The Impact of Personality Traits on Panic-Induced Emotional Contagion and Phototaxis Behavior: Physiological and EEG Analysis

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**Abstract**: Panic responses often lead to irrational behaviors. This study examines the influence of personality traits on panic-induced emotional contagion and phototaxis behavior, combining physiological measurements (Skin Conductance Level (SCL) and Electroencephalography (EEG)) with personality assessments (OCEAN model). The aim is to reveal the corresponding physiological and neurophysiological changes in panic-driven evacuation behavior across different personality types. 28 participants were divided into high extraversion-neuroticism (HEN) and low extraversion-neuroticism (LEN) groups based on their OCEAN traits. Two virtual reality experiments’results show that personality traits significantly affect phototaxis behavior, skin conductance response, and EEG activity. Specifically, the HEN group exhibited more pronounced phototaxis behavior, while the LEN group showed greater skin conductance increases and a significant reduction in θ-band. Additionally, under panic-inducing emotional contagion stimuli, the LEN group exhibited significant increases in both θ-band and α-band, whereas the HEN group showed only a notable increase in θ-band. These findings highlight the need to account for individual differences in emergency evacuation planning and suggest that personalized evacuation strategies could reduce risks and improve efficiency during emergencies.

**Keywords**: Emotional contagion; Phototaxis behavior; OCEAN model; Skin conductance level (SCL); Electroencephalography (EEG)

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### CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**1 INTRODUCTION**

With the development of urbanization and the increasing number of crowd-gathering activities, large-scale crowd gatherings are becoming common in cities, particularly in public places such as shopping malls, stadiums, and subway stations. These settings pose significant challenges to safe evacuation during emergencies. In the event of an emergency, crowds often experience panic, leading to irrational evacuation decisions and behaviors ([Shen et al., 2018](#Shen)), such as phototaxis, herd behavior, and risky backtracking, which can cause severe casualties and property damage. These consequences may even surpass the damage caused by the actual disaster itself ([Wang et al., 2015](#WangJ);[Zheng et al., 2019](#Zheng)).

Therefore, understanding the mechanisms of emotional influence and formulating effective evacuation decision-making strategies are of great significance. Researching the different physiological responses and behaviors of people with varying personality traits when confronted with panic emotions is crucial. Panic, induced by emergencies, is sudden and singular ([Guo et al., 2023](#Guo)), and emotional contagion involves psychological changes, making it difficult to quantify emotions. Currently, most researchers employ surveys or simulation models to explore the underlying mechanisms of emotional contagion, often combining the OCEAN personality model, emotional contagion models, and evacuation movement models to simulate emotional contagion during evacuation and quantify emotions and panic([Zou and Chen, 2020](#ZouQ);[Zhou et al., 2020](#ZhouR)). [Chen et al.(2024)](#Chen) developed a model of panic-induced evacuation behavior based on personality differences to explore the impact of these differences on evacuation progress. [Wang et al. (2023)](#WangG) applied the extended field model (FF) to study the influence of personality traits on panic and evacuation behavior, using questionnaires to investigate panic emotions. However, existing methods for quantifying emotions are subjective and lack precision.

With the advancement of neuroengineering management, physiological monitoring technologies have effectively addressed the challenges of psychological quantification by establishing mapping relationships between physiological and psychological states. Physiological monitoring devices can monitor individuals' physiological states without affecting their health, facilitating in-depth studies of emotional contagion. Electrodermal activity (EDA), generated by the sweat glands, is sensitive to sympathetic nervous activation triggered by psychological stimuli ([Boucsein, 2012](#Boucsein)). The skin conductance level (SCL), an indicator commonly used, reflects the subject's overall arousal state. Electroencephalography (EEG) signals, obtained through EEG, record the amplitude of brainbands generated by cortical neurons ([Han and Chun, 2021](#Han)) and can reflect both physiological and psychological responses ([Schoffelen et al., 2011](#Schoffelen)). As EEG signals directly reflect central nervous system activity, experts consider it more directly related to the subject's psychological response than other physiological reactions ([Buck, 1999](#Buck)). [Armougum et al. (2019)](#arm) studied the cognitive load of train passengers in real-life and virtual environments using skin conductance responses. [Lin. (2020)](#LinJ2020) researched the navigation behavior of individuals under stress during building fires, using immersive VR experiments with multi-channel sensory stimuli. [Occhialini et al. (2016)](#Occhialini) used EEG technology to quantitatively assess the perception of emergency navigation signs in virtual environments.

