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ORIGINAL RESEARCH

Emotional Recognition Training Enhances Attention to Emotional Stimuli Among Male Juvenile Delinquents

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Objective: Juvenile delinquents have deficits in emotional recognition that might play a critical role in the development of aggression. The present study aimed to investigate the effect of emotional recognition training and its consequences on emotional attention and aggression.

Methods: Seventy-three male juvenile delinquents were randomly assigned to two groups. One group was the modification group, which received eight days of training on an emotional recognition task. The purpose of the training was to modify interpretative biases in emotion recognition to encourage the perception of happiness over anger in ambiguous expressions. The other group was the waitlist group, which did not perform a task and continued with their usual programme. Before and after the training, participants completed the aggression questionnaire (AQ) and two behavioural tasks, including the emotional recognition task and a visual search task with happy and angry faces as targets.

Results: The modification group recognized more faces as happy after emotional recognition training than the waitlist group. Furthermore, the hostility in the modification group decreased significantly. Importantly, emotional recognition training further affected attention to emotional faces as participants responded faster in searching for happy and angry faces after training.

Conclusion: Emotional recognition training could modify juvenile delinquents' emotional recognition, enhance their visual attention to emotional faces and reduce hostility.

Keywords: emotional recognition training, juvenile delinquents, emotional attention, aggression

Introduction

Defects in emotional cognition are closely associated with mental health. For example, previous studies have revealed that individuals with anxiety or depressive disorder have deficits in recognizing facial emotions.[1–3] Juvenile delinquents, as a population with aggressive problems, also have defects in emotional cognition. For example, studies have revealed that both juvenile delinquents and adult offenders exhibit deficits in recognizing emotional faces, including happy, angry, fearful, sad, disgusted, and surprised faces.[4,5] These emotion cognition deficits may contribute to the high aggression level among juvenile delinquents, which may be explained by social information processing theory. According to this theory,[6–8] behavioural responses to social situations are the result of a series of social information processing steps. The first step of social information processing is to encode the sensory input of social information such as facial emotions and selective attention to social cues. Next, individuals interpret the social information and store the interpretation in their memory by creating mental representations. For example, an individual sees an angry face and interprets it as hostility towards him or her. This interpretation is then stored in the memory. Different mental representations can elicit different behavioural and affective responses, which is called response accessing. For example, interpreting another individual's angry face as hostility may induce reactions such as anger and aggression. However, accessed responses are not necessarily enacted in behaviour. Finally, individuals need to evaluate and make decisions based on laws, social rules,

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morals, and anticipated outcomes through the fourth step of response evaluation. In the framework of this theory, juvenile delinquents have biased recognition of facial emotions. For example, they misidentify disgust as anger more frequently than controls.[9] As a result, they tend to interpret ambiguous facial expressions in a negative or hostile way, which in turn may lead to aggressive acts in response to the current social situation. Therefore, aggression may be increased by bias or deficiencies in processing social information such as hostile cues or emotional cues.

Cognitive bias modification targeting selective interpretation (CBM-I) procedures can change an individual's negative interpretation bias by inducing more positive interpretations through feedback training when ambiguous information is presented.[10] Emotional recognition training based on CBM-I aims to change the recognition and interpretation of facial expressions. Previous studies have revealed that emotional recognition training reduced negative interpretation bias towards sad faces[11,12] and increased neural activation towards happy faces in the medial prefrontal cortex and bilateral amygdala,[13] supporting the efficacy of the training programme in biasing emotional cognitive processing. However, the consequences of the change in emotional recognition on behaviours are still unclear. Penton-Voak et al[14] trained antisocial individuals to recognize angry faces as happy ones and found that the training reduced their state anger and aggressive behaviour. Similarly, Wells et al[15] trained children with severe problem behaviours to improve their ability to recognize sad, fearful, angry, and neutral expressions and found that their behavioural problems subsequently decreased. In contrast, some studies have found that emotional recognition training had no evident effects on irritability symptoms[16] as well as state anger, aggression, and hostile attribution assessed in a game context.[17] The mixed results in previous studies suggest that emotional recognition training may affect behaviour indirectly. As social information processing theory proposes, emotional recognition bias is the first stage in aggression development. Many other factors may affect behavioural responses to emotional cues, for example, self-control ability. Therefore, to further elucidate the mechanism and consequences of emotional recognition training, in the present study, we adopted a training procedure similar to that of Penton-Voak et al[14] to bias participants' recognition of angry faces. Juvenile delinquents were the target population as their behavioural problems are evident. To examine aggression more comprehensively, physical aggression, verbal aggression, hostility and anger were measured before and after training.

