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The Effect of Auditory Stimuli on the Attention Bias of Threatening Information

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Abstract: *Auditory information plays a crucial role in humans' daily life, and different types of sounds can have varying influences on individuals. Throughout the history of human survival and development, the ability to quickly identify and respond to threats has been essential. Threatening attention bias is observed from infancy and develops gradually with an individual's growth. The purpose of this study is to explore the influence of auditory information on people's attention to threatening information in different scenarios. A total of 23 subjects were recruited and divided into three groups. Each group of subjects viewed specific scenarios under different background sounds: aggressive, peaceful, and no background sound. The viewing process was recorded using an eye-tracker. The experimental results showed that the first fixation duration in the aggressive sound group was significantly less than in the other two groups. This indicates that the subjects displayed avoidance of threatening information at the initial stage. The aggressive sound made people more alert and sensitive to potential dangers and threats, leading to a threat-avoidance behavior. This finding could enhance the understanding of threatening bias and can be leveraged in sound-related applications, such as video game design, audio guide design, and online course design.*

Keywords: *Eye-tracking, background sound, auditory information, threat, threatening attention bias, gazing attention*

1. Introduction

The limitation of processing resources in the visual system determines that we must carefully choose the information to be processed. The brain's attention control system plays a crucial role in this process, as it allows us to compare and integrate current information relevant to the task and purpose, while excluding and suppressing irrelevant stimuli. Through this intricate mechanism, we consciously select the most important information for processing, giving rise to what is known as selective attention [1]. However, in certain cases, humans may automatically process stimuli with an uncontrolled attention bias, which starts to manifest very early in infancy and is particularly pronounced when individuals encounter threatening information.

Threatening information, which triggers negative emotions like anxiety and fear, has been a critical element in human survival and evolution. The ability to rapidly detect and respond to threatening information serves as a vital basis for individuals to secure themselves and adapt to their environment [2]. Consequently, people tend to preferentially process threatening stimuli in various scenarios, and this capacity to quickly identify threat information has strengthened over the course of human evolutionary adaptation [3][4].

Researchers have extensively investigated the processing mechanism and influencing factors related to threatening information. While previous studies mainly focused on the intrinsic and personal traits of individuals, such as anxiety levels[5][6][7], the attention to threat information in specific situations has received relatively less attention. Meanwhile, the influence of music as a stimulus has been a subject of exploration. Auditory information significantly impacts various aspects of human life, including cognitive processes, emotions, attention, and memory [8][9][10]. Studies have demonstrated that music significantly affects people's attention. For instance, high-intensity concerts can lower individuals' attention levels [11], and musical training can notably enhance anterior attention processing in the brain [12]. In addition to music, other forms of auditory information may also influence people's attention bias.

The present study aims to delve into how different types of background sound can impact people's attention bias toward threatening information. By combining visual and auditory materials, participants

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will view scenarios of various scenarios while being exposed to three types of background sounds: threatening, peaceful, and no sound. Unlike previous studies, this research employs an eye-tracker to provide quantitative and precise measurements of participants' gazing attention. This innovative approach promises a more comprehensive understanding of the attention patterns exhibited by participants and how they respond to threatening information in diverse auditory contexts. By examining the interplay between auditory stimuli and visual stimuli in shaping attention biases, this study holds the potential to contribute valuable insights to the field of attention research and provide practical applications in various domains, such as the design of engaging and effective experiences in multimedia contexts.

2. Materials and Methods

2.1. Participants

The study included a total sample of 23 participants (Mage = 32.09, *SD* = 10.53), consisting of 11 female participants and 12 male participants. These participants were randomly recruited from a shopping mall. Prior to the experiment, all participants were informed that it involved eye-tracking technology, and they were also made aware of the potential benefits and risks associated with the research. Participants were assured that they had the option to withdraw from the experiment at any time if they felt uncomfortable. To show appreciation for their participation, small gifts were presented to the participants after they completed the experiment.

2.2. Stimuli

The purpose of this experiment is to investigate the influence of different background sounds on people's attention bias in response to threatening information. The auditory stimuli are categorized into three types: aggressive, peaceful, and no background sound. The aggressive group contains sound effects designed to create tension and a sense of insecurity, eliciting emotions such as fear, anger, and anxiety. The hypothesis is that participants will pay more attention to areas that may have potential dangers and threats when exposed to aggressive background sounds. Conversely, the peaceful group contains sound effects that create a sense of security and peace, leading to emotions such as relaxation and calmness. In this case, the hypothesis is that the subjects will pay less attention to areas that contain potential threats and dangers when exposed to peaceful background sounds.

During the experiment, all participants were divided into three groups based on the above three different sound stimuli. And each group was exposed to the sound in two scenarios. One is the forest view scenario (Scenario 1) and the other is the city view scenario (Scenario 2). Each scenario contains various elements, including potential dangers and threats. Areas of interest (AOIs) are focused on the corresponding threats and dangers in each scenario. For Scenario 1, the AOI contains the lush trees and bushes where beasts and other animals may hide. In Stimulus 2, the AOI is a person on a bike close to a taxi, which may evoke associations with potential accidents. The video including two scenarios and the corresponding audio sound were presented to the subjects. By examining participants' gaze patterns and attention to specific AOIs under different background sound conditions, this study aims to gain insights into how auditory stimuli influence attention bias to threatening information. The findings could contribute to a deeper understanding of the complex interplay between auditory and visual cues in shaping individuals' attention and emotional responses in different contexts.