Phototaxis behavior is predominantly found in the natural world. In emergencies, restricted visibility due to power outages, smoke, or other factors triggers irrational behaviors in panicked individuals, who tend to move towards brighter areas, often choosing brighter exits ([Wang et al., 2022](#WangD)). [Lovreglio et al. (2016)](#Lovreglio) studied the factors influencing pedestrian evacuation and demonstrated the significant impact of lighting on exit selection during evacuation. [Vilar et al. (2014)](#Vilar) using virtual reality, found that the brightness of evacuation exits significantly influenced navigation in both normal and emergency situations, sometimes more than the effectiveness of evacuation signs. [Guo et al. (2023](#Guo)) proposed an evacuation model considering the phototaxis behavior of panicked individuals with limited visibility, aiming to study the impact of phototaxis on evacuation processes. While simulation and experimental studies have observed phototaxis behavior, research on the phototaxis induced by panic and how different personality traits influence its underlying mechanisms remains relatively sparse.

In conclusion, although significant progress has been made in the study of pedestrian behavior and emotions during emergency evacuations, there is limited research on the stress responses and behaviors of individuals with different personality traits when faced with panic emotions. This gap exists partly due to the lack of relevant experience data and quantitative theories in panic conditions, and partly because emotions or psychological states are highly complex and difficult to explore ([Sun and Chen, 2023](#Sun)). Therefore, this paper investigates the phototaxis behavior and corresponding physiological changes of individuals with different personality traits during panic.

This study combines physiological monitoring and personality trait assessments to explore the influence of personality traits on panic-induced emotional contagion and phototaxis behavior, aiming to reveal the relationship between panic-driven evacuation behavior and neurophysiological responses. The remainder of the paper is structured as follows: Section 2 presents the materials and methods, Section 3 reports the experimental results, Section 4 discusses the findings, and Section 5 concludes with future outlooks.

### 2 METHOD AND MATERIALS

1. **Participants**

The recruitment and experimental procedures in this study adhered to the ethical guidelines of the World Medical Association (Declaration of Helsinki) and were approved by the Psychological Health Education Center Committee at Shenyang Jianzhu University. Participants were recruited through an online platform, with a total of 30 individuals recruited within the age range of 21–28 years. The final valid sample consisted of 28 participants, including 16 males (mean age = 24 years, standard deviation = 3.10) and 12 females (mean age = 29 years, standard deviation = 4.71). All participants were sufficiently familiar with the subway station (having visited the station at least five times) and were able to navigate to the exit on the -1 floor proficiently. Before the experiment, participants read and signed an informed consent form, and completed a questionnaire after the experiment. Each participant received a reward of 30 RMB.

1. **Equipment Design**

**2.2.1 Experimental Scenarios and Tasks**

A virtual reality simulation of the Youth Street Subway Station was constructed, with four exits (A, B, C, D) placed according to their actual locations. To increase the experimental saturation and eliminate potential interference from familiarity with the scenario ([Huang, 2021](#Huang)), two initial positions, Position 1 (P1) and Position 2 (P2), were set. Participants were instructed to successfully escape from any exit, following directional signs, as shown in [Figure 1](#fig1). Each participant participated in two experimental conditions: Experiment 1, where Exit B had no light source and Exit C had a strong light source; and Experiment 2, where the light source intensity at both exits was the same, with additional panic contagion stimuli included.

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| **FIGURE 1** Virtual Reality Scenario |

**2.2.2 Experimental Stimuli Materials**

Stimuli are mediums used by researchers to evoke emotional responses from participants. Currently, commonly used stimuli formats include video clips, images, sounds, and other media ([Bulagang et al., 2020](#Bulagang)). Dynamic videos, as compared to static images, have a stronger effect in promoting emotional responses ([Schaefer et al., 2010](#Schaefer)). In this experiment, participants were exposed to auditory and visual stimuli during the process to simulate a real emergency situation. Panic-inducing videos were also used to trigger participants’ panic emotions.

Based on the Chinese Digital Sound System ([Liu et al., 2006](#liu)) and the International Affective Digital Sound System ([Bradley and Lang, 1999](#Bradley)), auditory stimuli materials such as shouting, crying, screaming, explosions, wind, alarm sounds, liquid splashes, collisions, falling, and collapsing sounds were selected ([Xiong et al., 2015](#Xiong)). Additionally, visual stimuli, such as dim lighting, smoke, and dynamic fire effects, were designed to simulate an emergency situation.