A critical question of emotional recognition training is whether the training can alter the perceptual and attentional processing of emotional stimuli. According to the combined cognitive bias hypothesis, cognitive biases (eg, interpretive bias, attentional bias, memory bias) may act collectively to develop and maintain the symptoms of emotional disorders.[18] Evidence has shown that attentional bias may be associated with interpretive bias.[19–21] However, the causal relationship between these cognitive biases is still unknown. It was found that a single session of interpretive bias training could change the attentional bias of college students to adaptive cues that would help disambiguate the situation.[22] In addition, socially anxious individuals disengaged their attention from threatening stimuli more quickly after interpretation modification training.[23] These results suggest that the change in interpretive bias affects attentional bias. However, other studies have found that attentional bias training can increase positive interpretive bias, but interpretive bias training cannot cause significant alterations in attentional bias.[24,25] To settle this argument, we examined the effect of emotional recognition training on emotional attention. We adopt the visual search paradigm to examine visual attention to emotional stimuli. This paradigm is widely used in emotional attention studies.[26–32] Furthermore, one of the reasons for the less obvious change in emotional attention may be the insufficient dose of training. For example, participants received only 180 training trials in Penton-Voak et al's study.[14] To rule out this possibility, we trained participants with 480 trials in eight daily sessions.

To summarize, the present study trained male juvenile delinquents with an emotional recognition task to bias their interpretation of ambiguously angry faces as happy faces. Before and after the training, different forms of aggression were assessed to reveal the behavioural consequences of the training. Furthermore, the effect of training on visual attention to emotional faces was also examined. The findings of the present study can not only advance our understanding of the mechanism underlying emotional recognition training but also shed light on the development of efficient interventions for aggressive problems.

Materials and Methods

Participants

Eighty male adolescent delinquents who had severe conduct problems were recruited from three reform schools in Guizhou Province, China. They were randomly assigned to a modification group that received emotional recognition training during the study and a waitlist group that received the same training programme after the study. Each group contained forty participants. All participants were right-handed, and their vision or corrected vision was normal. Their ages ranged from 12 to 16. Exclusion criteria included a history of mental illness or a family member's history of mental illness. This study was approved by the Ethical Committee of Human Research at Zunyi Medical University and was in accordance with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Written informed consent was given by all adolescents and their legal guardians.

We performed a power analysis to determine the sample size using G-Power 3.1.9.7 software.[33] To find a significant interaction effect between the test phase and group, at the level of η_p^2= 0.1, α =0.05, power=0.95, the required total sample size was 22. We recruited 40 participants for both groups, resulting in a total sample size of 80. Four participants in the modification group and three participants in the waitlist group quit the experiment because of the termination of the study in the reform schools. As a result, the analyses were based on data from 36 participants in the modification group and 37 participants in the waitlist group. No significant difference in age was found between the modification group (M=15.03, SD=0.77) and the waitlist group (M=14.81, SD=0.97) (t(71)=1.06, p=0.294).

Questionnaire

At the pre-training and post-training sessions, all participants completed the aggression questionnaire (AQ).[34] This 29-item scale can be used to assess aggression and consists of four factors: physical aggression, verbal aggression, anger, and hostility. Participants rate each item on a Likert scale from 1=extremely uncharacteristic of me to 5=extremely characteristic of me. The higher the total score, the higher aggression is.

Emotional Recognition Training

Stimuli

The experimental stimuli were selected from the Chinese Facial Affective Picture System (CFAPS).[35] For each emotional category (happy and angry), two male and two female faces were selected as the prototypical faces. All pictures were greyscaled, and an oval mask was used to remove nonfacial features (eg, hair, neck, ears) from each face. All the images were cropped into a uniform size (370×400 pixels), and the brightness and contrast were matched.

