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The impact of urban graffiti with facial expressions on human behavioral and emotional experiences in a VR environment

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Abstract

Purpose – The present study investigates human behavioral and emotional experiences based on human-built environment interaction with a specific interest in urban graffiti displaying fear and pleasure-inducing facial expressions. Regarding human behavioral and emotional experience, two questions are asked for the outcome of human responses and two hypotheses are formulated. H1 is based on the behavioral experience and posits that the urban graffiti displaying fear and pleasure-inducing facial expressions elicit specified behavioral fear and pleasure responses. H2 is based on emotional experience and states that the urban graffiti displaying fear and pleasure-inducing facial expressions elicit specified emotional fear and pleasure responses.

Design/methodology/approach – The research design is developed as a multi-method approach, applying a lab-based experimental strategy (N:39). The research equipment includes a mobile electroencephalogram (EEG) and a Virtual Reality (VR) headset. The behavioral and emotional human responses concerning the representational features of urban graffiti are assessed objectively by measuring physiological variables, EEG signals and subjectively by behavioral variables, systematic behavioral observation and self-report variables, Self-assessment Manikin (SAM) questionnaire. Additionally, correlational analyses between behavioral and emotional results are performed.

Findings – The findings of behavioral and emotional evaluations and correlational results show that specialized fear and pleasure response patterns occur due to the affective characteristics of the urban graffiti's representational features, supporting our hypotheses. As a result, the characteristics of behavioral fear and pleasure response and emotional fear and pleasure response are identified.

Originality/value – The present paper contributes to the literature on human-built environment interactions by using physiological, behavioral and self-report measurements as indicators of human behavioral and emotional experiences. Additionally, the literature on urban graffiti is expanded by studying the representational features of urban graffiti as a parameter of investigating human experience in the built environment.

Keywords Emotional experience, Behavioral experience, Fear response, Human-built environment interaction, Pleasure response, Urban graffiti

Paper type Research paper

Since acceptance of this article, the following author(s) have updated their affiliation: "Burcu Nimet Dumlu" is at the "Embodied Media Lab, Graduate School of Media Design, Keio University, Tokyo, Japan".

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1. Introduction

Human experience based on human-built environment interactions is one of the major topics to be investigated in understanding the influence of environmental features on human responses. Human-built environment interaction considers the human experience a multi-dimensional, multi-disciplinary and multi-modal study of human responses to environmental stimuli. In the past several decades, developments in neuroscience and cognitive sciences have played a crucial role in understanding the impact of environmental features on the human experience, including behavioral, emotional, cognitive and sensational dimensions. The present study investigates the human behavioral and emotional experiences based on human-built environment interaction with a specific interest in urban graffiti displaying fear and pleasure-inducing facial expressions.

Urban graffiti research has a long tradition of being studied by a wide range of disciplines, including social sciences, cultural studies, environment and behavior studies, psychology, anthropology and most recently, neuroscience. Presently, the legitimacy of urban graffiti is accepted worldwide and has become an essential part of our urban lives. Additionally, a common consensus on the absolute impact of urban graffiti on the human experience, whether positive or negative, is established based on the extensive literature on the function, form and politics of urban graffiti (Austin and Sanders, 2007; Coffield, 1991; McAuliffe and Iveson, 2011; Rasidah *et al.*, 2016; Rubin, 2015; Sajadzadeh *et al.*, 2017; Tokuda *et al.*, 2019).

Furthermore, urban graffiti is a multi-dimensional visual phenomenon with representational and non-representational features which potentiate an interaction between brain functioning and the built environment. As Kandel *et al.* (2012) stated, human beings' visual experiences are object-centered based on the experience of complex visual components, associating them with past experiences. Therefore, urban graffiti's representational features have been considered a parameter for investigating human experience. In the scope of the study, the subject of urban graffiti is specified as emotionally charged facial expressions representing fear and pleasure-inducing facial elements to confront the lack of adequate research concerning the representational features of urban graffiti and their impact on human behavioral and emotional experiences. Fear and pleasure emotions are studied because they are primary emotions creating measurable bodily changes and behaviors (Kandel *et al.*, 2012).

The research design is developed as a multi-method approach, applying a lab-based experimental research strategy. The experimental setting is a virtual reality (VR) environment created as a virtual urban space. The research equipment includes a mobile electroencephalogram (EEG) device, a Looxid Link device (URL) and a VR headset. The behavioral and emotional human responses concerning the representational features of urban graffiti are assessed objectively by measuring physiological variables and subjectively by measuring behavioral and self-report variables. Furthermore, correlational analyses between behavioral and emotional results are performed. The experimental procedure includes the baseline survey, VR experiment and Self-Assessment Manikin (SAM) questionnaire. Systematic behavioral observation, EEG and SAM data are collected during the experimental procedure and analyzed both individually and correlationally. Moreover, the study materials are prepared by selecting the proper fear and pleasure-inducing urban graffiti, which would be applied to the VR model and by designing the VR model.

The paper is organized as follows. Section 2 covers the research background studies using fear and pleasure-inducing facial expressions as the representational features and multi-method approach examples using neuroscience research techniques. Section 3 discusses the research questions, and the formulated hypotheses are identified. Materials and methods are elaborated on in Section 4. The graffiti selection process and the design of the VR environment are indicated. Then, the experimental setting, procedure and equipment are introduced. Data collection and analysis techniques are also identified. In Section 5, the results are revealed and discussed, conforming to the hypothesis. Finally, in Section 6, the paper presents the contributions, limitations and future studies as a conclusion.

2. Research background

2.1 The use of urban graffiti displaying facial expressions

Most studies on urban graffiti are focused on explaining the presence of graffiti and the effect of the type of graffiti. However, the elements of urban graffiti significantly influence the human experience and require more detailed research due to their representational features (Mitschke *et al.*, 2017) and multidimensionality (Austin and Sanders, 2007). As human beings, we evolutionarily prioritize faces over other visual elements (Sussman and Hollander, 2015), and we have developed skills for face perceptions (Haxby *et al.*, 2000). Both evolutionarily and culturally, fearful facial expressions are considered dangerous environmental features (Darwin, 2004; Ekman *et al.*, 1969). Additionally, facial expressions are one of the most used stimuli sets in emotion studies (Adolph and Alpers, 2010; Adolphs, 2002; Lang *et al.*, 1993), which have been widely adopted in the study of human experience regarding emotions, behaviors, attention, engagement and liking because of their distinct effect on the brain and behavior (Kim *et al.*, 2018; Leder *et al.*, 2013; Mitschke *et al.*, 2017; Mogg and Bradley, 2010; Sutton *et al.*, 2019; Vuilleumier, 2007).

Furthermore, neuroscience studies suggest that a larger human brain area is responsible for face recognition than recognition of any other visual objects (Kandel *et al.*, 2012). Besides, a fearful facial expression evokes a response even if it exists subliminally and is perceived unconsciously (Kandel *et al.*, 2012). Therefore, as an approach to investigating human-built environment interaction concerning human behavioral and emotional experiences, the present study uses urban graffiti displaying fear and pleasure-inducing facial expressions as the environmental stimuli.