For the panic-inducing video materials, we initially collected 30 horror video clips. These clips were filtered through three rounds. In the first round, psychology professionals evaluated the clips based on video duration, complexity, and emotional arousal levels to ensure that participants would be physically adapted and experience an appropriate level of emotional arousal ([Li et al., 2017](#LiBJ)). Then, 15 university students (average age: 28, standard deviation: 2.1) were recruited for further testing, ensuring they had not participated in the formal experiment. Finally, psychology experts conducted a final review and selection. The chosen clips were sourced from the classic disaster movies The Day After Tomorrow and 2012. Each video lasted 50-60 seconds, featuring a tight narrative, tense atmosphere, dark tones, and unsettling background sounds, effectively inducing panic emotions in a short time.

**2.2.3 Questionnaire**

The Personality Traits and Panic Phototaxis Behavior Questionnaire was designed based on three aspects: personal information, participants' responses and behaviors, and the realism of the experimental scenario. The questionnaire is divided into five sections: basic information, personality traits (OCEAN model), emotional perception and expression, phototaxis behavior tendencies, and scenario arousal. The main focus is on participants’ subjective responses, aiming to further identify and interpret how different personality traits influence phototaxis behavior and physiological responses. This helps to reveal the role of individual characteristics in evacuation decision-making.

Basic information includes the participants' individual characteristics (gender, age), cognitive level (education level), fire drill or fire escape experience, and familiarity with the scenario. Evacuation behavior observes whether the participant is aware of their own phototaxis behavior. Scenario arousal includes both emotional arousal and the realism of the scenario's arousal, observing the emotional mobilization and the authenticity of the participants' responses.

1. **Equipment and Environment**

**2.3.1 Virtual Reality Scenario**

The virtual reality subway scene was constructed using Unity3D 2019.4.26.f1c1 software. To enhance the realism of the scenario, a particle system was used to import particle modules, adding dynamic fire and smoke, directional signs, exit labels, and collision detection, thereby generating a complete building fire scenario, as shown in [Figure 2](#Fig2).

In the controlled immersive virtual reality (VR) environment, the walking mode was used to balance ecological effectiveness and experimental operability ([Kinateder et al., 2014](#Kinateder)). Participants were required to wear EEG monitoring equipment, physiological monitoring devices, and a VR headset, using controllers to navigate and complete the evacuation task.

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| 屏幕截图 2025-01-12 161943 |  |
| 屏幕截图 2025-01-12 161454 |
| b) Virtual Reality Scenario | b) On-site Experimental Scenario |
| **FIGURE 2** Experimental Scene and Experimenter | |

**2.3.2 Electroencephalogram (EEG)**

EEG can reveal cognitive changes related to decision-making. In this experiment, the ErgoLAB EEG wearable brainband measuring instrument was used. It has 32 measurement channels, with a sampling frequency of ≥250Hz/channel, a measurement range of ≥±3000μV, and measurement accuracy of ≤0.0458μV. The input range is ±100mV. The time resolution of the accompanying training device is ≤1ms, with a scanning period of ≤20ms. It allows for numerical analysis of EEG frequencybands as well as statistical analysis of ERPbandforms and brain topography maps. [Figure 3](#Fig3) shows the electrode placement on the scalp.

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| 15c8c086490f99913b83018bc64c7f0 |
| **FIGURE 3** Electrode Placement on the Scalp. The prefixes "Fp," "F," "T," "C," "O," and "P" represent the frontal polar region, frontal lobe, temporal lobe, central region, occipital lobe, and parietal lobe, respectively. The suffix "z" indicates the center of the left or right hemisphere of the brain. Odd numbers refer to the left hemisphere, while even numbers refer to the right hemisphere. |

**2.3.3 Electrodermal Activity (EDA)**

EDA refers to the electrical conductance characteristics of the skin surface, which change with sweat gland activity. It is a commonly used physiological indicator of psychological and emotional states, reflecting the level of autonomic nervous system activity. In this experiment, EDA measurements were conducted using the ErgoLAB smart wearable wrist sensor. The sensor uses a wristband-integrated sensor and wireless radio frequency for real-time data collection, with a system sampling rate of ≥2000Hz/channel, system resolution ≥16Bit, measurement range ≥0 to 30μS, and measurement accuracy ≤0.01μS.