Similar to the method of Penton-Voak et al,[14] we used the prototypical happy face and the prototypical angry face from the same person to generate a linear morph sequence through WinMorph 3.01. Each emotional continuum consisted of 15 equally spaced face images with two prototypical faces as the endpoints (Figure 1A). A total of 4 continua were generated.

Procedure

Participants sat in a quiet room during the experiment while visual stimuli were presented on a 17-inch liquid crystal display on a Lenovo desktop with a resolution of 1600×900 and a refresh rate of 60 Hz.[36] The computer screen was placed 60 cm in front of the participants.

All the participants first completed an emotional recognition task to measure their baseline performance. As Figure 1B illustrates, each trial began with a fixation cross presented for 500~1500 ms. A face in one of the continua was then presented at the centre of the screen for 150 ms, followed by a 150 ms noise mask. Participants were instructed to make a 2-alternative forced choice with two keys. When they judged the face as a happy face, they pressed one key; otherwise, they pressed the other key. Each session contained 60 trials of emotional judgement. The 60 faces in the four happy-angry continua were pseudorandomly presented with each face appearing only once. The response key was counterbalanced across participants. A balance point could be estimated based on the responses for each emotional continuum. According to Penton-Voak et al,[14] the balance point of a continuum is the number of "happy" responses as a proportion of the total number of trials. For example, if a participant judged 40% of the faces in the "happy-angry"

