The Relationship Between Negative Attention Bias, Interpretation Bias, and Depression in College Students (Postprint)

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Abstract

Background: In China, college students have become a high-risk population for depression. Maladaptive attentional bias and interpretive bias constitute important factors in the onset and maintenance of depression. While previous studies have examined the characteristics of attentional bias and interpretive bias in depressed individuals, the mechanisms through which these biases influence depression remain to be elucidated. Objective: To investigate the relationships among negative attentional bias, interpretive bias, and depression in college students, and to explore the mediating and moderating roles of interpretive bias in the association between attentional bias and depression. Methods: Using random sampling, 66 college students from Xinyang University were recruited as participants between January and February 2023. The Beck Depression Inventory-II (BDI-II) was administered to assess depressive symptoms, an eye tracker was employed to record total fixation time bias scores, and interpretive bias materials were distributed to collect interpretive bias scores. Spearman correlation analysis was conducted for correlation analysis, PROCESS was utilized to test mediating effects, and linear regression was performed to examine the moderating effect of interpretive bias. Results: BDI-II scores were positively correlated with total fixation time bias scores ($r=0.688$, $P<0.01$), negatively correlated with relative interpretive bias scores ($r=-0.731$, $P<0.01$), and total fixation time bias scores were negatively correlated with relative interpretive bias scores ($r=-0.580$, $P<0.01$). The indirect effect of interpretive bias was 0.278, accounting for 42% of the total effect (95%CI: 0.148-0.453), confirming the mediating effect of interpretive bias. The interaction between total fixation time bias scores and relative interpretive bias scores was significant ($\beta=-3.479$, $P<0.05$), confirming the moderating effect of interpretive bias. Conclusion: Significant correlations exist among negative attentional bias, interpretive bias, and depression in college students. Individuals' negative attentional bias can influence depression both

directly and indirectly through interpretive bias. Interpretive bias moderates the effect of negative attentional bias on depression.

Full Text

The Relationship between Negative Attention Bias, Interpretation Bias, and Depression in College Students

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Abstract

Background: In China, college students have become a high-risk group for depression. Maladaptive attentional bias and interpretation bias are significant factors contributing to the onset and maintenance of depression. Previous studies have examined the characteristics of attentional and interpretation biases in depressed individuals, yet the mechanisms through which these biases influence depression remain unclear.

Objective: This study aimed to investigate the relationships between negative attentional bias, interpretation bias, and depression among college students, as well as to explore the mediating and moderating effects of interpretation bias in the association between attentional bias and depression.

Methods: Using a random sampling method, 66 university students from Xinyang College were selected as research participants between January and February 2023. The Beck Depression Inventory (2nd Edition) (BDI-) was used to assess participants' depressive symptoms. An eye tracker was employed to record total gaze time bias scores, and interpretation bias materials were distributed to collect interpretation bias scores. Correlation analysis was conducted using Spearman' s correlation analysis, mediation effects were tested using PROCESS, and the moderating effect of interpretation bias was examined through linear regression.

Results: BDI- scores were positively correlated with total gaze duration bias scores ($r=0.688$, $P<0.01$), negatively correlated with relative interpretation bias scores ($r=-0.731$, $P<0.01$), and total gaze duration bias scores were negatively correlated with relative interpretation bias scores ($r=-0.580$, $P<0.01$). The indirect effect of interpretation bias was 0.278, accounting for 42% of the total effect (95%CI: 0.148–0.453), confirming its mediating role. The interaction between total gaze duration bias scores and relative interpretation bias scores was

significant (β=-3.479, P<0.05), indicating a moderating effect of interpretation bias.

Conclusions: Negative attentional bias, interpretation bias, and depression are significantly interrelated among college students. Negative attentional bias not only directly influences depression but also indirectly exacerbates it through interpretation bias. Moreover, interpretation bias moderates the impact of attentional bias on depression, suggesting that adaptive interpretation patterns may mitigate the adverse effects of negative attentional processing.

Keywords: Depression; Negative attention bias; Interpretation bias; College students

Introduction

Depression is a common mood disorder characterized by at least two weeks of depressed mood, anhedonia, fatigue, and associated cognitive and somatic symptoms [1]. Surveys indicate that as of 2022, there were 95 million known cases of depression in China, with college students accounting for 21.4% of this population. The depression level among college students is higher than the national norm [2], posing significant threats to both their mental health and campus safety [3-4]. Therefore, investigating the influencing factors and pathogenic mechanisms of depression in college students is of great importance.