**2.4 Experimental Process**

Rest Phase: Participants first signed an informed consent form and wore the physiological data collection wrist sensors. During this phase, participants were allowed to relax. Preparation Phase: Participants completed a pre-experiment phase, reading the VR task instructions, wearing the VR headset, and engaging in VR practice tasks to ensure they adapted to the VR equipment.

Before the formal experiment, participants were informed that they would be involved in a virtual reality evacuation experiment. The specific task was to be in a subway station on the -2 level, where an emergency occurred, and they needed to find the exit on the -1 level to complete the evacuation. First, participants were exposed to panic-inducing video stimuli to activate their panic response. The type of content was explained to the participants beforehand, and they were informed they could opt out at any time during the video. The experiment included dynamic fire and smoke simulations, accompanied by noisy environmental sounds and sounds of panicking people. The first experimental task began thereafter. After completing this, there was a 5-minute relaxation phase to ensure participants' mental state was stable. Experiment 2 followed. Before each experiment, there was a 50-60s panic awakening phase.

Finally, participants removed the equipment and completed a self-assessment and scenario realism questionnaire after the experiment. The experimental flowchart is shown in [Figure 4](#Fig4).

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| **FIGURE 4** Experimental Flowchart |

**2.5 Data Processing**

**2.5.1 Preprocessing**

The EDA signals were preprocessed using ErgoLAB, including filtering, downsampling, segmentation, and smoothing to finalize the SCL data ([Yeom et al., 2021](#Yeom)). EEG signals were preprocessed using EEGLAB, a MATLAB-based program for EEG data processing. Abandpass filter was applied to remove artifacts caused by sweat and eye or mouth movements, as well as to eliminate frequencies below 0.1Hz and above 50Hz ([Delorme and Makeig, 2004](#Delorme)). Independent Component Analysis (ICA) was then used to remove any remaining artifacts ([Winkler et al., 2011](#Winkler)).

EEG data had a sampling rate of 256Hz, and after electrode preprocessing, a Fast Fourier Transform (FFT) was used to perform power spectral analysis, dividing the data into Theta (θ)band (4-8 Hz), Alpha (α)band (8-13 Hz), and Beta (β)band (13-30 Hz). θ-band in the frontal lobe are mainly generated during working memory tasks, attention concentration, and alertness ([Aftanas et al., 2003](#Aft)). α-band in the parietal and occipital lobes are mainly produced during working memory, mental load, attention concentration, and alertness ([Foster et al., 2017](#Foster)). β-band in the parietal and occipital lobes occur mainly when visual attention, concentration, or stress is present ([Kuribayashi and Nittono, 2017](#Kuribayashi)). Due to significant individual differences in the minimum and maximum EEG power, relative power values were used to correct for individual variations ([Han and Chun, 2021](#Han)).

**2.5.2 Statistical Analysis**

This study analyzes the corresponding changes between panic evacuation behavior and neurophysiology in relation to different personality traits. The Kolmogorov–Smirnov (K-S) test was used to check whether the OCEAN model data conformed to the normal distribution assumption, followed by Pearson’s correlation test to verify the relationship between personality traits and panic emotions.

Next, k-means clustering analysis was used to divide all participants into two groups, and mixed-design ANOVA was used to analyze the rationality of the group classification. The Shapiro-Wilk and Levene tests were applied to conduct basic checks on SCL data and relative EEG power. Independent-samples t-tests were used to observe whether there were significant differences in EDA and EEG responses between two groups with different characteristics during Experiment 1. Since Experiment 2 focused on observing changes in EDA and EEG under emotional contagion conditions for individuals with different personality traits, paired-samples t-tests were used to compare the pre- and post-emotional contagion data for different personality traits.

Data processing, analysis, and graphical visualization were performed using IBM SPSS Statistics 27. EDA and EEG signal preprocessing and analysis were done using ErgoLAB, MATLAB 2019a, and EEGLAB 2021.0.

### 3. RESULTS

**3.1 Personality Trait Classification (OCEAN)**

The OCEAN model includes five orthogonal dimensions: Openness (O), Conscientiousness (C), Extraversion (E), Agreeableness (A), and Neuroticism (N). Based on a carefully designed questionnaire ([Krosnick, 2017](#Krosnick)), this study analyzes the impact of participants' personality traits on panic emotions. First, the frequency count of participants' OCEAN results was analyzed, and preliminary Gaussian function fitting was performed. It was found that all five dimensions of personality traits followed a normal distribution, as shown in [Figure 5](#Fig5).

