Applied & Educational Psychology (2024)
Clausius Scientific Press, Canada

DOI: 10.23977/appep.2024.050112
ISSN 2523-5842 Vol. 5 Num. 1

Attention bias and intervention research of depressive patients to emotional faces

Yishuhan Shi

Wuhan University of Science and Technology, Wuhan City, Hubei Province, 430081, China

Keywords: Emotional faces, Depression, Attentional bias

Abstract: Depression, as a common psychological disorder, has attracted widespread attention in society. Patients with this disease often exhibit significant attentional bias towards negative emotional faces in the early stages. When they face a face with negative emotions, their attention is involuntarily drawn, and this situation becomes particularly complex in the post-processing of attention, making it difficult for them to escape and further deepening their emotional distress. Researchers have found that this attentional bias is closely related to changes in gray matter volume and concentration in the brain of patients with depression. These changes not only affect the brain structure of patients, but also lead to difficulties in emotional regulation. In other words, these changes in the patient's brain may be the root cause of their emotional distress. In order to help patients overcome this dilemma, attention bias modification (ABM) has gradually received attention from the medical community in recent years. ABM is a training method aimed at addressing attention bias, which aims to help patients better cope with and handle negative emotions by adjusting their attention patterns. When the patient's attention is no longer troubled by negative emotions, their emotional state is expected to be relieved and improved. When ABM is used in combination with antidepressants, its effect is more significant. In the future, primary health institutions may consider ABM as an effective treatment option, in parallel with drug therapy, providing patients with more treatment options. However, the mechanism of action of ABM remains a mystery. Although it is known that it can help patients adjust their attention, the underlying neural mechanisms and changes in brain structure still need further exploration. In order to better utilize ABM, future research should delve deeper into how it affects the brain structure and function of patients. Only in this way can more targeted intervention plans be developed for patients with depression, providing them with more effective treatment or prevention measures. I hope that in the near future, we can find more ways to treat depression, so that patients can quickly get out of the haze and embrace the sunshine again.

1. Introduction

Attentional bias refers to the change in the allocation of attention to a certain part or specific aspect of the stimulus environment when an individual receives external stimuli. It is a manifestation of the individual's selective activation of self-relevant and meaningful information and active inhibition of irrelevant stimuli. Some scholars believe that the information selectively

processed by individuals is consistent with their own experiences and traits [1]. Attention is also a prerequisite for the normal progression of various psychological processes. Therefore, changes in attention allocation may be predictors of certain disorders or indicators of symptom relief, especially for individuals with depression.

Life cannot be separated from interpersonal communication, and emotional faces, as an important component of social information, serve as feedback on attitudes and feelings, and a bridge between people. The processing and interpretation of emotional facial information is particularly important in interpersonal relationships, as it is related to individuals' cognition of environmental stimuli and self-evaluation. However, due to impaired cognitive function, depressed patients experience difficulties in receiving, processing, and transforming information. They selectively attend to emotional faces that align with their mood and struggle to disengage or avoid emotional faces that are unfavorable to them, thereby affecting their perception of the surrounding world. In recent years, numerous studies have found that depressed patients generally exhibit a negative bias. By reviewing relevant research literature in recent years, this article systematically describes the attentional bias of depressed patients towards emotional faces and its underlying neural mechanisms. This contributes to enriching the pathogenic and symptom maintenance theories of depression while providing new ideas for intervention, monitoring recovery training, and controlling recurrence.

2. Attentional Bias to Emotional Faces in Depressed Patients

2.1 Depressed patients exhibit attentional bias towards negative emotional faces

Previous studies have mainly utilized techniques such as eye tracking, ERP, and the dot-probe paradigm. Compared to healthy individuals, depressed patients exhibit attentional bias towards negative emotional faces such as sadness and disgust. Eye tracking technology has revealed that the attentional bias in depressed patients manifests as difficulty disengaging from negative emotional faces, with no abnormalities observed in the early stages of attention engagement. For example, in 2015, Duque and Vázquez found that depressed patients who were not taking medication showed longer first fixation durations and total fixation times on sad facial expressions. However, the study also noted that although angry faces are also negative emotions, similar attentional biases were not observed for angry faces. Furthermore, Koch et al. (2023) found that patients with major depressive disorder also exhibited attentional bias towards disgust faces, similar to that observed for sad faces. These findings suggest that, excluding the influence of antidepressant medications, depressed patients show increased attention engagement and difficulty disengaging attention from sad and disgusted faces, respectively.