2.2 The use of a multi-method approach for studying human experience

For decades, one of the primary research tools applied in the presence and effect of graffiti studies are self-reports, ethnographies, in-depth interviews, observations and visual data collection, generally used to study cultural and social issues (Fransberg *et al.*, 2023). Besides, self-reports and observations are the most commonly used tools in studying human experience from the perspective of traditional architecture and environment and behavior studies. However, these tools have some weaknesses, such as the interruption of the flow of information, the cut-in on the continuous sampling of affective states (Coan and Allen, 2007), the attentional biases towards the reports (McNally, 1996) and distortions due to social stereotypes or personal defense or avoidance (Armony and Vuilleumier, 2013) encountered in self-reports, and the research biases and reliability problems affecting the observations directly (Sommer and Sommer, 2002). Therefore, to elaborate on human-built environment interactions regarding the human experience, a multi-method approach based on objective and subjective measurements, including physiological, observational and self-reports, is applied in the present paper.

In recent years, there has been ever-evolving literature on using neuroscience approaches in architecture and built environment studies (Azzazy *et al.*, 2020; Higuera-Trujillo *et al.*, 2021; Karakas and Yildiz, 2020) that enables us to understand the human experience at psychophysiological and neural levels. The most recent researches include; investigating the impact of glass floors using a combined version of EEG, galvanic skin response (GSR), heart rate variability, eye-tracker and a questionnaire (Erkan, 2021), the investigation of the human reactions toward different space geometries using EEG measurements (Shemesh *et al.*, 2017) and the combination of EEG, GSR and eye-tracking measures (Shemesh *et al.*, 2021); the evaluation of the impact of interior forms on emotions and the affective states of inhabitants using a virtual version of SAM questionnaire (Banaei *et al.*, 2020), and using mobile EEG (Hekmatmanesh *et al.*, 2019); the quantitative relations between geometric properties of rectangular rooms and the architectural experience using questionnaires and scaling techniques in VR technologies (Franz *et al.*, 2005). It is evident in the literature that the triangulation of the data through the multi-method approaches raises the study's reliability, objectivity, credibility and validity.

Only a few studies have examined the impact of urban graffiti at physiological and neural levels. James and O'Boyle (2019) used functional magnetic resonance imaging (fMRI) and a questionnaire applied during the experiment via buttons to understand graffiti's negative impact on neighborhood safety evaluations. They investigated the impact of the presence of graffiti by applying a single form of graffiti to different neighborhood scenes by leaving aside the elements of graffiti. Mitschke *et al.* (2017) used an eye-tracker coupled with rating procedures and questionnaires in a real-world setting with a follow-up session in a lab environment to examine the people's experience of sculptures and graffiti. They referred to the importance of using a multi-method approach as compensation for the limitations of each method.

Furthermore, employing VR technologies for a multi-method approach enables examining certain environmental features and modified versions with significant clarity and accuracy. VR is a potent tool for studying human behavior with the ability to create three-dimensional computer-generated environments that allow humans to perceive their surroundings as Cartesian reality, where people can move and perceive in 3D trajectories (Brookes *et al.*, 2022). As Dumlu (2020a) explained, VR Head-Mounted Displays (HMDs) offer a more realistic and immersive digital experience than traditional computer modeling. By enabling users to see a digital representation of physical reality, VR HMDs go beyond the two-dimensional screen of a computer and allow users to experience a Virtual Environment (VE) with binocular vision that closely simulates real-world perception. Franz *et al.* (2005) identified that architectural research can be more empirical by using VR technologies with their flexibility of stimulation and easy-to-create controlled laboratory conditions while still providing a high degree of perceptual realism. In architecture and urban research fields, more researchers have focused on VR as a medium for conducting user studies, measuring perception of space or effects of architectural elements for both users and designers by applying empirical and experimental settings recently (Elver Boz *et al.*, 2022; Keshavarzi *et al.*, 2021; Llorca-Bofi and Vörlander, 2021; Zhang and Zhang, 2021; Dumlu, 2020a, b). Also, it is highlighted that VR has particular advantages with its immersive, interactive, multi-modal, multi-sensory ability to apply real-world features for neuroscience, psychology and cognitive science research (Bohil *et al.*, 2011; Loomis *et al.*, 1999).

Therefore, the present paper applies a multi-method approach using a VR environment to create a coherent research design with controlled stimuli, aiming to conduct a focused investigation of human behavioral and emotional experiences with urban graffiti.

3. Research questions and hypotheses

In the present paper, the representational features of urban graffiti, identified as fear and pleasure-inducing facial expressions, are prioritized due to their significant impact on the human brain and responses. To investigate the human behavioral and emotional experiences that occurred upon encountering urban graffiti displaying fear and pleasure-inducing facial expressions, two research questions (RQs) are asked:

RQ1. Which behavioral responses occur upon encountering urban graffiti displaying fear and pleasure-inducing facial expressions?

RQ2. Which emotional responses occur upon encountering urban graffiti displaying fear and pleasure-inducing facial expressions?

RQ1 and RQ2 are grounded on the impact of representational features of urban graffiti on human experience while furthering the inquiry by adding more dimensions, i.e. behavioral and emotional, and asking for an outcome regarding the human responses. RQ2 also subsumes the contributions of neuroscience and cognitive science studies in understanding human emotional experiences objectively with the help of physiological measurements. Eventually, the answers to RQ1 and RQ2 will contribute to a better understanding the human-built environment interactions.

After completing the required literature research and preliminary study, the present study's hypotheses based on the research questions are formulated as follows:

H1. Urban graffiti's representational features impact human behavioral responses.

H1-1. The urban graffiti displaying fear-inducing facial expressions elicit a behavioral fear response.

H1-2. The urban graffiti displaying pleasure-inducing facial expressions elicit a behavioral pleasure response.

H2. Urban graffiti's representational features impact human emotional responses.

H2-1. The urban graffiti displaying fear-inducing facial expressions elicit an emotional fear response.

H2-2. The urban graffiti displaying pleasure-inducing facial expressions elicit an emotional pleasure response.

4. Materials and methods

4.1 Participants

Fifty-four healthy volunteers (mean age = 22.7 years; range 18–55 years; 36% female, 64% male) participated in the experiment. The participants were recruited from Istanbul Technical University, including students and staff, with an e-mail invitation. A convenience sampling technique was applied to make accessing a broad range of groups easier due to gender, age, education level and demography. All the participants reported no previous victimization experience, no visual impairment and having normal vision (or corrected to normal). The local institutional ethics committee of Istanbul Technical University (2014/461) approved the experimental setup and protocols. Fifteen participants (10 men and five women) lacked complete data and were omitted; thus, 39 participants were included in the statistical results. The experimental procedure was introduced at the beginning of the process, and they were led to read and sign the consent form. When the instructions were clear to the participant, they were allowed to participate in the experiment.

4.2 Apparatus/environmental stimuli

4.2.1 Graffiti selection. The urban graffiti used in the VR experiment were selected using several steps. First, the urban graffiti examples were manually collected via an image search on the web, which were selected according to their representational features, including fear and pleasure-inducing facial expressions, whether easily perceivable or subliminal. Secondly, an online survey including image selection and emotional state questionnaires was developed to select the urban graffiti that trigger intense emotional responses. Finally, the urban graffiti examples were presented randomly and without research bias.