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| a) | b) | | c) |
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| d) | | e) | |
| **FIGURE 5** The frequency counts and Gaussian hunction of the OCEAN results for all subjects: (a) openness, (b) conscientiousness, (c) extroversion, (d)agreeableness and (e)neuroticism. | | | |

To explore the normal distribution characteristics of the personality dimensions, a Kolmogorov–Smirnov (K-S) test was conducted. [Table 1](#Table1) shows the K-S test results for the OCEAN model. The p-values for all five personality dimensions were greater than 0.05, indicating that the null hypothesis was not rejected and that the OCEAN results conform to a normal distribution.

**Table 1** K-S Test Results for the OCEAN Model

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| --- | --- | --- | --- | --- | --- | --- |
| **OCEAN dimensions** | **Number of subjects** | **Mean** | **Standard deviation** | **Skewness** | **Kurtosis** | 1. **Value** |
| Openness | 28 | 3.27 | 0.64 | -0.67 | -0.23 | 0.07 |
| Conscientiousness | 28 | 3.69 | 0.45 | -0.04 | 0.08 | 0.05 |
| Extraversion | 28 | 3.66 | 0.78 | -0.82 | 0.47 | 0.06 |
| Agreeableness | 28 | 3.83 | 0.70 | -0.62 | -0.20 | 0.08 |
| Neuroticism | 28 | 3.08 | 0.86 | -0.44 | -0.88 | 0.10 |

During the experiment, the influence of participants' personality traits on panic emotions became increasingly apparent, reflected in emotional expression and phototaxis behavior. To analyze the correlation between personality traits and panic emotions, Pearson's test was performed based on the panic emotion questionnaire scores. The results showed a significant positive correlation between extraversion and panic emotions (r = 0.366, p < 0.01), and between neuroticism and panic emotions (r = 0.150, p < 0.01). A significant positive correlation was also found between extraversion and neuroticism (r = 0.604, p < 0.01). Therefore, participants were divided into two groups using K-means clustering: Low Extraversion Neuroticism (LEN) group, consisting of 9 participants, and High Extraversion Neuroticism (HEN) group, consisting of 19 participants, as shown in [Figure 6](#Fig6).

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| **FIGURE 6** Participant classification results obtained through K-means clustering. |

Considering the two experimental conditions, participants made two path choices, and a Mixed ANOVA was conducted to further validate the rationality of the grouping. Significant differences were found in the within-group effects (F(1,28) = 15.83, p < 0.001), indicating that the path choice significantly affected the participants' panic responses. Additionally, significant differences were observed in the between-group effects (F(2,28) = 66.70, p < 0.001), showing that there were significant differences in path choices between participants with different personality traits. Therefore, the classification into two groups based on personality traits was statistically significant.

**3.2. Phototaxis Behavior Analysis**

In Experiment 1, the path selection of two groups with different personality traits was observed to identify significant differences, thereby analyzing the impact of personality traits on phototaxis behavior. Based on the survey results, the participants' path choices under the influence of lighting were identified, and an independent samples t-test was conducted for the path selection (Exit C with no light, Exit B with light). The result showed that t(28) = 2.743, p = 0.011 < 0.05, IC [0.119, 0.829], d Cohen = 1.110 > 0.5, indicating a significant difference in path choice between the two groups with a large effect size. Further analysis confirmed that the phototaxis response varied statistically between participants with different personality traits, with high extraversion and neuroticism participants exhibiting a more pronounced phototaxis behavior.

**3.3. Electrodermal Activity (EDA) Analysis**

The analysis of SCL data confirmed that it followed a normal distribution (Shapiro-Wilk test, p > 0.05) and homogeneity of variance (Levene test, p > 0.05).

In Experiment 1, the electrodermal response of participants with different personality traits was analyzed. An independent samples t-test was conducted for SCL, and the result showed that t(28) = -3.820, p < 0.01, IC [-6.710, -2.015], d Cohen = 1.546 > 0.5, indicating a significant difference between the two groups with a large effect size. This suggests that the electrodermal response differs statistically based on personality traits and has practical significance.