Cognitive theories of depression posit that negative cognitive biases form the basis for the onset and maintenance of depression [5]. Attention bias and interpretation bias represent two primary forms of cognitive bias [6]. Attention bias refers to differential allocation of attentional resources toward positive or negative stimuli compared to neutral stimuli. A negative attentional bias toward adverse stimuli constitutes a crucial factor in depression' s development and persistence. When individuals exhibit negative attentional bias, they predominantly receive negative stimuli, which over time creates adverse cognitive impacts and leads to depression [7]. Furthermore, attention bias modification training has effectively reduced depression levels [8-9]. In summary, attention bias plays an important role in both the development and alleviation of depression, leading to our hypothesis that attention bias correlates with and can predict depression.

Interpretation bias involves individuals making positive, neutral, or negative interpretations of ambiguous verbal or nonverbal information based on their habitual patterns [10]. Cognitive processing bias theory considers interpretation bias a core cognitive factor in depression [11]. Researchers suggest that activation of negative interpretation bias impedes the generation of benign interpretations [12]. As interpretation constitutes a vital component of cognitive processing, individuals' negative interpretation bias adversely affects cognition and subsequently triggers mood disorders such as depression [13]. According

to the combined cognitive biases hypothesis, attention bias and interpretation bias are inseparable and mutually influential [14]. Studies have indicated a positive correlation between negative attention bias and negative interpretation bias [15]. The depression reinforcement feedback cycle model posits that attention bias influences interpretation bias, which subsequently impacts depression onset and development [16]. When individuals exhibit negative attentional bias, they attend primarily to negative stimuli; combined with negative interpretation of received information, this increases the risk of depressive emotions. Therefore, interpretation bias may mediate the relationship between negative attention bias and depression. Additionally, research has found that positive interpretation bias can enhance self-regulation capacity and increase attention to positive information, thereby alleviating depression [17]. Consequently, we hypothesize that interpretation bias may also moderate the relationship between attention bias and depression.

This study examined college students'negative attentional bias toward emotional facial pictures through eye-tracking experiments and investigated interpretation bias in ambiguous social situations using interpretation bias materials. We aimed to clarify the relationships among negative attentional bias, interpretation bias, and depression in college students and further explore whether interpretation bias serves mediating and moderating roles between attentional bias and depression. This research holds important theoretical significance for analyzing the mechanisms through which negative attentional bias and interpretation bias affect depression and for developing effective cognitive bias modification training to alleviate depressive symptoms.

Methods

1.1 Study Participants

Using random sampling, we selected college students from Xinyang College as research participants between January and February 2023. Inclusion criteria were: (1) normal or corrected-to-normal vision, and (2) no sedative or stimulant use within 24 hours. Exclusion criteria included: (1) color weakness or color blindness, (2) history of brain organic disease, severe physical illness, or family history of mental illness, and (3) presence of anxiety symptoms [Beck Anxiety Inventory (BAI) score >14]. We used G*Power 3.1 to estimate sample size with the following parameters: effect size f=0.25, α=0.05, and 1-β=0.95, which indicated a minimum requirement of 54 participants. We distributed 300 questionnaires, recovered 251, of which 245 were valid. After contacting potential participants via text message, 70 agreed to participate in the eye-tracking experiment. Four participants were excluded due to excessive eye-tracking calibration errors, resulting in a final sample of 66 participants. This study was approved by the Xinyang College Biomedical Ethics Review Committee [Approval No. 2023(01)], and all participants provided informed consent.

1.2 Research Tools

1.2.1 General Information Questionnaire We collected participants' demographic information including gender, grade, only-child status, residence, and family structure.

1.2.2 Beck Depression Inventory (2nd Edition) (BDI-) We used the BDI- revised by Wang et al. [18] to assess participants' depressive symptoms over the past two weeks. The scale comprises 21 items rated on a four-point scale, with total scores of 14 or above indicating depression. Cronbach' s α coefficient was 0.94.

1.2.3 Beck Anxiety Inventory (BAI) We employed the BAI revised by Zheng et al. [19] for self-assessment of anxiety symptoms. The scale contains 21 items rated on a four-point scale, with higher scores indicating more severe anxiety. A total score above 14 suggests clinically significant anxiety. Cronbach' s α coefficient was 0.95.

