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Original Article

Exploratory Study: A Modification Training Method of Attentional Bias Toward Safety

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ABSTRACT

Background: The high sensitivity of individuals toward safety information in production activities, that is, attentional bias toward safety (ABS), can positively predict safe behaviors. It has become a hot topic in current organizational safety behavior research. However, there is no literature on its modification method.

Methods: Based on the modified dot-probe task, we designed a modification training method of ABS. The training method required subjects to respond to the location of detection points that presented after safety stimulus and neutral stimulus pictures. Subjects' attentional bias values of safety and neutral pictures were measured during the experiment. Twenty-one students were selected and divided into a control group and training group to gain comparable results.

Results: A novel training method was developed in this study to promote the efficacy of safety stimulus by activating ABS of the subjects. Moreover, repeated trainings and preacquired relative knowledge can enhance this effect.

Conclusion: This study develops an experimental approach to evaluate the effectiveness of safety education and safety training, and also provides a new research idea for accident prevention.

1. Introduction

Research showed that the risk perception of workers is closely related to their attention allocation and surrounding danger signals [1]. In recent years, with continuous exploration and in-depth study of unsafe behaviors, the attentional bias toward safety (ABS) has aroused extensive concern of more and more scholars in the field of organizational safety behaviors [2–4]. Attention is the orientation and concentration of psychological activities to certain objects. Its selectivity enables individuals to distinguish between important and negligible information in any practical activity, and selective preferential processes valuable information stimuli while suppressing unimportant information. In this way, the selectivity of attention ensures that the individuals can respond quickly to vital messages that appear at any time during an activity, which is called attentional bias [5,6]. Cisler et al proposed the definition of attentional bias in their study [7], that is, individuals assign attention priority or more to the threat stimulus than neutral stimulus. Thus, based on this definition, this paper defined ABS as a phenomenon that individuals have a higher sensitivity to safety stimulus, and have a stronger ability to capture safety information than neutral information on the premise of limited attention resources. Studies showed that if individuals regard safety as a significant intrinsic goal, they will have a higher sensitivity to safety information stimuli, for example, setting safety signs in the workplace, and thus they perform the work safely and spontaneously, that is, individuals have ABS [2–4]. Xu et al [2] pointed out that a higher degree of ABS can make individuals more likely to have proactivity safety behaviors, sequentially effectively avoiding risks. Mei et al [8] pointed out that proactivity safety behaviors can effectively reduce accidents and improve workplace safety. Therefore, it is extremely important to explore a training method to improve ABS.

The intervention strategy of attentional bias, that is, attentional bias modification training (ABM), also known as attention correction procedure, is a systematic operating procedure to change individual original attentional bias through planned training. Macleod et al [9] first used a modified dot-probe task to evaluate one's attentional bias toward threat information, and then proceed

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Table 1
Basic information on subjects

Variable	Training Group	Control Group	t/χ^2 Value	*p*
Age (y), mean ± SD	21.0 ± 1.247	21.0 ± 1.183	0.000	0.762
Female (%)	60	36.4	1.173	0.279
Major related subjects (%)	50	54.5	0.043	0.835

SD, standard deviation.

with attentional bias training. At present, studies on attentional bias training are mostly focused on subjects with post-traumatic stress disorder, depression, and other mental diseases, and the intervention effect of ABM on low self-esteem, anxiety, and substance addiction subjects has been confirmed [10–16]. However, there are few studies focus on the modification of ABS. The research on ABS mainly focuses on the cognitive load of safety signs [17–19].

Therefore, based on previous research, and combined with relevant knowledge in the field of organizational safety behavior, this paper proposed a hypothesis that ABS-modification training could activate and promote the level of individual ABS. This paper used the modified dot-probe task developed by Macleod et al [9] to design the ABS-modification training experiment. The experiment set most of the probe points at the side of safety stimulus to investigate the influence of training on individual ABS. Based on the cognitive psychology and safety behavioral science, this paper is aimed at giving a new scheme to improve employees' proactivity safety behaviors by exploring a training method, so as to prevent accidents.