In Experiment 2, the electrodermal response under emotional contagion was analyzed. A paired-samples t-test was performed on SCL for both conditions in Experiment 1 and Experiment 2. The results showed that for the LEN group, t(9) = -3.944, p < 0.01, IC [-5.221, -1.368], d Cohen = 1.315 > 0.5, indicating a significant difference in SCL, with a large effect size. For the HEN group, t(19) = 0.125, p = 0.902, IC [-1.721, 1.939], showing no significant difference in electrodermal response. This analysis confirmed that the LEN group showed statistically significant changes in SCL in response to emotional contagion, while the HEN group did not. [Figure 7](#Fig7) illustrates the distribution of SCL in the two experimental conditions for different personality trait groups. The results indicate that low extraversion and neuroticism individuals (LEN group) are more susceptible to panic-induced changes in emotion, as reflected by a significant increase in SCL. In contrast, high extraversion and neuroticism individuals (HEN group) showed minimal physiological changes after experiencing panic emotion.

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| **FIGURE 7** Box plot of participants' electrodermal response (SCL). Distribution of SCL for different personality trait groups in the two experimental conditions. |

**3.4 EEG Analysis**

In Experiment 1, we observed whether there were significant differences in θ-band, α-band, and β-band between the two groups of participants with different personality traits. Independent sample t-tests were conducted for the power of different EEGbands, as shown in [Table 2](#Table2). For θ-band, the result showed t(28) = -2.322, p = 0.028 < 0.05, IC [-0.074, -0.047], Cohen's d = 0.944 > 0.5, indicating a significant difference between the two groups in θ-band changes, with a large effect size.For α-band, the result showed t(28) = 0.073, p = 0.943, meaning no significant difference in α-band changes between the two groups.For β-band, the result showed t(28) = 1.868, p = 0.073, meaning no significant difference in β-band changes between the two groups.Therefore, the analysis confirms that the θ-band power differs statistically between individuals with different characteristics, while there are no statistical differences in α-band and β-band power.

**Table 2** Paired Sample t-test for θ-band , α-band , and β-band for Participants with Different Personality Traits

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| EEG band Classification | Number of subjects | Mean difference | Standard eror difference | t | p | 95% Confidence interval of the difference | | dCohen |
| Lower | Upper |
| θ-band | 28 | -0.039 | 0.017 | -2.332 | 0.028\* | -0.074 | -0.005 | 0.944 |
| α-band | 28 | 0.001 | 0.007 | 0.073 | 0.943 | -0.014 | 0.015 | 0.029 |
| β-band | 28 | 0.028 | 0.015 | 1.868 | 0.073 | -0.003 | 0.059 | 0.756 |

In Experiment 2, the differences in θ, α, and βbands under emotional contagion were observed in participants with different personality traits. A paired-sample t-test was conducted on the EEG frequency data for both Experiment 1 and Experiment 2, as shown in [Table 3](#Table3).

The results indicated that, for θ-band, both the LEN group and HEN group exhibited significant differences with and without emotional contagion (p < 0.05), with large effect sizes (dCohen > 0.5). Specifically, under emotional contagion, the LEN group showed a significant decrease in θ-band, while the HEN group showed a significant increase. For α-band (α), the LEN group exhibited significant differences with and without emotional contagion (p < 0.05), with large effect sizes (dCohen > 0.5). However, the HEN group showed no significant difference (p > 0.05). Under emotional contagion, the LEN group exhibited a significant increase in α-band. For β-band (β), no significant differences were observed in either the LEN or HEN groups with or without emotional contagion (p > 0.05).Therefore, the analysis confirms that the EEG power of the LEN group differed statistically with and without emotional contagion, mainly manifested as a significant decrease in θ-band and a significant increase in α-band. This suggests that individuals with low extraversion and neuroticism are more sensitive to panic emotions, leading to significant changes in θ and α-band. In contrast, the HEN group showed a significant increase in θ-band under emotional contagion, suggesting that individuals with high extraversion and neuroticism are less affected by panic emotions compared to those with low extraversion and neuroticism. [Figure 8](#Fig8) presents the box plot of relative EEG power responses, reflecting the distribution of θ, α, and β-band in both experiments for different personality trait groups.