2.3. Design and Procedure

For this study, a random selection of adults was recruited as subjects. The equipment required for the experiment included a desktop eye-tracker (Tobii 4C), a laptop, a display screen, and a noise-canceling headset. The display screen was connected to the laptop to present stimuli, while the eye-tracker was placed at the bottom of the screen and connected to the laptop to collect the subjects' gazing data. The noise-canceling headset was used to play audio, and the laptop facilitated the observation of subjects' gazing behaviors and the control of the experiment.

During the experiment, the participants were divided into three groups: Group A, Group B, and Group C. Each group observed two different scenarios, which served as the dependent variables. The independent variables were the sound effects played alongside each scenario. Group A was exposed to aggressive audio, Group B to peaceful audio, and Group C served as the control group with no

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background sound. Each scenario was presented for 10 seconds. Before the formal start of the experiment, all subjects had to undergo a nine-point calibration procedure to ensure the eye-tracker could successfully collect data. After calibration, the subjects proceeded to the formal experiment. The two scenarios were presented to the subjects with the corresponding background sounds. Upon completion of the experiment, the subjects received a gift as a token of appreciation. To ensure the reliability of the results, subjects who finished the test were not allowed to exchange information with those who hadn't started yet.

The area of interest (AOI) for each image was defined as the part that contained potential threats or dangers. The eye-tracker recorded various eye-movement data, including the total fixation duration (TFD), fixation count (FC), and the first fixation duration (FFD). These eye-movement data were exported for further analysis. By utilizing this equipment and experimental setup, the study aims to gain valuable insights into how different background sounds influence participants' attention bias to threatening information. The combination of eye-tracking technology and auditory stimuli allows for a more comprehensive understanding of the participants' responses and gaze patterns, contributing to a deeper understanding of attention processes in various contexts.

2.4. Data Analysis

To compare participants' eye gaze among Group A, Group B, and Group C, we conducted single-factor ANOVA statistical analyses for TFD, FC, and FFD. Additionally, post-hoc multiple comparisons were performed to further analyze and determine the differences among them.

3. Results

3.1. Between-group single-factor ANOVA analysis of TFD

The results of ANOVA analyses showed that there was no significant difference ($F = 0.52$, $p > 0.05$) in the total fixation duration among Group A (aggressive) ($M = 6.06$, $SD = 1.43$), Group B (peaceful) ($M = 5.54$, $SD = 1.05$), and Group C (control) ($M = 5.47$, $SD = 1.12$).

3.2. Between-group single-factor ANOVA analysis of FC

The results of ANOVA analyses showed that there was no significant difference ($F = 0.47$, $p > 0.05$) in the fixation count among Group A (aggressive) ($M = 18.12$, $SD = 5.71$), Group B (peaceful) ($M = 20.15$, $SD = 4.39$), and Group C (control) ($M = 18.83$, $SD = 5.36$).

3.3. Between-group single-factor ANOVA analysis of FFD

The results of ANOVA analyses showed that there was no significant difference ($F = 1.17$, $p > 0.05$) in the first fixation duration among Group A (aggressive) ($M = 0.31$, $SD = 0.21$), Group B (peaceful) ($M = 0.25$, $SD = 0.08$), and Group C (control) ($M = 0.44$, $SD = 0.37$).

3.4. Between-group single-factor ANOVA analysis of TFD in Scenario 1 and Scenario 2

In Scenario 1, the total fixation duration (TFD) of Group A (aggressive) ($M = 8.69$, $SD = 1.42$), Group B (peaceful) ($M = 8.69$, $SD = 2.02$), and Group C (control) ($M = 9.53$, $SD = 1.16$) showed no significant difference ($F = 0.44$, $p > 0.05$). In Scenario 2, the TFD of Group A (aggressive) ($M = 1.69$, $SD = 1.66$), Group B (peaceful) ($M = 1.85$, $SD = 1.19$), and Group C (control) ($M = 3.54$, $SD = 2.34$) also exhibited no significant difference ($F = 1.96$, $p > 0.05$).

3.5. Between-group single-factor ANOVA analysis of FC in Scenario 1 and Scenario 2

In Scenario 1, the fixation count (FC) of Group A (aggressive) ($M = 29.64$, $SD = 9.16$), Group B (peaceful) ($M = 28.63$, $SD = 4.17$), and Group C (control) ($M = 32$, $SD = 10.68$) showed no significant difference ($F = 0.23$, $p > 0.05$). In Scenario 2, the FC of Group A (aggressive) ($M = 5.91$, $SD = 5.24$), Group B (peaceful) ($M = 7.13$, $SD = 2.90$), and Group C (control) ($M = 11.5$, $SD = 7.54$) also exhibited no significant difference ($F = 1.84$, $p > 0.05$).