2. Methods

2.1. ABS-modification training

The ABS-modification training method we developed is based on a modified dot-point task, and the safety information materials we used are real scene photos containing safety signs and other safety measures. This paper first time used dot-point task in psychology to evaluate the individual ABS and to provide direct experimental means to strengthen individual safety sense. The modification training method of ABS can test the effectiveness of safety education and safety training, and timely adjust the employees with low safety awareness. Unlike previous studies, ABS-modification training focus on improving people's proactivity safety behaviors rather than measuring the cognitive loads and features of safety signs and safety images [17,18,20].

2.2. Participants

The experiment screened 30 participants among 121 senior and graduate students majoring in safety engineering or civil engineering. Thirty college students were selected based on their construction site internship experience, which should be last at least a year. Nine of them were excluded from the experiment as they responded less than 150 ms with more than 20 incorrect answers in 50 advance practice trials, and 21 students were remained to take part in the formal examination. The final participants' ages ranged from 19 to 24 years, the average age is 21.0 ± 1.183 years. Their naked eye vision or corrected vision is normal, all right hand, no color blindness or color weakness, no history of mental illness. None of the participants had taken part in a similar experiment before. Before the experiment, the students were informed of the requirements, and they volunteered to participate in it.

This paper is aimed at conducting an ABS-modified experiment toward safety pictures stimulus. Considering the balance of age, gender, and major, the participants were divided into two groups, with 11 in the control group and 10 in the attentional bias training group. See Table 1 for the comparison of basic conditions between the two groups.

2.3. Equipment and materials

The experiment was programmed by the Experimenter's Prime (best) 2.0 (E-prime, Psychology Software Tools, USA) and the stimulus was presented on the 15.6-inch color LED display of Lenovo ideapad320 computer. The screen background is black, the resolution is 1,920 × 1,080 pixels, and the refresh rate is 60 Hz.

Examples of safety stimulus pictures and neutral pictures used in the experiment are shown in Fig. 1.

A total of 120 images, 270 × 400 pixels in size, were used in the experiment after color removal process by Adobe Photoshop CC version 19.1.9 (Adobe Systems Incorporated, USA). Sixty pictures are safety information stimulus, which contains safety signs, protective facilities, and other safety factors, selected from a real scene. The rest of the images are neutral stimulus, which have been selected from China Geographic Magazine.

2.4. Procedure

The experiment adopted a 2 × 2 two-factor mixed design, specifically 2 (Group: attentional bias training group, control group) × 2 (Stimulus images: safety information pictures, neutral pictures). The group is the intersubject variable, the stimulus picture is the intrasubject variable, and the response time to the target stimulus is the dependent variable. The experiment required both the training and control groups to complete the pre-test task, training task, and the post-test task successively.

Emmelkamp, Macleod and Clarke [21,22] found the inconsistencies of attentional bias effect after a meta-analysis of the research on attentional bias training. Therefore, to further investigate the activation and promotion effect of ABS-modified training

(A) **(B)**

Fig. 1. Examples of safety stimulus images (**A**) and neutral stimulus images (**B**).

on the effect of ABS, the training frequency was taken as a factor influencing the training effect in this paper. Therefore, participants in the attentional bias training group were randomly divided into training group 1 and training group 2, with five people in each group. Group 1 proceeded with the attentional bias training for four times, with a duration of 1 week. The interval between the fourth training task and the post-test task was 24 hours. In training group 2, the attention bias training task was halved. During the experiment, the subjects were asked to perform a separate experiment, focusing on a computer screen and responding to stimulus through a standard keyboard. The distance between the eyes and the center of the computer screen was about 70 cm.

The experiment was carried out 100 times within two groups, each of which had 50 trials. In the experiment, all stimulus materials were presented twice. In 80% of the experiments, a safety stimulus picture and a neutral stimulus picture were presented. To offset the individuals' practice effect and expectation effect, in the remaining 20% of the experiments, two neutral pictures were presented.