**Table 3** Paired-Sample t-Test for θ, α, and βbands under Emotional Contagion in Participants with Different Personality Traits.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| EEG band Classification | Personality Trait Classification | Number of subjects | Mean | Standard deviation | Standard eror mean | t | p | 95% Confidence interval of the difference | | dCohen |
| Lower | Upper |
| θ-band | LEN | 9 | -0.040 | 0.036 | 0.012 | -3.361 | 0.010\* | -0.067 | -0.013 | 1.120 |
| θ-band | HEN | 19 | 0.029 | 0.058 | 0.013 | 2.179 | 0.043\* | 0.001 | 0.057 | 0.500 |
| α-band | LEN | 9 | 0.013 | 0.013 | 0.004 | 3.024 | 0.016\* | 0.003 | 0.026 | 1.008 |
| α-band | HEN | 19 | -0.010 | 0.030 | 0.007 | -1.435 | 0.168 | -0.025 | 0.005 | -0.329 |
| β-band | LEN | 9 | 0.013 | 0.031 | 0.010 | 1.298 | 0.231 | -0.010 | 0.037 | 0.433 |
| β-band | HEN | 19 | -0.018 | 0.062 | 0.014 | -1.295 | 0.212 | -0.048 | 0.011 | -0.297 |
| \*. The correlation is significant at the 0.05 level (two-tailed). | | | | | | | | | | |

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| a) | b) | c) |
| **FIGURE 8** Box plot of relative EEG power response. Distribution of θ-band, α-band, and β-band in the two experimental groups based on different personality trait classifications. | | |

To observe the EEG activity of participants with different personality traits more clearly, we investigated the differences in brain activity response power and regions. We selected the average power scalp maps for the two groups on three relative EEG powerbands. Blue represents lower brain activity or power levels, usually associated with reduced activity in specific brain regions. In contrast, green, yellow, and red indicate progressively higher EEG activity or power values, typically related to enhanced activity in these regions.

[Figure 9](#fig9) a) and b) show the scalp topography distribution of θ-band, α-band, and β-band for participants in different personality trait groups during the two experimental conditions. Based on the scalp topography maps, it is evident that, when affected by panic emotions, different EEGband powers change significantly in the two participant groups. For LEN trait participants, α-band show a noticeable increase after experiencing emotional contagion. For HEN trait participants, θ-band show a noticeable increase after experiencing emotional contagion. Specifically, emotional contagion primarily affects the EEG power in the frontal and parietal regions.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | θ-band | α-band | β-band |  |  | θ-band | α-band | β-band |  |
| LEN |  |  | ab633e31f9b07c8f10d9180a76f18b7 |  | LEN |  |  |  |  |
| HEN |  |  |  | HEN |  |  |  |
| a) Experiment 1 | | | | | b) Experiment 2 | | | | |
| **FIGURE 9** Scalp topography maps of relative EEG power. The distribution of θ-band, α -band, and β -band on the scalp in two experimental conditions for different personality trait groups. | | | | | | | | | |

### 4. DISCUSSION

The aim of this study is to observe the influence of personality traits on panic-induced emotional contagion and phototaxis behavior. We conducted two virtual reality experiments with a combination of physiological measurements (SCL and EEG) and personality traits (OCEAN) to assess the effects on phototaxis behavior, skin conductance, and relative brainband activity, revealing the corresponding changes in panic evacuation behavior and neurophysiology across different personality traits.

Based on the OCEAN model, the 28 participants were divided into two groups: high extraversion-neuroticism (HEN) group (9 participants) and low extraversion-neuroticism (LEN) group (19 participants). We analyzed the emotional expression and phototaxis behavior of both groups and found significant differences in path selection within each group, and between groups, with different personality traits showing notable differences in path choice ([Li, 2021](#LiJ2021); [Deng et al., 2024](#Deng); [Song et al., 2024](#Song)). The analysis of phototaxis behavior revealed that people with HEN exhibited more pronounced phototaxis, suggesting they are more sensitive to light and tend to choose brighter exits compared to those with LEN.

The skin conductance data showed significant differences between personality traits. In Experiment 1, under varying light intensities, we observed significant differences in skin conductance reactions between the two groups. In Experiment 2, after emotional contagion, there was a significant increase in SCL in the LEN group, while there was no significant change in the HEN group. This indicates that LEN participants are more susceptible to panic emotions, while HEN participants show minimal physiological change in response to panic. These findings are consistent with existing literature ([Chen et al., 2024](#Chen)).

Brainband data also showed significant differences between personality traits. In Experiment 1, we observed significant differences in θ-band power between the two groups, but no significant differences in α-band and β-band power. Personality traits can affect individuals' responses to emotional stimuli, with θ-band playing a key role in working memory and alertness. The environmental changes due to different light conditions likely triggered the participants' alertness or anxiety responses, reflected in significant changes in θ-band, while α-band and β-band are more related to cognitive processing and attention, possibly linked to emotional regulation and cognitive processing styles.