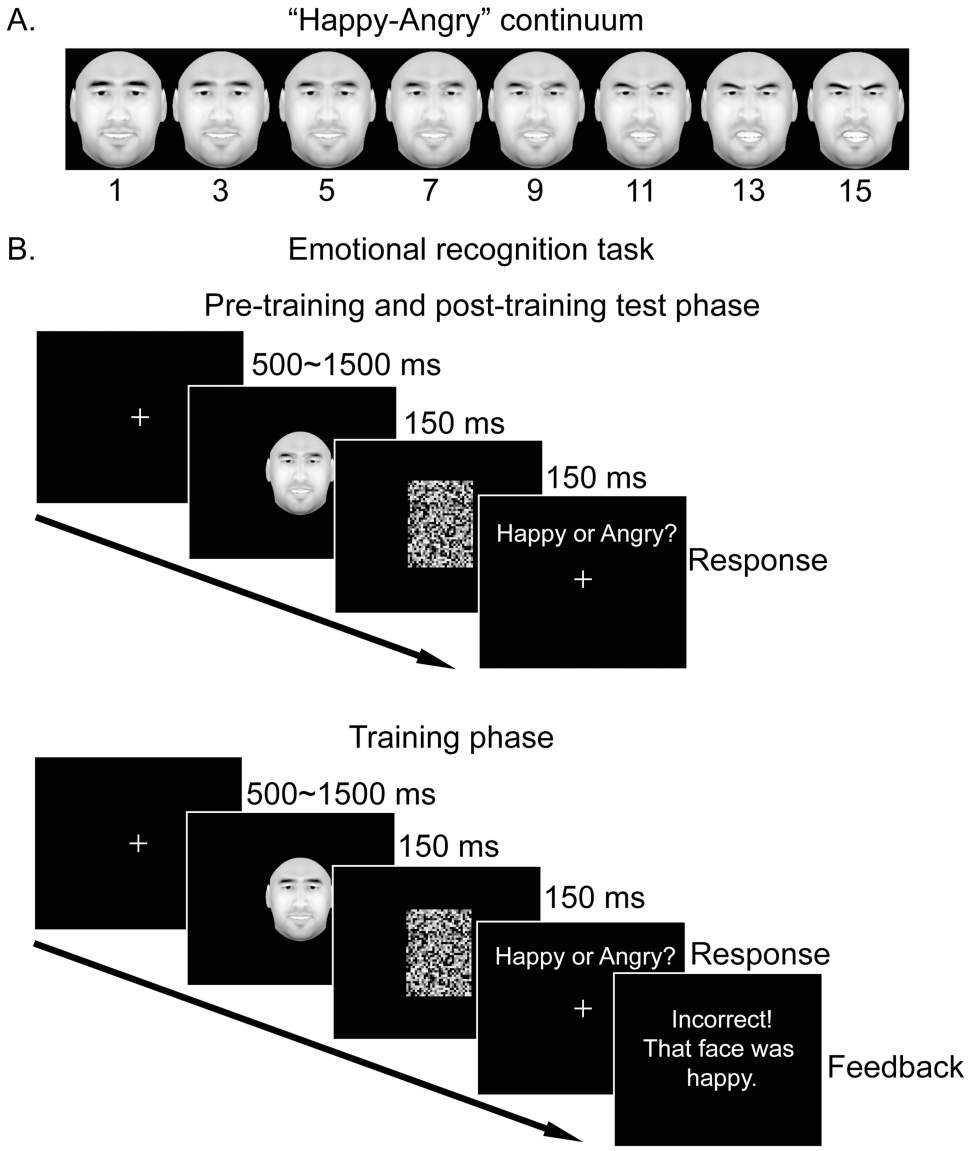

Figure 1 Stimuli and procedure of the emotional recognition task. **(A)** A demonstration of a "happy-angry" continuum. The prototypical happy face and the prototypical angry face from the same identity are the endpoints of the continuum. Fifteen equally spaced face images are generated. **(B)** The procedure of the emotional recognition task. The upper one demonstrates a typical trial in the pre-training and post-training test phases. No feedback is provided. The lower one demonstrates a typical trial in the training phase. Feedback is provided after the participant's response.

continuum as "happy", the balance point should be 0.4 for this participant. The balance point image could then be determined correspondingly in the continuum, which represents the image in which the participant was equally likely to perceive happiness or anger. The higher the balance point, the angrier the balance point image, indicating that the participant judged angrier faces as happy.

After the baseline measurement, the modification group was trained with a modified version of the emotional recognition task for eight days. In the training phase, the task was similar to that in the pre-training measurement, except that a feedback screen was added at the end of each trial. The feedback criterion was set at the image of two units biased to anger from the balance point image of each participant. For example, if the balance point image in the "happy-angry" continuum was the 7.5th angry image (ie, the 7.5th happy image), the criterion was set at the 5.5th angry image (ie, the 9.5th happy image). Happy responses to happier faces and angry responses to angrier faces compared with the criterion were correct responses, and the feedback of "correct" was presented. Otherwise, when the participant made an incorrect response, the feedback of "incorrect, that face was happy/angry" was presented. By this procedure, faces

recognized as angry at baseline (eg, 6th and 7th faces in the continuum) were classified as "happy", and the recognition of emotions in these faces was modified accordingly. On each day of the training session, participants completed the same number of tasks as in the baseline measurement. Each participant was trained for eight days. Participants in the waitlist group received no training task.

At the post-training session, all participants completed the tasks the same as the pre-training session, ie, the emotional recognition task with no feedback.

Visual Search Task

At the pre-training and post-training sessions, all participants completed the visual search task for facial emotions.

Stimuli

The experimental stimuli were selected from the Chinese Affective Picture System (CAPS). Search targets included 16 happy and 16 angry faces, half of which were female faces. Fifty-eight neutral faces (29 female faces) were selected as distractors. All pictures were preprocessed the same way as those in the emotional recognition experiment. Independent-samples *t*-tests showed that the valence of happy faces (M=6.75, SD=0.51) was significantly higher than that of angry faces (M=2.62, SD=0.40) ($t(30)=-25.56$, $p<0.001$). Moreover, no significant difference in arousal was found ($t(30)=1.58$, $p=0.124$) (M(SD): happy 5.71(1.11), angry 6.44(1.47)).

Procedure

As Figure 2 illustrates, each trial of the task began with a white fixation cross presented in the centre of the black screen for a random period of 500~1500 ms. Subsequently, an array of 8 faces appeared until a response was made. Participants were asked to press one key (F) as quickly and accurately as possible if they found the target (a happy or angry face) among the distractors (neutral faces) and another key (J) if they did not find the target. After the response, a blank screen was presented for 500 ms. In total, 2 blocks consisting of 96 trials were included in this experiment. In each block, the target emotion was fixed. Thirty-two out of 48 trials in each block contained a target, while the other 16 trials did not. The order of the 2 blocks was randomized across participants.