In the experiment, the fixation point "+" was firstly presented on the screen for 500 ms, and then two stimulus images were presented on the left and right sides of the screen for 500 ms, respectively. After the image disappeared, the detection point "*" randomly appeared in the position where the picture was previously presented. Participants were required to press "F" when the detection point was on the left side, and "J" when the detection point was on the right side. In the pre-test and post-test tasks, the detection points were likely to be found in both neutral and safety stimulus with an equal probability. During the training task, when the training group was presented with a safety-neutral stimulus pair, the position of the detection points always appeared on the side where the safety information stimulus was presented. When a neutral stimulus pair was present, the detection point appeared randomly, with a balance of left and right. In the control group, the probability of detection points appearing in the position of safety information stimulus and the neutral stimulus was equal, and the training task was carried out four times in a week. The single flow of the experiment is shown in Fig. 2.

3. Results

The data of this study were processed and analyzed by Statistical Product and Service Solutions 22.0 (SPSS, International Business Machines Corporation, USA). Using the analysis methods, for example, one-way analysis of variance (ANOVA) and repeated measures ANOVA in SPSS software, to explore the significant analysis of the interaction of experimental influence factors and their main effects of ABS-modified training, and to provide statistical data support for the study.

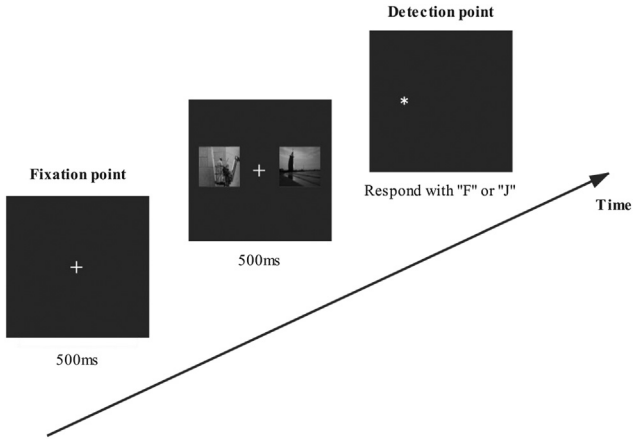

Fig. 2. Single flow chart of the experiment.

First, the experimental data were preprocessed according to the study of Fox et al [23], and 4,120 experimental data were retained, accounting for 98.1% of the total. In this paper, the attentional bias value is defined as below: the response time of the safety information stimulus minus the response time of the neutral stimulus. The experimental data of the attentional bias training pre-test and post-test were processed, the descriptive statistics of the two groups of safety attention-biased scores are shown in Table 2.

The attentional bias value is the difference value of reaction time between safety stimulus and neutral stimulus. The smaller it is, the more attention the subjects transfer to safety information. Table 2 showed that participants in the control group had less attentional bias value in both pre-test and post-test, and the subjects in training group also had similar performance in the pre-test. Only the participants in the training group have large attentional bias values. Furthermore, two-way ANOVA analysis of the data 2 (Group: training group, control group) × 2 (Measurement order: pre-test, post-test), which showed that the main effect of measurement order was very significant, $F = 28.416$, $p < 0.01$; the main effect of group was not significant, $F = 1.306$, $p > 0.05$; the interaction between group and measurement order was significant, $F = 3.885$, $p < 0.05$. The simple effect analysis of group and measurement order showed that the average difference of the post-test response time between the training and control groups was significant at the level of 0.05, and the post-test response time of the training group was less than that of the control group.

These results clearly showed that the attentional bias value in pre-test and post-test has changed in both groups. In the training group, a notable difference in ABS score can be seen in pre-test and post-test, indicating that more attention was paid to safety stimulus after the training task. Similar changes are also observed in the control group, with relatively smaller deviation. Therefore, it is evident that the attentional bias training tasks toward safety have improved subjects' attention to safety information.

To further explore the factors that may affect attentional bias training effects, the average response time to safety stimulus in pre-test and post-test between participants from related and unrelated backgrounds was compared. The results are shown in Table 3.