2.2 Early Attentional Bias towards Negative Emotional Faces in Depressed Patients

The existence of negative attentional bias in depressed patients has been confirmed, and this bias also exists in the initial attention allocation stage. Previous studies have explored this based on behavioral and electroencephalographic (EEG) indicators. For example, Trapp et al. (2018) asked participants to view pairs of emotional images for 100 milliseconds or 500 milliseconds and then press a button to indicate the side where a cue appeared as quickly as possible. A significant bias towards happy and angry faces was observed in patients with major depressive disorder during the first 100 milliseconds, with little change in attentional processing afterwards (100ms-500ms). This suggests that attentional bias towards emotional stimuli in major depression may occur during the early stages of attentional processing.

As the occurrence of some important life events is inherently a risk factor for the development of

depression, patients with a history of child abuse in the depressed sample showed reduced attention to angry and sad faces, indicating their avoidance of processing threatening and negative stimuli. Conversely, in a study examining the interaction of attention, interpretation, and memory in depressed patients, it was found that early attentional bias towards negative information activates related negative memories, and the activation of negative memories makes depressed patients more prone to attending to negative information in their environment. These findings suggest that early in the attentional process, childhood traumatic experiences, as a form of negative memory, influence the direction of attentional bias towards negative faces in depressed patients to some extent. Furthermore, for depressed individuals with both childhood trauma and recent stressful life events, childhood traumatic experiences only predict attentional bias towards sad stimuli when the individual has also recently experienced stressful life events. This is consistent with findings that attention to negative information is associated with a tendency to remember more negative experiences [2]. By linking negative attentional bias to known risk factors, these studies further demonstrate that attentional bias in depressed patients is related to stressful life events, and this effect is primarily manifested in the early stages of attention.

2.3 Difficulty in Disengaging from Negative Attentional Bias in the Later Stages of Attention

Hu Qian et al. (2019) found that during the initial stages of attention, participants treated positive or negative stimuli equally. However, after processing negative information, it became more difficult to shift attention away from it. Compared to healthy individuals, depressed patients allocated more attention to sad faces, and the attentional bias was manifested as difficulty in disengaging attention in the later stages of attention. The attention patterns of both groups were similar for happy faces, but for neutral faces, the healthy group preferred a pattern similar to that for happy faces, while the patient group preferred a pattern similar to that for sad faces. Another study analyzed individuals' electroencephalographic (EEG) components and found that compared to invalid sad cues, patients with major depressive disorder showed greater P1 and P3 amplitudes in response to valid sad cues. The P1 component is associated with rapid and unconscious bottom-up attention allocation, while the P3 component is related to top-down voluntary attention allocation. The findings suggest that patients allocate more attention to sad cues in both the automatic and voluntary stages of attention allocation, indicating the presence of a negative, mood-congruent attentional bias [3].

Studies have confirmed that depression can lead to a lack of protective biases in early attentional activities among adult individuals. Overall, due to their own low mood, depressed patients have a negative bias towards emotional faces, and their cognitive function is impaired to a certain extent. Once negative stimuli enter the attention span and undergo information processing, it becomes difficult to disengage from them in the later stages of top-down attention. Meanwhile, this attentional bias is influenced by stressful life events. Depressed patients with a history of child abuse show reduced attention to angry and sad facial expressions, and adversity in early life is significantly associated with reduced attention to negative facial expressions. Sensitivity to negative stimuli helps abused individuals recognize them in a timely manner, thereby avoiding processing negative stimuli as a form of self-defense.

3. The Underlying Neural Mechanisms of Attentional Bias in Depression

Attention, as the primary prerequisite of cognitive processes, is considered a hallmark deficiency in depressed patients. The mechanisms affecting attentional bias in depressed patients are complex and are closely related to their own negative self-schemas, lack of positive biases, abnormalities in sustained attention, and interference with attentional inhibition. Meanwhile, changes and abnormal

activation in brain region structures, as well as abnormalities in neural network function, are also factors that contribute to the presence of specific attentional biases in depressed patients.