Design and Analysis

To compare the pre- and post-training performance of emotional recognition, a 2 (test phase: pre-training and post-training) × 2 (group: modification and waitlist) mixed design ANOVA was conducted on the balance point. To further

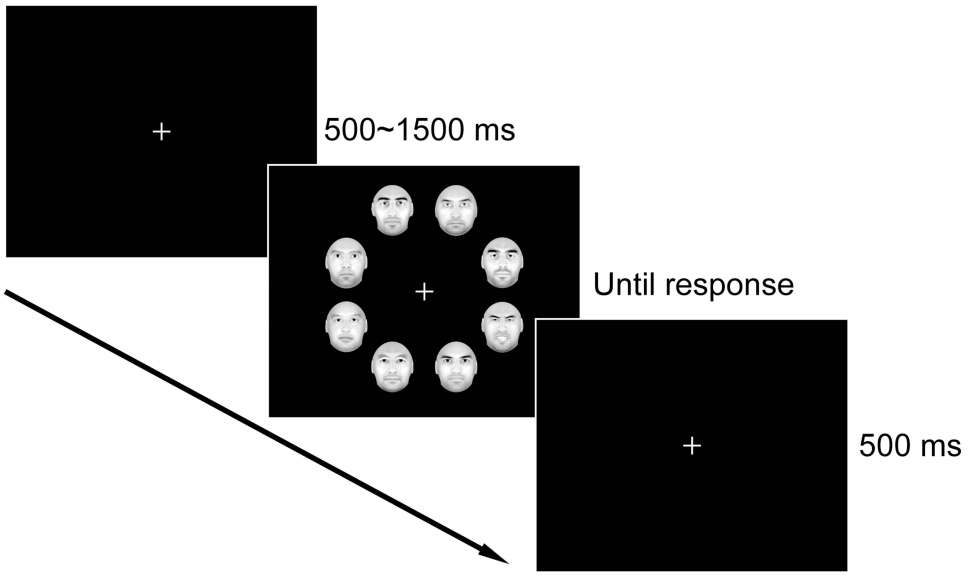

Figure 2 The procedure of the visual search task. Participants are required to search for a happy or angry face among 7 neutral distractors.

investigate the change in balance points during the training phase, a one-way ANOVA was conducted for the modification group.

To compare the level of aggression before and after training, 2 (test phase: pre-training and post-training) × 2 (group: modification and waitlist) mixed design ANOVAs were conducted on the AQ scores.

Regarding the visual search experiment, we first excluded outliers of trials defined as RTs outside M±3SD. Then, 2 (facial emotion: happy and angry) ×2 (test phase: pre-training and post-training) × 2 (group: modification and waitlist) mixed-design ANOVAs were conducted on the accuracy rate and reaction time (RT).

Results

Emotional Recognition Training

The change in balance points is demonstrated in Figure 3. A 2 (test phase: pre-training and post-training) × 2 (group: modification and waitlist) mixed design ANOVA was conducted on the balance point. A significant interaction effect was found ($F(1,71)=25.97$, $p<0.001$, $\eta_p^2=0.268$). A simple effect analysis indicated that there was significant improvement in the balance point for the modification group ($p<0.001$, Bonferroni corrected) but not for the waitlist group ($p>0.05$, Bonferroni corrected). To further investigate the change in balance points during the training phase, we conducted a one-way ANOVA based on the points from Day 2 to Day 9. The results showed that there was no significant main effect of test phase ($F(7,245)=1.49$, $p=0.170$, $\eta_p^2=0.041$), indicating that balance points changed little during the training phase. A paired sample *t*-test on the points between Day 1 and Day 2 indicated that significant improvement occurred on the first day of training ($t(35)=2.94$, $p=0.006$). These results suggest that only a small amount of training may substantially change emotional recognition.

Aggression

A 2 (test phase: pre-training and post-training) × 2 (group: modification and waitlist) mixed design ANOVA was conducted on each dimensional score as well as the total score of the AQ. The scores are presented in Table 1. The interaction effect was found only on the hostility dimension ($F(1,71)=8.50$, $p=0.005$, $\eta_p^2=0.107$). A simple effect analysis indicated that hostility decreased after training for the modification group ($p<0.001$, Bonferroni corrected) but not for the waitlist group ($p>0.05$, Bonferroni corrected). For other dimensions and the total score, the interaction effects and main effects were nonsignificant (all $p>0.05$).