The sample group consisted of 118 volunteering participants (mean age = 31.4 years; range 20–60 years; 47% women, 53% men). The students and the academic personnel of the authors' institutions were recruited through e-mail to become participants in this preliminary study. Before applying the questionnaire, an informed consent form was acquired from each participant. The questionnaire included (1) questions regarding image selection and the emotional state of the participant, which rate the facial expressions in the given urban graffiti in terms of the fear and pleasure induction levels using a five-point Likert scale (1- not inducing, 3- neutral, 5- extremely inducing) and (2) demographic questions. Finally, 12 out of 21 urban graffiti following the survey results were selected shown in Figure 1. The weighted average of each graffiti's fear and pleasure induction rates was sorted in descending and ascending order, respectively. The urban graffiti examples were consistently labeled using the fear and pleasure emotion rates revealed from the survey results, as indicated in Figure 1. Thus, two identifiable categories, fear-inducing and pleasure-inducing urban graffiti, were created.

Consequently, six urban graffiti with the highest induction rate of pleasure and six with the highest induction rate of fear were selected. The 12 chosen urban graffiti were integrated into the virtual urban model at the end of this screening procedure. The color scheme and the labeling system, e.g. G1, G2, etc., refer to the order of graffiti that the participants would encounter while walking in the virtual urban model.

4.2.2 Environmental modeling in VR technologies. VR technologies were employed as a medium for the experiment, and the experimental setting was designed as a virtual urban space specifically for the purpose of the present study. The virtual urban environment was modeled in Google Sketchup and uploaded to the VR headset via VRSketch.

The design process of the virtual urban model included several steps based on intense teamwork that contributed to creating a focused study on urban graffiti with an increased impact. First, the related literature was studied including the level of realism, using urban elements and social agents and the application criteria of urban graffiti. According to Scurati *et al.* (2021), the level of realism in a VR environment depends on the purpose of the experience; providing a focused representation could create an experience with presence. Additionally, to create a real-life scale in a VR environment, designing depth perception

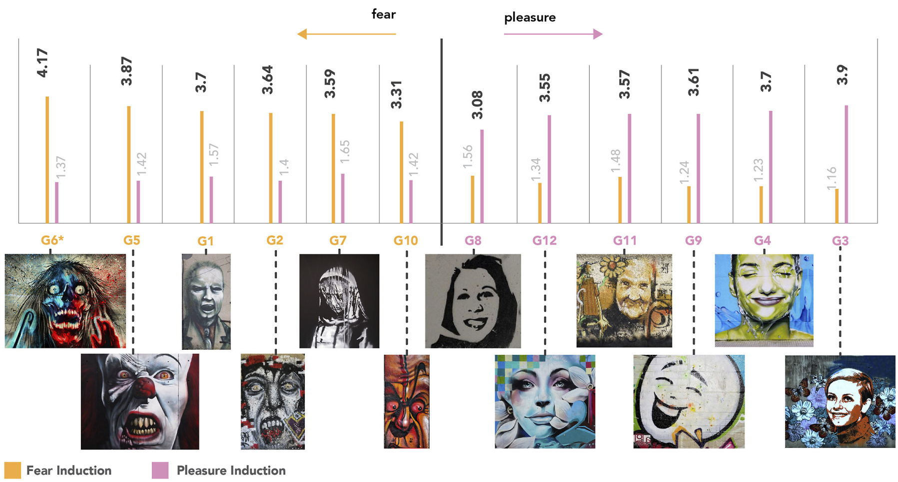


Figure 1.
The survey results

Source(s): Figure created by author

facilitated by shape, size, volume, proportion and scale refers to the level of realism (Paes *et al.*, 2023), even without building hyper-realistic characteristics as responsive agents (urban elements and social agents). Furthermore, as Shemesh *et al.* (2017) emphasized, isolating the desired variables by eliminating some properties of an environment is essential for conducting a controlled experiment and collecting accurate physiological data. Therefore, in the present study, the level of realism was provided by creating a real-life scale urban environment contingent upon the scale of applied urban graffiti with accurate distances, shapes, sizes, volumes and proportions. Additionally, the VR environment was designed with the idea of how we encounter the facade-sized graffiti on blind walls sampling a not-real but precisely developed place with the appropriate street width and facade sizes in the virtual space.

Next, the design criteria of the VR model were specified, including the main characteristics of the urban environment and the application of urban graffiti and applied to the VR model. As urban characteristics, (1) continuous courtyard patterns with greenery indicating non-pedestrian surfaces were created to provide dedicated spaces for encountering urban graffiti, (2) the building blocks were designed based on the morphological properties of building masses by disregarding colors, openings, and textures, (3) the orientation of building blocks was located shifted according to the placement of urban graffiti, (4) urban elements such as pavements, streetlights, urban furniture except trees were ignored, (5) social agents as humans were disregarded and (6) daylight was used. Additionally, as application criteria of urban graffiti, (1) each graffiti was applied on surfaces invisible from the route unless reaching the exact location, (2) urban graffiti examples were displayed randomly to prevent creating predictable patterns of fear-inducing and pleasure-inducing stimuli and (3) Each graffiti was placed on different surfaces of the building masses including left and right sides, straight or perpendicular alignments of the route to create a surprise effect, shown in Figure 2.

Finally, a pilot study was developed to test the VR environment using the research team as an expert group. A sampled VR experience from the study was prepared as shown in Figure 3 which indicated the walking area in detail. The narrowest pass between two buildings on the route was arranged from 10 meters to 20 meters, and the height of the building blocks was between 15 meters and 50 meters (this interval is accurate for urban dwelling settlements) to create a better real-life scale in width and length.

Each participant, except for the model's designer, experienced the VR environment as it would be used in the main experiment (5 expert evaluations). The research team was informed about the design criteria of the VR model and asked to evaluate the appropriateness of the criteria with the aim of the study. During the pilot study, for each participant, the total time spent in the model was calculated and after the experiment, focus group interviews were developed to collect insights. The insights included removing the trees not to block the visibility of urban graffiti, creating better building orientations to improve the surprise effect and limiting the total time spent by 5–7 min using a locomotion technique known as teleportation command in VR (based on the user's pace). Consequently, the final model emerged by applying the results of the pilot study.

Source(s): Figure created by author

Figure 2.
Some exemplary scenes from the VR environment for G5, G4 and G3, respectively

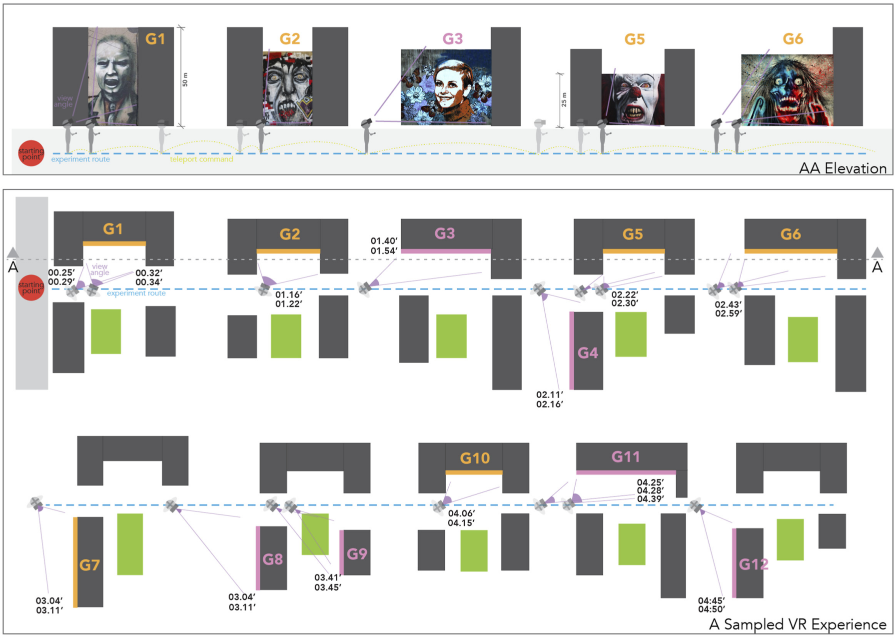


Figure 3. A sampled VR experience

Source(s): Figure created by author

The final model was 350 m wide and 900 m long, with a 180 m wide and 800 m long walking area. The aim of building a wider virtual model was when users saw through the voids between buildings; they could see building blocks that might improve the level of immersion. Figure 4 shows the detailed drawings of the VR model; Figure 4(a) the walkable area, the route length is 800 m, Figure 4(b) the applied urban graffiti, Figure 4(c) the entire site plan drawing.