3.1 Abnormal Gray Matter Volume in Brain Regions Related to Depression

Looking back at previous studies, most attribute the cause of attentional bias to changes in gray matter volume and concentration in the brain. In depressed patients, there is an increase in gray matter volume in the posterior cingulate cortex and inferior frontal gyrus, and a decrease in gray matter volume in the middle frontal gyrus, superior frontal gyrus, and lingual gyrus. The increase in gray matter volume in the inferior frontal gyrus is associated with sustained attention. One study found that remitted depressed patients had mild visual attention deficits related to reduced gray matter volume in the left postcentral gyrus and bilateral medial superior frontal gyrus. The depressed group had reduced gray matter volume in the left dorsolateral prefrontal cortex and impaired auditory and visual attention related to the thalamus and amygdala/parahippocampal regions. Depressed patients had reduced gray matter concentration in the left inferior temporal cortex, right orbitofrontal cortex, and dorsolateral prefrontal cortex, and reduced gray matter volume was found in the left hippocampus, cingulate gyrus, and thalamus. The cortical network, including the superior frontal, inferior parietal, and superior temporal regions, is involved in top-down attentional control , which may be related to the psychopathological changes and cognitive deficits of depression , thereby affecting the later stages of top-down attention. Leung et al. (2009) found that this attentional bias towards negative stimuli is closely related to reduced gray matter concentration in the right superior frontal gyrus, right anterior cingulate gyrus, and right fusiform gyrus. Taken together, changes in gray matter volume and concentration in brain regions related to attentional and cognitive functions in depressed patients may be important factors leading to their attentional bias.

3.2 Abnormal activation of related brain regions in patients with depression

Feng Yigang et al. (2019) found that the occipital lobe in patients with depression θ，α Abnormal energy in the frequency band, showing a state of energy rightward lateralization, continuously paying attention to the occipital lobe θ、α The frequency band energy shows a significant negative correlation [4]. The main function of the occipital lobe is to process visual information. This study suggests that the low-frequency energy asymmetry on both sides of the occipital lobe in patients with depression leads to a decrease in hemispheric functional coordination and efficiency in information transmission, ultimately resulting in impaired visual attention function and affecting their sustained attention function. Attention deficit may also be related to insufficient motivation for reward generation. A study has found that rewards increase activation of the frontal striatum and hippocampus/temporal regions in the control group, but these regions are inactivated in patients with severe depression. And these brain regions are closely related to attention, indicating that the motivation of depression patients cannot upregulate attention networks compared to healthy individuals, leading to varying degrees of attention deficit. In addition, Yang et al. (2023) demonstrated through the saccade test that the difficulty in resisting attention to negative stimuli in patients with depression is due to impaired working memory and rumination function, which interferes with attentional inhibition in the evaluation process. Moreover, the decreased connectivity between the frontal parietal system involved in attentional cognitive control and emotional regulation in patients with depression, as well as the low connectivity between the frontal parietal system and the parietal region involved in the dorsal attention network that focuses on the external environment, may reflect a decrease in attentional reorientation responses to significant cues.

Overall, the gray matter volume of relevant brain regions involved in visual attention, sustained attention, and top-down attention stages undergoes varying degrees of changes, leading to abnormal attention related functions in patients with depression. The reward activated attention related brain regions in the healthy population are not activated in patients with depression, and their connectivity between related neural networks is reduced. These may lead to difficulties in transferring attention to negative faces in patients with depression, resulting in expected attentional bias.

4. Application of attentional bias modification in improving depressive symptoms

4.1 Attention bias correction training can improve depressive symptoms

Due to the constantly changing neural basis of learning and memory, patients with depression have a deep-rooted negative attentional bias, such as a tendency to focus on and recall negative information [5]. The role of drug therapy and psychotherapy in alleviating symptoms and long-term efficacy is limited, with 40% of patients having no or only partial response to treatment, and less than one-third of patients fully recovering after treatment. For patients with severe depression, partial relief can only be achieved after treatment and it takes a long time to fully recover their function. Compared to drug therapy and psychotherapy, the advantage of ABM is that it is a computer based protocol that modifies specific attention biases through repeated attention training, making it a promising intervention method. Attention bias correction training is divided into mixed type ABM (directing attention towards positive stimuli and away from negative stimuli) and positive type ABM (directing attention towards positive stimuli). Although changing attentional bias can help alleviate depressive symptoms, current research results are inconsistent.