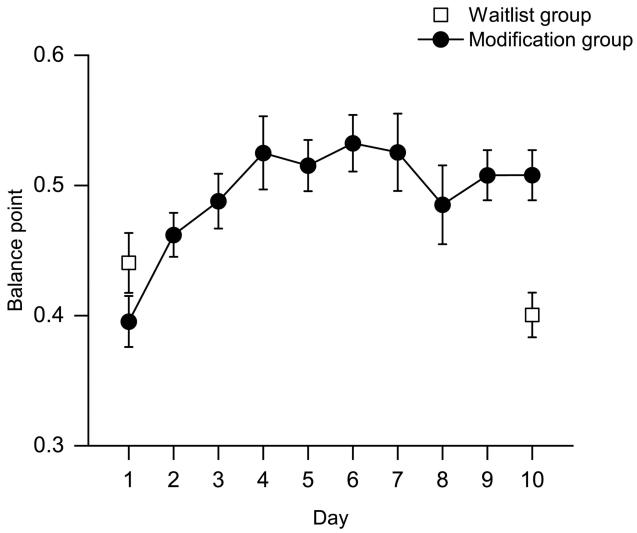

Figure 3 Results from the emotional recognition experiment. Day 1 and Day 10 are pre-training and post-training tests, respectively, while Day 2 to Day 9 is the eight-day training phase. A higher balance point indicates a higher proportion of happy responses in recognizing a face continuum. The error bar denotes 1 standard error of the mean.

Table 1 The Scores of the Aggression Questionnaire (AQ): Mean(SD)

	Modification Group (N=36)		Waitlist Group (N=37)	
	Pre-Training	**Post-Training**	**Pre-Training**	**Post-Training**
Physical aggression	19.11(4.79)	17.94(3.92)	17.97(4.44)	17.76(5.24)
Verbal aggression	14.31(3.28)	14.42(3.39)	14.76(4.17)	14.22(4.76)
Anger	13.69(4.17)	13.97(3.38)	14.24(3.74)	13.73(4.60)
Hostility	14.61(2.69)	12.14(2.86)	13.59(2.40)	13.27(3.64)
Total score	61.72(11.48)	58.47(9.41)	60.57(10.24)	58.97(15.59)

Visual Search Experiment

Accuracy Results

The accuracies are presented in Table S1. A 2 (facial emotion: happy and angry) × 2 (test phase: pre-training and post-training) × 2 (group: modification and waitlist) mixed-design ANOVA showed that there were no significant interaction effects among the three factors or between any two factors (all p>0.05). There was a significant main effect of facial emotion ($F(1,71)=116.76$, $p<0.001$, $\eta_p^2=0.622$), indicating that the search accuracy was higher for the happy face. Other main effects were nonsignificant (all p>0.05).

Reaction Time Results

The RTs are presented in Table S2. First, a 2 (facial emotion: happy and angry) × 2 (test phase: pre-training and post-training) × 2 (group: modification and waitlist) mixed design ANOVA was conducted on the RT. The interaction effect among the three factors was significant ($F(1,71)=7.74$, $p=0.007$, $\eta_p^2=0.098$), suggesting that training may affect the relationship between facial emotion and the test phase. Therefore, we conducted two 2 (facial emotion: happy and angry) × 2 (test phase: pre-training and post-training) ANOVAs separately for the two groups.

For the modification group (Figure 4A), the interaction effect between facial emotion and test phase was significant ($F(1,35)=30.16$, $p<0.001$, $\eta_p^2=0.463$). Simple effect analyses revealed that 1) RTs were shortened by training for both facial emotions (both $p<0.05$, Bonferroni corrected) and 2) the RT was shorter for happy faces than for angry faces before training ($p<0.05$, Bonferroni corrected), while the difference became nonsignificant after training ($p>0.05$). These results indicated that the improvement in the RT was larger for angry faces than for happy faces.

For the waitlist group (Figure 4B), there was no interaction effect between facial emotion and test phase ($F(1,36)=1.59$, $p=0.216$, $\eta_p^2=0.042$). The main effect of test phase was nonsignificant ($F(1,36)=2.71$, $p=0.109$, $\eta_p^2=0.070$), indicating no changes in the RTs. The main effect of facial emotion was significant ($F(1,36)=52.45$, $p<0.001$, $\eta_p^2=0.593$), indicating that participants responded faster to happy faces than to angry faces.