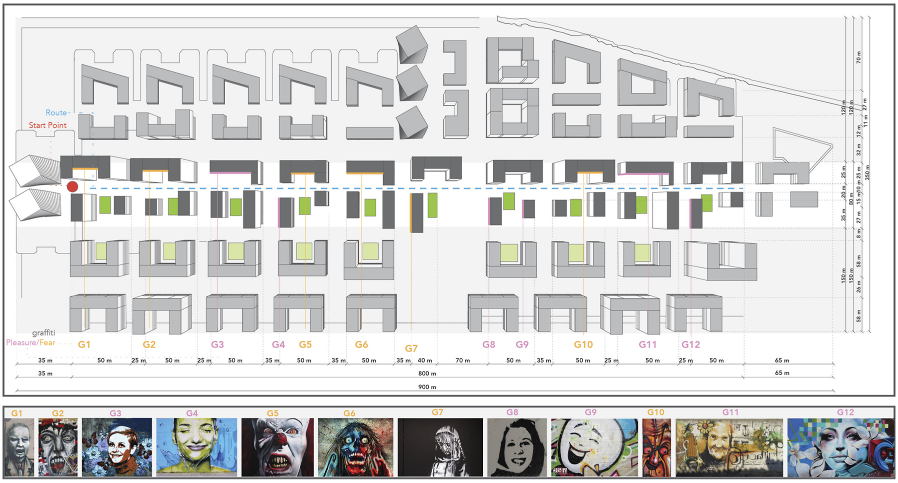


Figure 4. The site plan of the environmental design

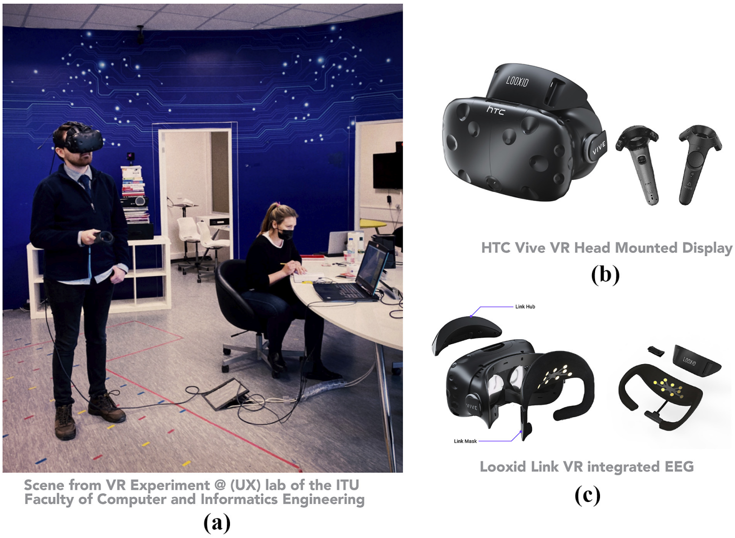
Source(s): Figure created by author

4.3 Experimental setting and procedure

The experiments were carried out in the user experience (UX) lab of the Faculty of Computer and Informatics Engineering at Istanbul Technical University. An isolated room with the necessary free space for the VR setup (approximately 4 square meters) was prepared. The computer-based SAM questionnaires were applied in a separate room to prevent unexpected encounters. The room and the devices used in the experiment were presented in Figure 5; Figure 5(a) the experimental setting, Figure 5(b) the VR headset (HTC Vive) and Figure 5(c) the mobile EEG device (the Looxid Link Package for Vive).

The experiment was carried out according to a defined experimental procedure. The experimental procedure's schematic representation indicating each phase's duration was shown in Figure 6.

The experimental procedure started with the baseline survey, which was developed to decide on the proper participants and applied through the website (https://freeonlinesurveys.com/). The baseline survey gathered demographic information, as well as information about general health conditions, vision impairments, usage of stress-related medicine or treatment, drinking caffeinated beverages, last night's sleep quality and current stress levels for each candidate of the participant. Then, the proper participants were guided to the isolated room for the VR experiment. The participants were informed that their brain signals would be collected via a mobile EEG integrated into a VR headset; their eye, head and virtual bodily movements would be recorded by collecting VR screen recordings; and the timing information about their looking towards graffiti would be noted to obtain the timestamps for the synchronizing the EEG data and VR screen recordings.



Source(s): Figure created by author

Figure 5. The experimental setting and the devices worn by the participant

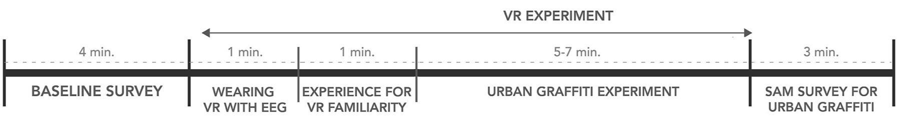


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Figure 6. The experimental procedure

The VR experiment was designed as the main part that lasted approximately nine minutes in total. The participants were allowed to move their bodies freely without relocating them during that whole time. Furthermore, the participants were asked to walk using teleport and stay upright during the experiment to minimize the effect of any external stressors. After introducing the devices and the experimental setting, the participants were equipped with wearable devices and stayed equipped during the VR experiment.

First, the participant was virtually spawned in a three-dimensional room with a view for one minute to become familiar with the VR headset and teleportation. Afterward, the participant was allowed to roam freely until they felt relaxed in the virtual environment. Then, as the main part of the VR experiment, the participant experienced the virtual urban model displaying the selected 12 urban graffiti. The participant was placed at the route's starting point and told to follow the path on the ground using the teleportation technique, which allows virtual locomotion using the VR controller's trigger buttons. The participant was asked to look at the urban graffiti placed on the walls of the urban model for at least 3 s to gather consistent EEG data whenever they saw one. When the participant reached the end of the route, the session was finished and the participant was unequipped.

Finally, the participant was taken into the complementary room to complete the SAM questionnaire when the VR experiment was over. After the participants were informed about the meaning of valence, arousal and dominance value and how to rate a stimulus through the SAM scale, they reported their emotional experiences with the graffiti through the SAM questionnaire.

4.4 Data collection and analysis

4.4.1 Observational measurements. Behavioral observation is a commonly used tool for the study of the non-verbal actions of human beings. In the present paper, the participants' behaviors, including looking behaviors and bodily behaviors, were observed during the VR experiment and the data was collected as VR screen recordings captured at eye level. Looking behaviors, following eye and head movements and bodily behaviors, following bodily direction and movement, were considered indicators of the intentions to act of participants while experiencing a virtual urban environment. The content analysis method was applied in the study of those video recordings. Using content analysis for making valid inferences from the video recordings provided a systematic and objective plan to construe the participant's behavioral experiences with urban graffiti.