4.2 Attention bias modification can early prevent the occurrence of depression

Most adults experience depression during adolescence, and adolescents have greater plasticity. Early intervention in adolescent attention bias may have a positive effect on the onset and development of depression. Negative attentional bias is crucial for the formation of negative cognitive bias. Yang et al. (2016) recruited 45 adolescents with severe depression and presented a series of neutral sad word pairs to the positive ABM group, with 90% of the probes appearing in the neutral position and 10% in the sad position; The subjects in the placebo group received the same training task, but the appearance of the probe was randomly and evenly distributed at the positions of neutral and sad words [6]. It was found that there was no immediate difference in self-reported symptoms between the two groups of participants; For the evaluation of clinical symptoms, the ABM intervention group had lower clinical physician assessed depressive symptoms compared to the placebo group.

College students have a higher level of knowledge and are more likely to receive new interventions and training. ABM has a preventive effect on the occurrence of depression in college students. Dai et al. (2019) conducted mixed type ABM and positive type ABM on depressed college students at both clinical and non clinical levels, and found that the symptoms evaluated by clinical doctors were alleviated, while also having a positive effect on non clinical samples. For patients with a bias towards negative stimuli, a mixed type ABM that shifts attention from negative stimuli to positive stimuli is more effective; For patients with severe lack of positive stimulus bias, positive ABM training that directs attention to positive stimuli is more effective [7]. This also suggests that we should adopt different ABM strategies for depression patients with different attentional biases.

4.3 Anxiety level affects attentional bias modification in alleviating depression

The improvement of anxiety contributes to the reduction of depressive symptoms, indicating that anxiety is a factor affecting the therapeutic effect of ABM. B ø et al. (2021) found that the effectiveness of ABM treatment increased with the severity of symptoms and symptom load. Specifically, participants with more severe anxiety symptoms before treatment showed relatively better intervention effects. This study takes an important step towards the mechanism of action of ABM, indicating that anxiety symptoms can serve as an important basis for developing personalized ABM treatment plans, and this method is more suitable for depression patients with anxiety disorders.

The above research provides strong evidence that ABM can alleviate depression symptoms in clinical evaluation, and further proves that anxiety levels also affect the relief effect of ABM on depression patients to a certain extent. ABM can not only be published on digital platforms, but also does not require interaction with therapists, which can better meet the psychological needs of depression patients. Therefore, the combination of ABM and antidepressant drugs can be relatively easily applied in primary health institutions, providing a method for treating depression and further clinical practice.

5. Summary and Outlook

5.1 Strengthening the study of attentional bias characteristics and neural mechanisms in individuals with depression

Firstly, most studies use a single method to detect patient attention bias, such as eye tracking technology, ERP technology or point detection tasks, and visual search tasks. And these methods need to be carried out in specific environments, which may lead to participants behaving differently from their daily lives, thereby affecting the experimental results. For example, in visual search tasks, when the task becomes more complex, participants may make more errors. Therefore, in future research, multiple detection methods should be combined, such as reaction time tasks or brain imaging techniques, to obtain more comprehensive attention bias information.

Secondly, sample size, geographical and cultural background may affect the representativeness of the results. The symptoms and manifestations of different patients are not entirely the same, which may lead to differences in their eye movement patterns or different strategies in the same task, which can affect the reliability of research results. In future research, the sample size should be increased to enhance its representativeness; And taking into account individual differences to obtain more accurate results.

Finally, emotional stimuli often use static facial images, which is significantly different from the dynamic and diverse triggers of sadness in real life. Currently, most studies present neutral emotional faces in pairs, and there is no competition for multiple emotional stimuli. Therefore, it is uncertain whether attentional bias will only manifest in specific presentation modes. In future research, emotional stimuli should be realistic and presented in diverse ways to evaluate the attentional bias characteristics of patients from multiple perspectives.

5.2 Conduct in-depth research on the treatment or intervention of ABM for depression

Depression is often accompanied by varying degrees of anxiety and influences each other. Anxiety and depression symptoms jointly lead to psychological and physical discomfort, and may worsen each other, so the treatment of the two is closely related. Research has shown that depression patients with severe pre-treatment anxiety symptoms exhibit better intervention effects,

indicating that the degree of pre-treatment anxiety symptoms can affect the treatment effectiveness of ABM. This finding provides clues for personalized treatment of ABM. In future research, it is necessary to delve into the specific improvement effects of ABM on depressive symptoms and the impact of anxiety levels on them, to determine whether ABM can be used as a cross diagnostic treatment or for preventing seizures and treating symptoms, and to make sufficient preparations for further developing targeted rehabilitation plans.

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