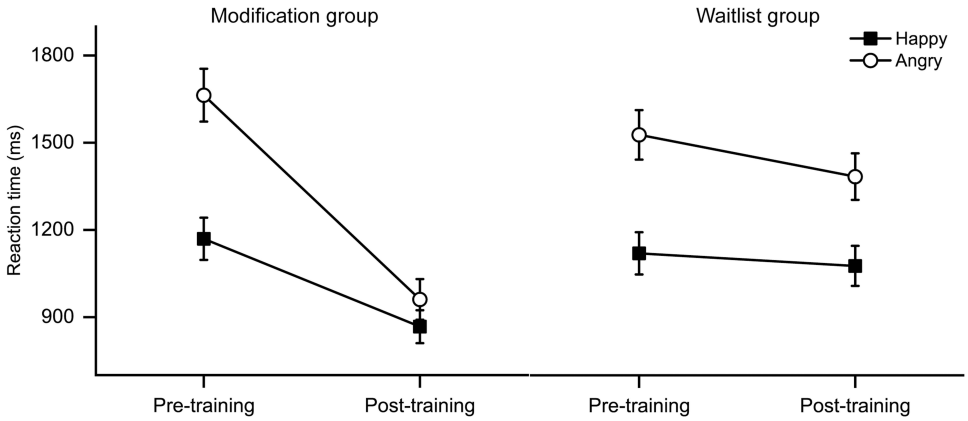

Figure 4 RT results from the visual search experiment. The left panel demonstrates the results from the modification group, while the right panel demonstrates the results from the waitlist group. The error bar denotes 1 standard error of the mean.

Discussion

In the present study, we trained male juvenile delinquents with a modified version of emotional recognition training that was shown to be effective in reducing the hostile interpretive bias of ambiguous angry faces.[14] Our results showed the training effect on emotional recognition and revealed the training-induced reduction in the hostility of the participants, although the overall aggression level was not significantly altered. Furthermore, we found that the training may enhance visual attention to emotional faces by shortening reaction times in searching for both happy and angry faces. These results suggest that hostility and emotional attention could be affected by emotional recognition training, indicating a common mechanism of emotional cognition and the important role of emotional recognition in the development of aggression.

The emotional recognition training developed by Penton-Voak et al[14] is impressive as only four sessions with 180 trials of training could induce large changes in emotional recognition and aggressive behaviours. It would be interesting to investigate whether the training effect increases with the amount of training and how fast the training saturates. Another study with the same procedure as Penton-Voak et al also showed the efficiency of four sessions of training and found that the effect remained two weeks later.[14,17] Similar results were also found in a study that adopted a one-week training procedure, which revealed that the training effect remained six weeks later.[37] In addition to angry faces, a study on sad and fearful faces found that two or three sessions of training could bias the recognition of negative faces to positive faces.[38] In the present study, we found that the first day of training could induce a large change in the bias point and that the training effect changed slightly in the remaining days of training, indicating that the amount of training had little influence on the training effect. Our results are consistent with previous evidence that showed that even a single session of training could increase pro-social interpretation bias.[22] However, it should be noted that although the amount of training may not influence the training effect on emotion recognition, whether it affects the training effect on other cognitive functions and the persistence of the training effect require further investigation.

There is a long-term debate on whether emotional recognition training can affect behaviour among highly aggressive individuals. According to social information processing theory[6–8,39] and social cognitive theory,[40,41] behavioural responses to social situations are the result of social information processing, which is driven by top-down cognitive structures (eg, cognitive schemas). The distorted cognitive structure formed by the adverse experiences of juvenile delinquents automatically guides their biased social information processing, which leads to maladaptive behavioural responses. According to these theories, hostile interpretation bias to facial emotions should be a critical factor in the development of aggressive behaviours. Interventions on the hostile interpretation bias may reduce aggression. However, the evidence is not consistent. Some studies have shown that emotional recognition training can improve social behaviour. For example, some studies found that training for angry faces significantly reduced anger and aggression[14] and that training for angry, sad, and fearful faces reduced the severity of juvenile delinquency.[38] However, other studies did not find such an effect on social behaviours. For example, it was found that aggressive, hostile, and prosocial behaviours did not change after a one-week emotional recognition training.[22,37] Our results may provide new insights into the discrepancies among previous findings. In the present study, the overall aggression level of juvenile delinquents did not change significantly, while training only reduced hostility. These results suggest that training may have a relatively strong effect on attribution and attitude and may not necessarily affect behaviours directly. Some factors may prevent aggressive behaviours. For example, studies have consistently shown that self-control is a critical factor that directly affects aggression.[42–50] Individuals with high self-control may not show aggression even if they perceive hostility or anger from the behaviour or facial emotions of others. In addition, a study showed that the effect of training on physical aggression was only significant in juvenile delinquents with a higher hostile interpretation bias at baseline.[51] Therefore, psychological characteristics at baseline may also be a critical factor. Future studies are required to explore the mechanism of emotional recognition training on aggression to find an effective behavioural intervention.

