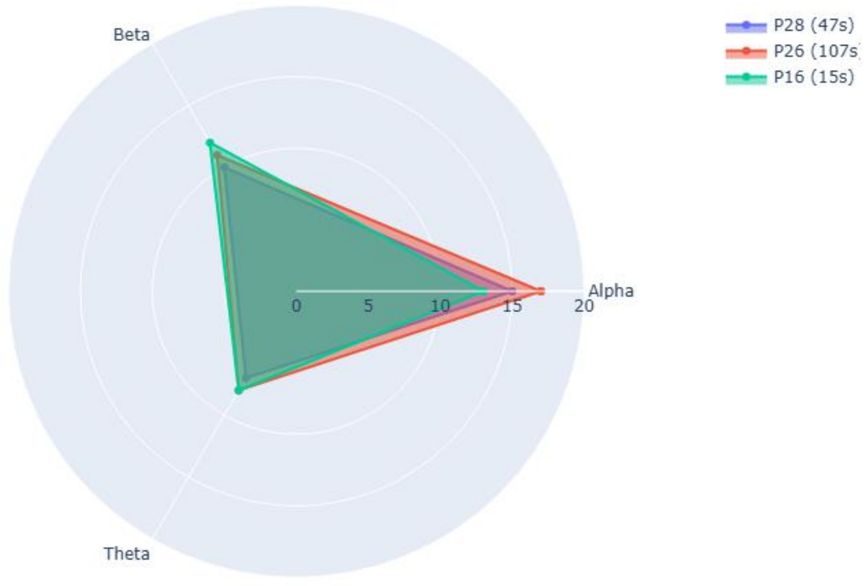

Figure 12. Brain wave patterns across participants (P16, P26, P28)

9. Discussion

The association between visual attention, emotional responses and neurofeedback patterns during interface interactions is discovered via significant insights revealed by the simplified analysis of the experimental design dataset. Banner ads and video replay buttons on websites can hold users' attention for lengthy periods because of visual attention patterns. User experiences are greatly influenced by these factors; for example, if you take your time to tweak the contact form or navigation menu, you can find that your cognitive processing improves and your emotional involvement grows. We can learn a lot about the emotional stimuli elicited by specific interface components from the wide range of reactions recorded by participants. These components can boost user engagement since participants exhibit curiosity when confronted with homepage banners and demonstrate substantial interest in video content.

However, when seen through the lenses of neurofeedback theory and user interface design theory, it is evident that there is room for improvement in the design of contact forms to make them more rewarding and less bothersome for users. This research highlights the necessity of integrating physiological data, such as neurofeedback, into the design process to understand better and accommodate users' emotional responses. Interacting with film content may elicit a meditative or introspective state, as shown by an increase in alpha wave amplitude. These findings provide a foundation for designing interface elements that are both engaging and effective in eliciting targeted emotional responses. They are also crucial for maintaining the user's interest in the interactive feature, since an increase in beta wave amplitude signals higher cognitive engagement. In addition, users may feel emotional stimulation during complex interactions; hence, interfaces should be improved to lessen user pain and loss.

The need for specific design strategies to address the demands of different user groups is further highlighted by research into demographic groupings, which has shown that users' emotional responses and gaze habits shift. Incorporating neurofeedback data, self-reported emotional reactions and eye movement monitoring into design is emphasised in this study. One possible use of this approach is the development of interfaces capable of evoking strong emotional responses from users. Theoretical analysis underscores the potential advantages of undertaking research and design across multiple dimensions. Findings from this study have the potential to alter the creation of interfaces, provide users with something tangible, boost their satisfaction and stimulate more research into user-centred design principles, among other things. Integration of neurofeedback with user interface design theory might assist us in comprehending consumers' emotional reactions, which in turn could lead to the development of products that meet their needs and enhance their experience. In addition to providing more information for upcoming design studies, these themes also provide further incentive to delve further into concepts of user-entred design.

10. Conclusions

Investigated herein are the connections, within the framework of interface interactions, between affective responses, visual focus and neurofeedback patterns. The results show that customers' visual attention patterns may influence their experiences and hold their interest for a long time. Research like this strengthens the case for why it's so important to consider users' emotions when designing interfaces. The physiological foundation of our emotional reactions to interfaces could be better understood with the use of neurofeedback theory.

The findings indicate that exposure to specific interface elements can increase alpha wave amplitude, which is associated with deeper cognitive processing and engagement. This suggests that interactive features can be designed to foster more meaningful and immersive userexperiences. User interfaces should be refined to minimize negative emotional responses and cognitive overload, particularly during complex interactions. Findings from the research further stress the significance of tailoring design approaches to certain user demographics. It recommends using eye movement tracking, self-reported emotional responses and neurofeedback data in the design process. Interfaces that evoke powerful emotional reactions from users might be developed using this method.

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