The content analysis process included defined procedures and rules (Downe-Wamboldt, 2009). First of all, the video recordings were divided into fragments showing the actions of participants with the encountered graffiti. Those fragments were examined as the unit of analysis for answering RQ1 and studying H1, i.e. H1-1 and H1-2. Secondly, looking behavior and bodily behavior categories were created based on the participant's behavioral patterns, and a coding scheme was suggested for quantizing the qualitative, human behavior (Saldana, 2016). The coding system was based on the occurrence of specific behavioral patterns, indicating significant attributes of the individuals' behavioral experiences. For this study, two proficient individuals were defined as coders who developed and applied a particular protocol of coding to translate the behaviors into measurable data after watching the 39 individuals' video recordings in detail. Finally, the coders quantified the coding system by determining the absence and presence of actions in the video recordings' fragments (absence = 0, presence = 1).

The coding protocol included the first cycle coding system and evaluation criterion for the coding scheme. The first cycle coding system had **general look, single glance, scanning, fixation, focus on a face, focus on teeth, focus on eyes and walk-and-watch and stop-and-watch behaviors**. After thoroughly reviewing all the recordings a second time, some codes were eliminated and consolidated due to inadequate data. In the second cycle coding system, **general look, scanning, fixation and focus on facial features** behaviors were applied to study the looking behavior category, and **walk-and-watch and stop-and-watch** behaviors were examined under the bodily behavior category.

The evaluation criteria were defined and the data content was analyzed according to the following rules in the **"looking behavior"** category: **The general look** was evaluated as a fixed look lasting less than 5 s; **scanning** behavior was observed when the participants scanned the urban graffiti with directional and continuous head movements without eye fixation. **Fixation** behavior was based on the number and duration of fixations and assessed through two behavioral patterns; the former was a fixed look that occurred during scanning behavior and the duration of fixation was more than 3 s, and the latter was the same as a general look but the duration of the fixation was more than 5 s. The **focus on facial feature** behavior was a specialized fixation behavior in that the participant fixated look on facial features for more than 3 s. Additionally, the participants moved through the virtual VR model using the VR controller's trigger buttons, which enabled us to recognize the bodily direction and movement in the "**bodily behavior"** category; the **walk-and-watch** and **stop-and-watch** behaviors were perceived by the distinct attributes of varied walking preferences of the participant.

Furthermore, an analysis based on the duration of "**looking behaviors"** was done for each graffiti, including average looking durations and minimum and maximum times spent. The participants' looking durations were calculated by measuring the time difference between the beginning and the end of the experience for each urban graffiti. Finally, the quantified data was used to perform correlational analyses between behavioral and emotional results to understand the impact of urban graffiti on human experience thoroughly.

4.4.2 Electroencephalogram (EEG) measurements. EEG measurement is widely used in investigating the brain's electrical activity during an event affecting the body-brain systems. EEG devices vary in their connection types (wired and wireless), electrode connection (wet and dry), number of channels and electrode placements (Soufineyestani *et al.*, 2020). This study uses the Looxid Link package for Vive, which is developed as an integrated accessory device for the HTC Vive VR Headset. The device is wireless, dry and has six channels. Additionally, it offers several advantages throughout the experiment, such as using a unified device that removes mobility and artifact problems (Sá *et al.*, 2020). The device collects delta (1–3 Hz), theta (3–8 Hz), alpha (8–12 Hz), beta (12–38 Hz) and gamma (38–45 Hz) brainwaves from the brain's prefrontal area through the AF3, AF4, AF7, AF8, Fp1 and Fp2 channels with a sampling rate of 500 Hz (Costa *et al.*, 2021). Additionally, the device tracks EEG signals with yielding attributes like attention, relaxation and brain balance.

In analyzing the data, the focus was laid on measuring the changes in brain activity in response to exposure to urban graffiti with facial expressions in a VR environment, emphasizing the emotions of fear and pleasure. Furthermore, EEG data were also used to explore the correlations between observational and EEG data. The "average band powers" were calculated as the area under Welch's periodogram, which was the sum of the areas of parabolas fitted to the power spectral density estimates of each frequency band. This measure estimated the power of each frequency band in the EEG signals. The Looxid Link SDK was used to obtain these estimates. Additionally, RStudio was used as the development environment for implementing the data analysis and visualization scripts. The R language and its associated statistical packages were used for preprocessing EEG signals, such as removing artifacts, applying filters, segmenting the signals and performing correlational analysis.

4.4.3 Self-report measurements. The studies on emotional experience include a broad range of models, including discrete and dimensional perspectives over the years

(Armony and Vuilleumier, 2013). In the scope of the study, a dimensional model called the Circumplex Model of Affect was applied to measure and evaluate participants' emotional experiences. James Russell (1980) introduced the Circumplex Model of Affect as a two-dimensional model that posits the emotion on a circumplex or two orthogonal axes. The first axis refers to the valence axis, which represents pleasantness/unpleasantness, pleasure/displeasure, or good feeling/bad feeling, whereas the second axis refers to the arousal axis representing exciting/relaxing or active/calming dimensions. Russell and Mehrabian (1977) established the third dimension as a third axis referring to the dominance that represents the level of control categorized as dominance/submissiveness or dependent/independent. The Self-Assessment Manikin (SAM) scale was used to develop a dimensional study of human emotions, which was developed by Bradley and Lang (1994) to evaluate participants' emotional responses through valence, arousal and dominance dimensions. Our study utilized a computer-based seven-point scale, as shown in Figure 7.

The SAM scale was applied as the post-questionnaire not to distract the participants' attention during the VR experiment and to acquire precise physiological and behavioral data. In addition, the SAM values were measured to understand the subjective experience of individuals for each urban graffiti on the pleasure, arousal and dominance scale and to perform statistical analysis to examine the relationship between SAM values and the human fear and pleasure response. The analysis starts with the recorded SAM responses on each of the 12 urban graffiti for each participant, which was documented in a spreadsheet. Next, each urban graffiti's mean valence, arousal and dominance scores were calculated and discussed. Additionally, the correlations between observational measurements and SAM scores were also inquired.

5. Results and discussion

5.1 Behavioral evaluation

This section studies human behavioral experiences regarding urban graffiti displaying fear and pleasure-inducing facial expressions. We expect to find answers for RQ1 and validate H1, including H1-1 and H1-2, through the results of the observational analysis.

The content analysis results revealed from the behavioral observations are displayed in Table 1, representing both the code-wise and the cumulative presence values according to the

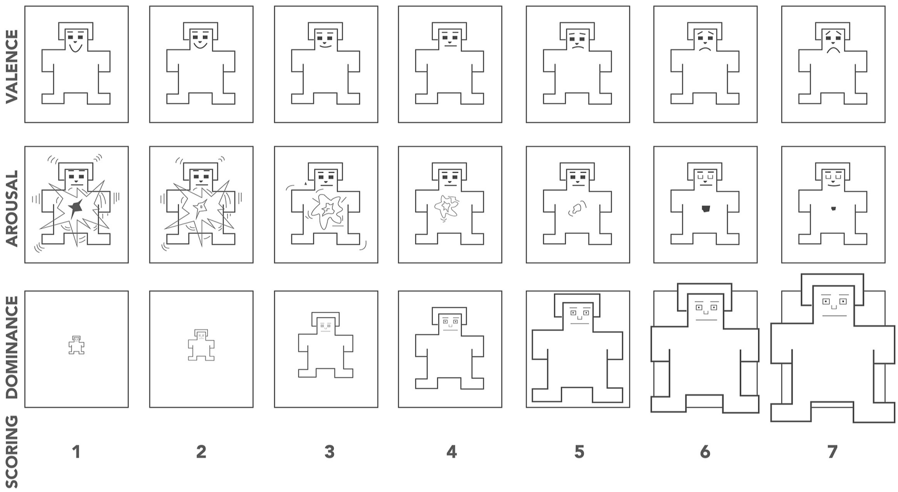

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Figure 7.
Seven-point scale SAM questionnaire

proposed coding system for each graffiti. Additionally, the highest values for each code and the highest cumulative values are highlighted to indicate the dominant behavior for each graffiti. Besides, Table 1 shows the findings in two groups, fear and pleasure-inducing, to find polarities or commonalities in the participants' behaviors.