Our results reveal that emotional recognition training affected not only the judgement of emotions and behavioural consequences but also the basic cognitive processing of emotional stimuli as visual attention to emotional faces was facilitated. These results support the combined cognitive bias hypothesis, which proposes that cognitive biases may act collectively to develop and maintain the symptoms of emotional disorders.[18] Why does emotional recognition modification affect emotional attention? There may be several reasons. First, in the present study, juvenile delinquents constantly

modified their judgement of emotional stimuli according to feedback. During the training, participants established a clear criterion for the emotional categories, which may reduce uncertainty in searching for an emotional target. It is proposed that the emotional evaluation system can enhance the perceptual representation of a specific emotional stimulus and make it more salient, and a salient stimulus is more likely to capture attention.[52] In the present study, emotional recognition training improved the emotional evaluation system, which makes the meanings of emotional faces more salient in perceptual representations and thus improves the speed of attention orientation to these emotional faces. The second possibility might be familiarity with the emotional stimuli. Participants viewed the emotional faces repeatedly during the training and thus became increasingly familiar with these kinds of faces. Christie and Klein[53] proposed that the stored representations in our brains may capture visual attention to related items; that is, knowledge experiences can facilitate attention to related stimuli. A large number of studies have revealed the effect of familiarity on attentional processing.[54] For example, familiarity was shown to enhance automatic attentional orientation;[55] word familiarity modulated attention to emotional words;[56] and high familiarity reduced the demand for attentional resources in face recognition.[57] Electrophysiological evidence also showed that highly familiar faces induced a shorter latency of P300, which corresponds to attentional resource allocation, compared with unfamiliar faces.[58] Therefore, as familiarity with emotional faces increases with training, visual attention to these faces may also increase accordingly. Further studies are required to investigate the effect of increased attention on other cognitive processing and behaviours among juvenile delinquents.

The present study also had some limitations. First, we only explored the influence of emotional recognition training on emotional attention through the visual search paradigm. Other cognitive processing may be investigated in further studies. Second, attention is a complex cognitive process that contains multiple subsystems, such as attentional facilitation, attentional inhibition, and attentional reallocation. Our study could not distinguish between these processes, and other paradigms should be used to explore the impact of emotional recognition training on emotional attention in more detail. Third, studies have shown that cognitive bias modification for attention (CBM-A) is also an effective intervention for defects in emotional cognition[24,59,60] and even can decrease socioemotional problems.[61–63] Further studies are needed to explore the effect of CBM-A on defects in emotional cognition and aggression in juvenile delinquents. Fourth, we did not take the sociodemographic characteristics of the participants into account. For example, as the major offensive behaviours of the current sample were robbery and theft, it was impossible to subdivide our sample into more detailed groups. However, the severity of offensive behaviours may be associated with emotional cognition. Therefore, future studies may investigate the impact of sociodemographic characteristics such as the type of offence on emotional recognition training and emotional cognition. Finally, the brain mechanism of emotion recognition training is still unclear, and whether it changes the function of the sensory cortex requires further investigation.

Conclusion

Emotional recognition training may modify juvenile delinquents' emotional recognition. Furthermore, it enhances their visual attention to emotional faces and reduces hostility, indicating that the training may directly affect the encoding of the sensory input of facial emotions as well as the interpretations stored in memory. However, the influence of the training on behavioural outcomes may be indirect and uncertain. These findings advance our understanding of the mechanism underlying emotional recognition training.

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Disclosure

The authors report no conflicts of interest in this work.

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