In Experiment 2, we observed the effect of emotional contagion on brainband power in different personality traits. The brainband power under emotional contagion conditions showed significant differences, mainly affecting the frontal and parietal regions. In the LEN group, θ-band decreased significantly, while α-band increased significantly. In contrast, in the HEN group, θ-band increased significantly under emotional contagion. θ-bands are typically associated with emotional regulation, attention, and activation of working memory ([Kosachenko et al., 2023](#Kosachenko)). LEN participants are more affected by negative emotions, as evidenced by the significant decrease in θ-band during emotional contagion. This is likely due to their poorer emotional regulation abilities and lower emotional stability. In contrast, HEN participants showed a significant increase in θ-band, indicating they may be more sensitive to others' emotions, which influenced their brainband activity. α-bands are usually associated with relaxation, attention, and cognitive load ([Romeo et al., 2024](#Romeo)). The significant increase in α-band in the LEN group after emotional contagion may suggest that LEN individuals tend to cope with emotional fluctuations through self-regulation and a calmer approach. On the other hand, HEN group showed no significant changes in α-band, which may indicate their stronger emotional regulation mechanisms. β-bands are generally related to focused attention, anxiety, or cognitive tasks ([Jiang et al., 2020](#Jiang)). However, in this experiment, emotional contagion did not significantly affect β-band changes, suggesting that emotional contagion primarily influenced emotional responses rather than cognitive load or attention.

By analyzing phototaxis behavior, skin conductance, and relative brainband activity, we have clarified the significant impact of personality traits on phototaxis behavior, skin conductance reactions, and brainband activity. Given the differences in participant traits, this study highlights the responses and behaviors of individuals with different personality traits in panic evacuation situations. This suggests the limitations of implementing a unified evacuation strategy and emphasizes the importance of personalized evacuation training. The results provide a foundation for individualized and scientifically based evacuation training plans, helping reduce training costs and increase overall evacuation efficiency. Moreover, by revealing the patterns of emotional contagion and decision-making behavior in panic situations, the study offers valuable insights for optimizing evacuation guidance strategies and supports the development of more efficient evacuation management systems.

Although the conclusions drawn from this study hold certain reference value, there are some limitations. First, considering the feasibility and operability of the experiment, the participants were university students and faculty from Chinese universities. Despite efforts to expand the age range of the sample, there remains a difference compared to actual passengers, limiting the generalizability of the results. Second, the sense of immersion and realism of the scenario needs further refinement, including the closeness of the stimuli to real-life scenarios and whether the emotional arousal effects meet the standards. These are areas for improvement in future research.

Therefore, in future studies, we will increase participant diversity and group representation, while improving the ecological validity of virtual reality to enhance the realism and reliability of evacuation simulations ([Zou et al., 2017](#ZouHliN)), aiming for broader applicability to real-life situations. Our ultimate goal is to apply the research findings to emergency evacuation management practices, optimize evacuation guidance strategies, and improve the effectiveness of personalized training, contributing to the establishment of more efficient evacuation management systems ([Zou, 2017](#ZouH2017)). However, it is undeniable that personality traits significantly impact evacuation efficiency, as evidenced by the differences in behavior, skin conductance, and brainband data, which provides a theoretical foundation for subsequent research.

### 5. CONCLUSION

This study explored the impact of personality traits on panic-induced emotional contagion and phototaxis behavior through two virtual reality experiments. We analyzed phototaxis behavior, skin conductance reactions, and brainband activity to reveal corresponding changes in panic evacuation behavior and neurophysiology across different personality traits. All participants were divided into two groups: HEN and LEN, with significant differences observed in personality traits, phototaxis behavior, SCL, and EEG. The study found that, after grouping by personality traits, high extraversion-neuroticism individuals exhibited more pronounced phototaxis and greater sensitivity to light compared to LEN individuals. Skin conductance data indicated that LEN individuals were more susceptible to panic emotions, while HEN individuals exhibited minimal physiological change in response to panic. Brainband data demonstrated that personality traits significantly influenced brainband changes under emotional contagion, particularly affecting brainband power in the frontal and parietal regions. This study, through analyzing the reactions and behaviors of different personality traits in panic evacuation, provides valuable insights into individual psychological processes and corresponding neurophysiological mechanisms, emphasizing the importance of personalized evacuation plans and optimized evacuation strategies for panic evacuation guidance and crowd management.

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