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3.6. Between-group single-factor ANOVA analysis of FFD in Scenario 1 and Scenario 2

In Scenario 1, the fixation count (FC) of Group A (aggressive) (M = 0.83, *SD* = 0.62), Group B (peaceful) (M = 0.53, *SD* = 0.26), and Group C (control) (M = 1.23, *SD* = 1.51) showed no significant difference ($F = 1.17$, $p > 0.05$). However, in Scenario 2, there is a significant difference ($F = 9.46$, $p < 0.05$) among Group A (aggressive) (M = 0.23, *SD* = 0.12), Group B (peaceful) (M = 0.32, *SD* = 0.17), and Group C (control) (M = 0.58, *SD* = 0.11). Specifically, the first fixation duration (FFD) of Group A is significantly smaller than in the other two groups.

All results are listed in Table 1.

Table 1: TFD, FC and FFD results for Scenario 1 and Scenario 2 in three groups

	TFD		FC		FFD	
	Stimulus 1	Stimulus 2	Stimulus 1	Stimulus 2	Stimulus 1	Stimulus 2
Group A	8.19	1.68	29.64	5.91	0.83	0.23
Group B	8.69	1.85	28.63	7.13	0.53	0.32
Group C	9.53	3.54	32	11.5	1.23	0.58

4. Discussion

The purpose of this study is to explore the impact of different types of audio stimuli on individuals' attention bias towards threatening information. Three types of background sounds were chosen as stimuli: Group A ("aggressive"), Group B ("peaceful"), and Group C ("control" – no sound). Each group of subjects viewed two scenarios, "the forest" and "the street view." Areas containing potential danger or threats in each secnario were considered as AOIs. The comparison of total fixation duration (TFD), fixation count (FC), and first fixation duration (FFD) among each group aimed to reveal any differences in participants' gazing behaviors under different sounds, reflecting their attention bias in response to threatening information.

Through ANOVA analysis of TFD and FC, it can be observed that the three groups receiving different sound stimuli showed no significant differences. However, for FFD in Stimulus 2, Group A had a significantly lower value than the other two groups, indicating avoidance of threatening information under the "aggressive" background sound.

For Stimulus 2, the FFD analysis of the three groups showed that the FFD of Group A was significantly lower than that of the other two groups, suggesting that participants in Group A avoided viewing the stimuli at the first moment. Calvo and Nummenmaa [13] proposed an alert-avoidance pattern based on the "cognitive-motivation" view [14]. They believe that attention is initially oriented towards threatening information and then directed away from it. An alert-avoidance pattern occurs when the information is presented for more than 3000ms [15]. In this experiment, the aggressive audio and scenarios were presented for over 3000ms, reaching the minimum threshold for triggering a threat-avoidance pattern. Although people tend to pay attention to threatening information, fear may cause them to overlook it at first glance. The aggressive audio makes people more alert and sensitive to potential dangers, explaining why participants in Group A had a shorter FFD compared to the other two groups, showing apparent avoidance of threat information.

This phenomenon was not found in Stimulus 1, which depicts "the forest," while Stimulus 2 is "the street view." Stimulus 2 is more closely related to people's daily life, showing an individual on a bike crossing the street with a taxi facing them, stimulating people's "threat alarm" regarding their safety, such as car accidents. In contrast, the forest landscape in Stimulus 1 is less dangerous and less closely related to people's daily lives. Subjects may not easily associate this scenario with threatening information, leading to no observed threat avoidance. This aligns with the conclusions of Zhang Yu [16] and Qiu Xiaowen [17], who suggest that high-intensity threatening information could induce alert-avoidance.

To further enhance this study, future research could increase the number of subjects beyond the current 23, generating more statistically significant results. Additionally, exploring different scenarios and their influences on people's attention bias would provide a more comprehensive understanding of the phenomenon. Different types of scenarios could be investigated to gain insights into the nuances of attention bias in response to threatening information under various contexts. This approach could shed light on how individuals process threatening information in different real-life situations.

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In addition to expanding the participant sample size and exploring different scenarios, further improvements to this study could involve investigating the role of individual differences in shaping attention bias towards threatening information under different audio stimuli. Factors such as personality traits, past experiences, and cultural backgrounds might influence how individuals respond to various sounds and threatening stimuli. By considering these individual differences, researchers could gain a more nuanced understanding of the mechanisms underlying attention bias.

5. Conclusion

In this study, we aimed to investigate the impact of auditory stimuli on people's attention bias towards threatening information. To achieve this, we selected three types of background sounds as stimuli, namely "aggressive," "peaceful," and "no sound." The eye-tracking results provided valuable insights, revealing that participants exhibited a significantly higher first fixation duration towards threatening information in the "aggressive" group compared to the other two background sounds. This finding indicates that the aggressive sound had the effect of making people more alert and sensitive to potential threats and dangers. As a result, it seems to trigger a "threat-avoidance" mode, leading individuals to initially overlook the threatening information presented.

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