First, for the fear-inducing urban graffiti category, **scanning**, **fixation** and **focus on facial features** are found as the dominant "looking behavior", while **stop-and-watch** behavior is revealed as the dominant "bodily behavior". In detail, G1 has the second highest value for focus on facial features, which is over 10. G5 has no dominant behavior considering looking behavior but gets the highest degree of stop-and-watch behavior. G6 is coded with the highest scanning and fixation behavior and relatively higher stop-and-watch behavior. G7 has an idiosyncratic situation among the fear-inducing urban graffiti, which is observed to be significantly higher with the general look behavior. Finally, G10 has the highest scanning, fixation and focus on facial feature values. Additionally, G2, G6 and G10 get the highest cumulative presence values of the 12 urban graffiti, creating a recognizable behavioral relation based on fear-related features.

Second, for the pleasure-inducing urban graffiti category, the **general look** is identified as the dominant "looking behavior", while **walk-and-watch** behavior is found to be the dominant "bodily behavior". G3 has no dominant behavior in looking behavior category but gets the highest value of walk-and-watch behavior. G4, G8, G9 and G12 are significant with general look behavior values. G11 is recognized as significantly higher for scanning behavior. G3 and G11 have a unique situation among the pleasure-inducing urban graffiti by being coded with a relatively higher focus on facial feature values.

Finally, the findings about the looking durations are shown in Table 2, representing the average, minimum and maximum looking durations. Again, the highest average looking durations and the maximum time are highlighted.

One significant result revealed from the findings is that there is no coherence between the looking duration and the emotions elicited by the urban graffiti. G2, G3, G5, G6, G10 and G11 have the highest average of looking durations. Additionally, G3, G5, G6, G10 and G11 have

	Coding scheme	Looking behavior				Bodily behavior		
	Graffiti	General look	Scanning	Fixation	Focus on facial features	Walk-and-watch	Stop-and-watch	Cumulative presence value
Fear-Inducing Urban Graffiti (39 Users)	G1	23	18	16	*11*	0	1	69
	G2	22	26	27	8	0	3	*86*
	G5	24	22	24	5	1	*5*	82
	G6	15	*30*	*30*	5	0	4	*84*
	G7	*34*	10	27	2	0	0	73
	G10	17	*33*	*35*	*15*	0	1	*101*
	SUM	135	*140*	*159*	*46*	1	*14*	
Pleasure-Inducing Urban Graffiti (39 Users)	G3	24	26	21	*6*	*6*	0	83
	G4	*30*	12	16	0	2	0	60
	G8	*32*	7	19	0	1	0	59
	G9	*33*	7	23	0	4	0	67
	G11	14	*33*	23	*6*	3	1	80
	G12	*33*	8	24	0	0	1	67
	SUM	*166*	93	127	12	*16*	2	

Note(s): The italics values are significant for being the highest
Source(s): Table created by author

Table 1. The summary table of the content analysis

the most extended looking durations, over 20 s. This might be associated with a higher engagement level due to the urban graffiti's visual quality as colors, alignment, number and arrangement of elements regardless of elicited emotions. Lastly, the findings show that a dramatic change occurs between each graffiti's minimum and maximum values. Therefore, it is inferred that each user has their own behavioral patterns. The users who tend to spend a rather short time engaging in urban graffiti have lower looking durations for each graffiti. In contrast, users who tend to spend a rather long time engaging in urban graffiti also have higher looking durations for each graffiti.

The findings of the observational study support H1 considering the impact of urban graffiti's representational features on human behavioral responses. Besides, H1-1 claims that "the urban graffiti displaying fear-inducing facial expressions elicit a behavioral fear response." Supporting H1-1, it is revealed from the observational results that "stop-and-watch" behavior is a fear response that occurs encountering urban graffiti displaying fear-inducing facial expressions in the bodily behavior category. In the literature, freezing is one of the most common fear expressions (Adolphs, 2002). Therefore, the "stop-and-watch" behavior has been interpreted as a freezing behavior that suspends the experience for a while. Additionally, the results show that "stop-and-watch" behavior is mainly coupled with the "fixation" behavior, concentrating on "focus on facial features" in the looking behavior category, which might be rooted in our past experiences considering fearful facial expressions as threats.

H1-2, which also states, "The urban graffiti displaying pleasure-inducing facial expressions elicit a behavioral pleasure response," is supported by the observational results. It is revealed that "walk-and-watch" behavior occurs in the bodily behavior category encountering the pleasure-inducing urban graffiti. It is mostly experienced with "general look" behavior in the looking category. "Walk-and-watch" behavior has been interpreted as a pleasure response occurring in a relaxed and comfortable situation and not interrupting the experience, representing a sustained response pattern.

5.2 Emotional evaluation

The human emotional experiences based on encountering urban graffiti displaying fear and pleasure-inducing facial expressions are studied through psychophysiological evaluations based on EEG analysis and SAM evaluations. As a result, we expect to find answers for RQ2 and validate H2, H2-1 and H2-2.

5.2.1 EEG results. The Looxid link provides both mind index (attention and relaxation values) and feature index (average band powers of the delta, theta, alpha, beta and gamma brainwaves from the AF3, AF4, AF7, AF8, Fp1 and Fp2 channels) results. Figure 8 presents the constructed box plot representing the patterns of attention and relaxation values obtained during looking at the 12 urban graffiti. Additionally, a paired *t*-test was used to determine whether there was any difference between individuals' graffiti-based relaxation and attention levels; that is, whether the fear and pleasure-inducing urban graffiti examples significantly impacted the human emotional experience. One significant result is that the coherence

Table 2.
The findings of looking duration analysis

Looking durations	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12
Average Looking Duration (s)	5.74	*9.28*	*9.85*	6.85	*8.62*	*11.20*	8.23	6.29	7.10	*10.18*	*10.14*	7.87
Min (s)	3	4	4	3	4	3	3	2	2	2	2	2
Max (s)	12	17	*21*	15	*22*	*23*	13	13	14	*20*	*20*	16

Note(s): The italics values are significant for being the highest
Source(s): Table created by author