1.2.4 Facial Expression System Emotional facial pictures were selected from the facial expression system established by Liu et al. [20] for mood disorder research. The system includes 20 positive, 20 negative, and 40 neutral facial pictures, all in black and white. Emotional valence comparisons revealed significant differences between neutral $(4.31\$\pm0.23) and negative (2.57\pm0.24) pictures (t = -40.23, P < 0.01), between neutral and positive (6.43\pm0.28) pictures (t = 14.05, P < 0.01), and between positive and negative pictures (t = 21.39, P < 0.01). Arousal comparisons showed significant differences between neutral (4.00\pm0.54) and negative (5.04\pm0.22) 4.78, P < 0.01) and between neutral and positive (5.11\pm\$0.06)$ pictures (t=4.01, P<0.01), but no significant difference between positive and negative pictures (t=1.81, P=0.18). We paired the 80 pictures into four types: positive-neutral, neutral-positive, negative-neutral, and neutral-negative [21], with 10 pairs per type. All pictures were standardized to 7 cm × 10 cm, with 2 cm between paired pictures.

1.2.5 Eye Tracker We used an Eyelink 1000 Plus eye tracker to collect eye movement data for assessing attentional bias. The system featured a 19-inch monitor with $1024\$\times\$768$ pixel resolution and 60 Hz refresh rate, sampling at 1000 Hz with 9-point calibration. Participants positioned their chins on a chinrest 65 cm from the screen, with gaze centered at the upper quarter of the screen to accurately capture eye movement trajectories and extract parameters [21]. We used total gaze duration bias scores as the eye movement index, defined as total fixation time on a single facial picture' s region of interest (ROI). ROIs were rectangular areas matching picture dimensions (7 cm × 10 cm). Total gaze duration bias scores were calculated as fixation time on negative faces divided by total fixation time on both faces in each trial. Scores >0.5 indicated overall attentional maintenance on negative faces, scores =0.5 indicated no attentional bias, and scores <0.5 indicated attentional avoidance of negative faces [22].

1.2.6 Interpretation Bias Materials We used interpretation bias materials to assess participants' interpretation bias [23]. The materials comprised 20 ambiguous social scenarios, each followed by three possible interpretations representing positive, neutral, and negative interpretation biases. Participants rated the likelihood of each interpretation based on their feelings and experiences using a 5-point scale: 0=completely impossible, 1=somewhat possible, 2=moderately possible, 3=very possible, and 4=extremely possible. We used relative interpretation bias scores for data analysis. Hirsch et al. [24] proposed using relative interpretation bias to measure interpretation bias degree, calculated as positive interpretation bias score minus negative interpretation bias score. This value reflects the overall direction and magnitude of interpretation bias, with higher scores indicating more positive bias and lower scores indicating more negative bias; the sign indicates the overall bias direction [25].

1.3 Experimental Procedure

Upon arrival at the laboratory, we verified participant information and assigned identification numbers. After starting the experimental program, we seated participants at the workstation and positioned their chins on the chinrest, adjusting seat height as needed. Following preparation, participants read the instructions and confirmed their understanding of the experimental operations and procedures. We conducted nine-point calibration twice, ensuring errors remained within 1 degree, before commencing the formal experiment. Each trial began with a fixation cross "+" presented for 1000 ms at the center of the screen. Once participants focused their attention, emotional face pairs appeared on the left and right sides of the screen for 5000 ms before disappearing, followed by the reappearance of the fixation cross. This sequence repeated until all 40 face pairs were presented in random order. Participants were instructed to view the screen attentively throughout the experiment. The experimental procedure is illustrated in Figure 1 [Figure 1: see original paper].

Following the eye-tracking experiment, participants were guided to a lounge where they listened to relaxing music for 10 minutes to minimize any emotional priming effects from the emotional pictures. We then distributed paper-based interpretation bias materials, asking participants to carefully read each scenario, imagine themselves in the described social situation, and rate each interpretation based on their personal feelings without time constraints.

1.5 Statistical Analysis

We performed statistical analyses using SPSS 23.0 and the PROCESS macro. Normally distributed data were expressed as mean±standard deviation ($\bar{x}\pm s$), while non-normally distributed data were presented as median (quartile 1, quartile 3) [M(Q1, Q3)]. Between-group comparisons were conducted using Mann-Whitney U tests. We examined common method bias using Harman' s single-factor test. Spearman correlation analysis explored relationships among attentional bias, interpretation bias, and depression. Mediation effects were tested

using Model 4 in PROCESS with 5000 bootstrap samples. Moderating effects were examined through linear regression analysis, with simple slope plots generated for visualization. Statistical significance was set at P<0.05.

Results

2.1 Basic Information of Study Participants

BDI- scores differed significantly by only-child status (P<0.05) but showed no significant differences by gender, age, residence, or family structure (P>0.05), as shown in Table 1 .