Table 3 illustrated that the reaction time of different major participants in the training group to safety stimulus were all reduced to a certain extent. The professional-unrelated participants had a quicker response in the post-test than the pre-test, and the difference was greater than that in professional-related participants. Furthermore, ANOVA analysis of the data 2 (Major type: correlated, unrelated) × 2 (Group: training group, control group) × 2 (Measurement order: pre-test, post-test) was carried out. The results showed that the interaction between major type and measurement order was extremely significant, $F = 18.067$, $p < 0.01$. The simple effect analysis of the major type and measurement order also showed that the average response time of pre-test and post-test of different professional participants was significantly different, and the post-test response time of major-unrelated participants was uncommonly lower than that of the major correlated participant. In conclusion, it is noted that the ABS training task is affected by the

Table 2
The statistical description of scores of ABS in the training and control groups

	Training Group	Control Group
Pre-test attentional bias value	1.57 ± 6.36	0.01 ± 64.50
Post-test attentional bias value	−13.60 ± 141.65	5.63 ± 39.95

*The figure before "±" sign is the mean value of the attentional bias value and the figure after "±" sign is the standard deviation.

Table 3
The mean value of safety stimulus-response time (ms) measured in pre-test and post-test of different major participants in the training group

Major types	Pre-test reaction time	Post-test reaction time	Difference value
Related	382.00	374.60	7.40
Unrelated	405.13	365.56	39.57

individual professional type, and participants with unrelated major types have better training effects.

Finally, to explore the influence of training times on the training effect of attentional bias training task toward safety, the data of post-test response time of participants with different training frequency in the training group was processed. Descriptive statistics of post-test attention-biased scores of subjects in different training groups and major types are shown in Table 4.

Table 4 showed that for major correlated participants, the increase in the training frequency could promote the individual ABS. However, for professional-unrelated participants, when the training was twice a week, the individual ABS is significant, when the number increased to four times a week, the individual showed an attentional bias toward neutral information and its safety attention-biased scores below that values in the pre-test in the training group. The reaction time to safety stimulus (371.47 ms) is longer than the mean values of major irrelevant participants in the training group (365.56 ms). Based on the researches [24,25], it is speculated in this paper that when the training times reach four times a week, participants with irrelevant professional types may have attention avoidance toward safety information.

Koster et al [24] pointed out that the individual had a shorter response time to the detection points on the same side of the target stimulus and a longer response to the detection points on the other side, which resulted in a consistency effect. However, if the participant responded more slowly to the ipsilateral detection point of the target stimulus and the reaction of the opposite side detection point was faster, the participant was considered to have an attentional avoidance toward the target stimulus. Therefore, consistent response time and inconsistent response time of the participants were analyzed to investigate whether the major-unrelated participants in training group 1 had ABS. The results showed that the inconsistent response time of the participants (358.35 ms) was shorter than that of the consistent response time (371.47 ms), that is, when the training frequency reached four times a week, the participants appeared to have an attention avoidance of safety information.

Further analyzed the data of 2 (Training Group: training group 1, training group 2) $\times$ 2 (Major type: correlated, unrelated) $\times$ 2 (Measurement order: pre-test, post-test) using three-factor ANOVA, the results showed that the measurement order main effect was significant, $F = 5.244$, $p < 0.05$, the interaction between major type and measuring order was notable, $F = 11.419$, $p < 0.01$, the interaction between training group and major type was also significant, $F = 5.957$, $p < 0.05$.

In conclusion, the modification training method of ABS we developed in this paper could activate and improve individual ABS level. The major-related individual had a better training effect, which was also positively correlated with the training frequency. For the major-unrelated individual, the training effect was obvious when the training task was conducted twice a week; when the training task frequency reached four times a week, the major-unrelated individual had an attention avoidance. Therefore, the modification training method of ABS can be an available method aimed at safety education and safety training in enterprises. With a reasonable frequency of training task, it could have a positive impact on reducing unsafe behaviors of employees and preventing accidents.

Table 4
The statistical description of scores of ABS in post-test of different majors and groups in the training group

		Training Group 1 reaction	Training Group 2 reaction
Major types	Related	-58.24 ± 142.61	-19.82 ± 279.7535
	Unrelated	7.91 ± 3.76	-8.00 ± 34.36

*Training group 1 refers to the group that completed four times of attentional bias training tasks in 1 week. Training group 2 was the group that completed two attentional bias training tasks in 1 week.