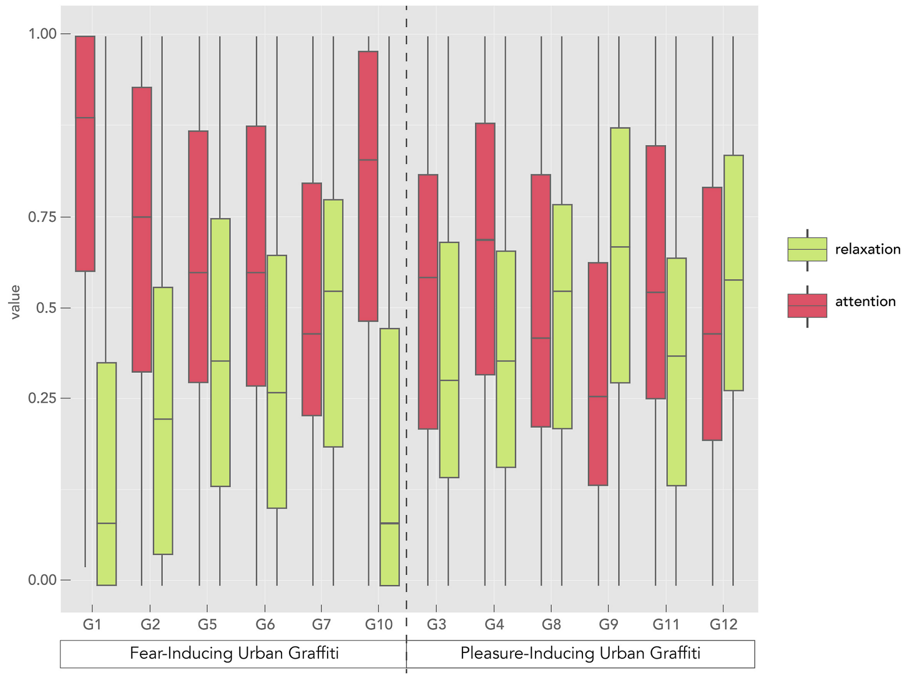

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Figure 8. EEG mind index results

Table 3. Graffiti-based findings for relaxation and attention levels. SD= Standart deviation; Min = Minimum Values; Max = Maximum Values

		Relaxation				Attention			
		Median	SD	Min	Max	Median	SD	Min	Max
Fear-Inducing Urban Graffiti	G1	0.14	0.21	0.01	0.78	0.81	0.21	0.18	0.99
	G2	0.31	0.21	0.00	0.75	0.66	0.23	0.15	1.00
	G5	0.37	0.23	0.06	0.95	0.60	0.22	0.05	0.99
	G6	0.35	0.21	0.06	0.86	0.63	0.22	0.09	0.95
	G7	0.50	0.21	0.09	0.91	0.46	0.22	0.12	0.94
	G10	0.17	0.25	0.01	0.96	0.74	0.24	0.02	0.95
Pleasure-Inducing Urban Graffiti	G3	0.36	0.24	0.00	0.91	0.54	0.24	0.12	1.00
	G4	0.44	0.22	0.09	0.90	0.64	0.23	0.05	0.95
	G8	0.53	0.21	0.12	0.96	0.48	0.21	0.05	0.82
	G9	0.62	0.22	0.10	0.96	0.36	0.20	0.04	0.83
	G11	0.43	0.21	0.07	0.83	0.54	0.22	0.07	0.91
	G12	0.55	0.23	0.05	0.88	0.47	0.21	0.09	0.86

Confidence level (95.0%)
Source(s): Table created by author

between attention and relaxation level of the brain is found to be different for fear-inducing urban graffiti except for G7; conversely, there is no coherence at all for pleasure-inducing urban graffiti. As seen in Table 3, G7 (Relaxation, Median = 0.50, SD = 0.21, min = 0.09, max = 0.91; Attention, Median = 0.46, SD = 0.22, min = 0.12, max = 0.94) demonstrates high relaxation and low attention levels unlike other fear-inducing urban graffiti. Considering the fear-inducing urban graffiti examples, the relevant sample t-test showed that there was a significant area of difference in relaxation and attention levels for G1, G2 and G10 (paired t-test, $p < 0.001$), a relatively substantial range for G5 (paired t-test, $p = 0.022$) and G6 (paired t-test, $p = 0.002$). Considering the pleasure-inducing urban graffiti examples, G4 (paired t-test, $p = 0.013$) and G9 (paired t-test, $p = 0.001$) were moderately significantly different in relaxation and attention levels. At the same time, for G8, G11 and G12, there were no significant statistical differences in relaxation and attention levels.

The feature index results are represented through the frequency band powers; however, no significant results have been revealed for identifying the emotional experiences of individuals. This result supports the study of Bekkedal *et al.* (2011), which stated that identifying the neural representations of emotional processes might not be possible by the EEG signals recorded from the brain's surface.

Regarding RQ2 and H2, the EEG results support our hypothesis, considering the impact of urban graffiti's representational features on emotional responses. The findings of EEG measurements provide substantiating results for H2-1, which claims that "the urban graffiti displaying fear-inducing facial expressions elicit an emotional fear response." However, no evidence exists to verify H2-2, which claims that "The urban graffiti displaying pleasure-inducing facial expressions elicit an emotional pleasure response." It is inferred from the results that emotional fear response was identified with high attention and low relaxation levels. Furthermore, the contributions of using physiological data in identifying emotional responses are yielded.

5.2.2 SAM results. The SAM results are represented through the mean values of the 12 urban graffiti shown in Figure 9 in a 3D plane.

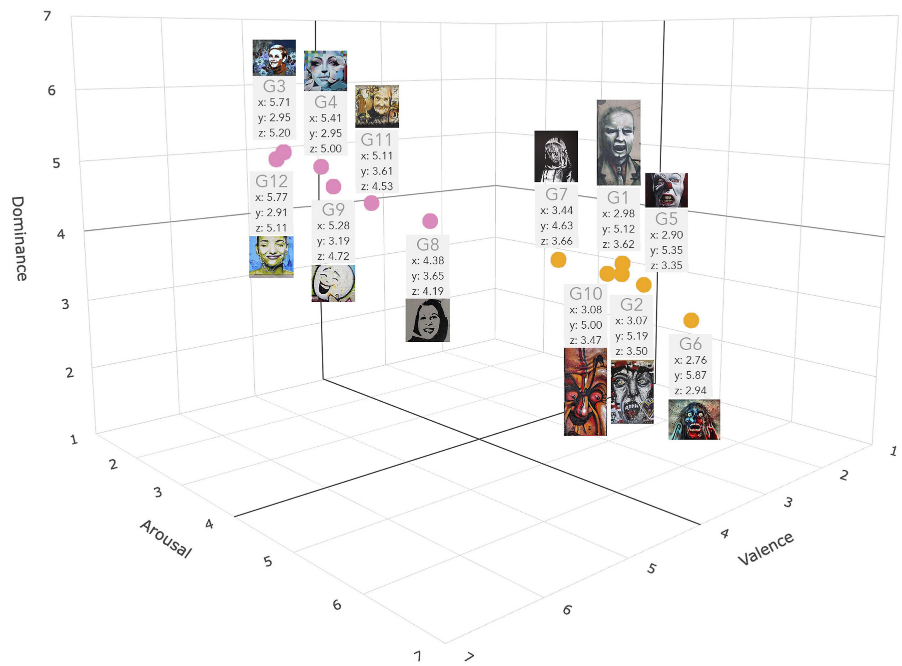

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Figure 9.
Mean valence, arousal and dominance results using the SAM scale

G1, G2, G5, G6 and G10, which are fear-inducing urban graffiti examples, are scored rather lower in valence, higher in arousal and lower in dominance. On the other hand, G3, G4, G8, G9, G11 and G12, which are pleasure-inducing urban graffiti examples, are scored fairly higher in valence, lower in arousal and relatively higher in dominance which is over 4. The polarity of the valence and arousal values occurs as expectedly. For the dominance values, it is revealed that the dominance scores have a significant negative association with arousal scores while having a relatively positive association with valence scores. The findings align with Bradley and Lang (1994)'s findings that state a positive relation between pleasure and dominance scores.