4. Discussion

4.1. Main findings

This study designed an experiment and developed a modification training method of ABS to explore the adjustment method of ABS, and concluded that the training method could activate the ABS of individual, and the effect of that training method toward safety is comprehensively influenced by the individual major type and training frequency. The specific performance is that there was a significant difference between the training results of individual majoring in safety engineering-related subjects in pre-test and post-test, and the training results were more significant with the increase of training times. The training effect of individuals whose major is unrelated to safety engineering was affected by the number of training times. The individual has an attention avoidance of safety when the training times are more, which may due to the difference between the samples, or the promotion effect of the attentional bias training is conditional [26]. The internal mechanism of ABM remains to be further studied [27,28]. However, the experimental results obtained in this paper preliminarily confirm the effectiveness of attentional bias training in improving individual ABS.

The effect of modification training is affected by the major type and the number of training times. For individuals who have participated in safety education and training before, the training effect is more significant. Moreover, when the training frequency is four times a week, the values of individual ABS is more than three times that of the training times twice a week. For individuals who have not been exposed to system safety education and training, attentional bias training can instantly activate one's ABS. The results show that the modification training method of ABS is effective and simultaneous in activating and regulating the ABS. Moreover, Zhao et al [11] noted that the effect of attentional bias training would gradually become more significant over time. Therefore, based on this result, this study concluded that the modification training of ABS is highly likely that the training effect will be more obvious over time. The method we developed can be used as an economical and practical training means in safety education and training.

4.2. Theoretical and practical significance

The study of the training method of ABS is of great theoretical significance to establish and perfect safety education and training system and reduce unsafe behavior. Through the exploration of the modification training method of ABS, it is confirmed that the individual ABS can be adjusted by carrying out the planned attentional bias training. Moreover, a reasonable number of training can make individual attention turn from neutral stimulation to safety stimulation. The results further enriching and developing the cognitive theory in the field of safety. This paper investigated the activation and promotion mode of ABS, to provide a psychological

basis for enterprise safety education and training. The research results will promote the study of safety psychology and behavioral science in the future, and enhance the importance of safety psychology in enterprises, and thus promote the establishment and improvement of safety education and training system.

This study also provided insights into safety education and training and safety management practice in enterprises. The modification training method of ABS can be used to train and examine the sensitivity of employees to safety information, and to investigate the effectiveness of safety information, for example, safety signs. The intervention cost of this approach is low and is not restricted by the industry type, which can be used by various enterprises to improve safety management and safety performance. Furthermore, the measurement results of ABS training can provide abundant feedback for enterprise leaders, safety management personnel and employees, so as to ensure the rational formulation of enterprise safety policies and the effective implementation of enterprise safety management.

4.3. Deficiencies and future research directions

Although this paper explores a corrective training approach of ABS from the perspective of cognitive behavior and obtains some exploratory results, there are still some shortcomings in this study. The experimental results may be affected because of the heterogeneity of samples. Moreover, this paper cannot be ruled out to have a certain effect of practice due to the experimental materials used in the pre-test and post-test of training task are the same.

Therefore, given to the limitation of this paper, researchers can consider a better controlled subjective sampling and more abundant experimental materials in future efforts. Furthermore, further research directions are to combine with tools such as eye trackers and other apparatus to deeply explore the modification training method of ABS and its intrinsic mechanisms.

5. Conclusions

This study conducted an exploratory experiment on modification training method of ABS. The main conclusions are as follows:

ABS-modification training could activate and improve one's attention to safety information, and the effect of this training approach is influenced by the individuals' educational background and the training frequency. The individual major is correlated with safety engineering; the training result is more significant and positively correlated with the number of training rates; the individual with unrelated major may have attention avoidance. Based on the results, it is relatively appropriate when training twice a week. The modification training method of ABS can be as a low-cost and practical means in enterprise safety education in the future. It can enhance the sensitivity of employees toward safety information and reduce the occurrence of unsafe behaviors, which has certain practical significance.

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Conflicts of interest

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the position presented in, or the review of, the manuscript entitled, "Exploratory study: a modification training method of attentional bias toward safety".

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