Following the findings of the SAM questionnaire, RQ2 is answered and H2 is validated. Supporting H2-1, the fear-inducing urban graffiti elicits an emotional fear response characterized by high arousal, low valence and low dominance. On the other hand, the pleasure-inducing urban graffiti elicit an emotional pleasure response characterized by low arousal, high valence and high dominance supporting the H2-2.

5.3 Correlational results

This section illustrates the correlation between human behavioral and emotional responses regarding urban graffiti displaying fear and pleasure-inducing facial expressions. This correlation study investigates whether there is a significant relationship between the behavioral and emotional results to reveal the impact of urban graffiti displaying fear and pleasure-inducing facial expressions. We expect to support H1, including H1-1 and H1-2 and H2, including H2-1 and H2-2, through the correlation results of behavioral and emotional data.

In performing correlational analyses, the observational results, the graffiti-based average of the EEG results and the graffiti-based average of the SAM scale results were used. A Pearson correlation test was computed in RStudio, and the ggcorplot package in R language was used for visualizing the correlations. In the graphs, the number and color in each block determined the correlation value. The red coloring identified the positive correlations, while the blue coloring identified the negative correlations. Additionally, values with a *p*-value of more than 0.05 were excluded from determining the impact of urban graffiti on behavioral and emotional experience, represented by the boxes marked with a cross.

The correlation between observational and EEG results is shown in Figure 10. An opposition between relaxation and attention values was found, as expected and it was found that all the variables of observational measurements have significant relationships with relaxation and attention values except for fixation behavior.

Regarding H1, including H1-1 and H1-2 and H2, including H2-1, the correlation between observational and EEG data results supported the findings of observational and emotional evaluations. The "general look" and "walk and watch" behaviors being identified as behavioral pleasure responses, as claimed in Section 5.1, H1-2, were negatively correlated with attention values being identified as emotional fear-response, as found in Section 5.2.1,

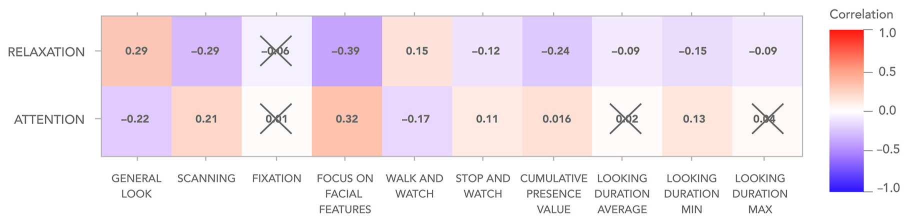

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Figure 10. The correlational analysis of observational and EEG results

H2-1. Furthermore, the highest correlation coefficient is indicated for “focus on facial features” behavior which is positively correlated with attention. Supporting H1-1 and H2-1, “focus on facial features” and “attention” were the attributes characterized by the fear response, as stated in Sections 5.1 and 5.2.1.

The correlations between observational and SAM results are shown in Figure 11. All the variables have a significant relationship. However, the highest correlation coefficient was found between valence and arousal values and the bodily behavior category (walk and watch, stop and watch).

Regarding H1, including H1-1 and H1-2 and H2, including H2-1 and H2-2, the correlation between observational and SAM data results supported the results of behavioral and emotional evaluations. The “general look” and “walk and watch” behaviors were positively correlated with valence and dominance values while negatively correlated with arousal values, along with the findings in Sections 5.1 and 5.2.2, supporting H1-2, and H2-2. Additionally, “stop and watch” and “focus on facial features” behaviors were positively correlated with arousal values while negatively correlated with valence and dominance values which agreed with the findings in Sections 5.1 and 5.2.2, supporting H1-1, H2-1.

6. Conclusion, limitations and future works

The present study examined the impact of urban graffiti displaying fear and pleasure-inducing facial expressions on human behavioral and emotional responses. The study’s multi-method approach, applying a lab-based experimental research strategy using a VR environment, was based on subjective and objective assessments of human responses. Physiological, behavioral and self-report measurements were used in behavioral and emotional evaluations, contributing to the literature on human-built environment interactions and urban graffiti by adding the representational features of urban graffiti as a parameter for investigating human experience in the built environment.

The results of the present study answered the research questions and verified the hypotheses: 1) the findings of the present paper indicate that the representational features of urban graffiti significantly impact human behavioral and emotional experiences producing specified behavioral and emotional responses (RQ1, H1 and RQ2, H2). Additionally, according to the results in Tables 1–3, and Figures 8–11 it is found that fear responses (H1-1, H2-1) and pleasure responses (H1-2, H2-2) have apparent patterns. Based on the systematic observations, the behavioral evaluations reflect that a behavioral fear response elicited by the urban graffiti displaying fear-inducing facial expressions is identified with “scanning”, “fixation” and “focus on facial features” in the looking behavior category and “stop-and-watch” behavior in the bodily behavior category. On the other hand, a behavioral pleasure response elicited by the urban graffiti displaying pleasure-inducing facial expressions is

Source(s): Figure created by author

Figure 11.
The correlational analysis of observational and SAM results

characterized by the "general look" in the looking behavior category and "walk-and-watch" behavior in the bodily behavior category.

The emotional evaluations were done by EEG and SAM measurements. According to the EEG results, the emotional fear response elicited by the urban graffiti displaying fear-inducing facial expressions is associated with high attention and low relaxation levels. At the same time, no response pattern is detected for the emotional pleasure response elicited by the urban graffiti displaying pleasure-inducing facial expressions. Regarding the SAM results, the emotional fear response is identified by high arousal, low valence and low dominance. In contrast, the emotional pleasure response is characterized by low arousal, high valence and high dominance.

The present study has limitations based on the technical experimental parameters. Due to using a 6-channel mobile dry-EEG device collecting brain signals from the surface, the emotional experience of individuals was not able to be precisely studied at the neural level based on frequency band powers, even though it was assumed that the mobile EEG was adequate to reach new knowledge based on the feature index. Therefore, the mind index data was used in identifying emotional experiences. Additionally, some difficulties occurred in assessing looking behavior from the VR recordings, such as capturing the fixations. Therefore, the coding scheme of the observational study indicating the focus on the eye and the focus on teeth were consolidated as a focus on facial features in the second cycle coding scheme.

As a future work, a detailed investigation focusing on the identification of emotional experience at neural levels will be carried out with a technically improved experimental setting, including an improved EEG and an eye tracker. Additionally, machine learning model generation techniques regarding emotion recognition would be developed for further studies. In the end, to understand the potential of the VR environment, a variety of elements which are social agents, interactive urban features, natural elements and daylight, will be implemented in the experimental procedure as variables to measure their effects on the human experience.

In conclusion, the research has suggested valuable results for understanding human behavioral and emotional experiences based on encountering the fear and pleasure-inducing urban graffiti examples. The study's practical implications, which means the operationalizations of the resulting evidence and the studied hypotheses, may contribute to the urban design processes. Urban graffiti becomes one of the crucial urban design elements that impact the human experience requiring consideration of the representational features. Moreover, the legislators and the regulators of the design disciplines may benefit from the findings of the present research in the application of graffiti examples in the urban environment.

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