Table 1 Basic information of participants [M(Q1, Q3), scores]

Characteristic	BDI- Score
Overall	13.500 (5.000, 21.000)
Male	13.000 (5.000, 20.000)
Female	14.000 (5.000, 27.000)
Lower grade (Freshman/Sophomore)	13.000 (5.000, 19.500)
Upper grade (Junior/Senior)	21.000 (4.500, 29.500)
Only child	28.000 (12.750, 32.500)
Non-only child	12.000 (5.000, 19.750)
Urban residence	13.500 (5.000, 21.000)
Rural residence	13.500 (5.500, 23.000)
Intact family	13.000 (4.250, 20.000)
Non-intact family	16.000 (7.750, 24.750)

2.2 Common Method Bias Test

We used Harman's single-factor test to assess common method bias. Exploratory factor analysis without rotation of all measurement items revealed eight common factors with eigenvalues greater than 1. The first common factor explained 26.92% of total variance, below the 40% threshold proposed by Podsakoff et al. [26], indicating no serious common method bias in this study.

2.3 Correlation Analysis

Participants' mean BDI- score was 13.500 (5.000, 21.000), mean total gaze duration bias score was 0.468$±0.091, $and mean relative interpretation bias score was 15.410±$18.423. BDI- scores were positively correlated with total gaze duration bias scores (P<0.01), indicating that higher depression scores were associated with longer viewing times for negative pictures. BDI- scores were negatively correlated with relative interpretation bias scores (P<0.01), meaning higher depression scores corresponded to lower relative interpretation bias. Total gaze duration bias scores were negatively correlated with relative interpretation bias

scores (P<0.01), such that greater attentional bias toward negative faces was associated with more negative interpretation bias (Table 2).

Table 2 Correlation analysis of depression, attention bias, and interpretation bias among college students

Variable	BDI- Score	Total Gaze Duration Bias	Relative Interpretation Bias
BDI-Score	—	0.688a	-0.731a
Total Gaze Duration Bias	0.688a	—	-0.580a
Relative Interpretation Bias	-0.731a	-0.580a	—

Note: a indicates P<0.05; —indicates duplicate data not shown.

2.4 Mediating Effect of Interpretation Bias

Correlation analysis revealed significant relationships among BDI- scores, relative interpretation bias scores, and total gaze duration bias scores. Following Wen and Ye' s procedure for mediation effect testing [27], we conducted mediation analysis using PROCESS Model 4 with 5000 bootstrap samples. If the 95% confidence interval did not contain zero, the mediation effect was considered significant. Results are presented in Tables 3 and 4 .

Total gaze duration bias significantly predicted BDI- scores (β=0.656, P<0.01). After adding the mediator, total gaze duration bias remained a significant predictor (β=0.378, P<0.01). Additionally, total gaze duration bias negatively predicted relative interpretation bias (β=-0.561, P<0.01), while relative interpretation bias negatively predicted BDI- scores (β=-0.496, P<0.01). The 95% confidence intervals for both the direct effect of total gaze duration bias on BDI- scores and the indirect effect through relative interpretation bias did not contain zero, confirming the mediation effect. The direct effect was 0.378, accounting for 58% of the total effect (95%CI: 0.185–0.570), while the indirect effect was 0.278, accounting for 42% (95%CI: 0.148–0.453). In summary, total gaze duration bias both directly predicted BDI- scores and indirectly influenced them through relative interpretation bias, indicating partial mediation (Figure 2 [Figure 2: see original paper]).

Table 3 Linear regression analysis of mediating effects of interpretation bias

Model	Outcome	Predictor	β	t	P
1	Relative Interpretation Bias	Total Gaze Duration Bias	- 0.561	- 5.423	<0.01
2	BDI- Score	Total Gaze Duration Bias	0.656	6.300	<0.01
3	BDI- Score	Total Gaze Duration Bias	0.378	4.694	<0.01
		Relative Interpretation Bias	- 0.496	- 5.139	<0.01

Note: a indicates P<0.01; Model 1 tests the effect of the independent variable (total gaze duration bias) on the mediator (relative interpretation bias); Model 2 tests the total effect of the independent variable on the dependent variable (BDI- score); Model 3 tests the direct effect of the independent variable on the dependent variable while controlling for the mediator.

Table 4 Mediating effects path analysis of interpretation bias

Effect	Relative Effect Value	95%CI
Direct effect	0.378	(0.185-0.570)
Indirect effect	0.278	(0.148-0.453)
Total effect	0.656	(0.467-0.844)

Note: —indicates no data.

2.5 Moderating Effect of Interpretation Bias

To examine the moderating effect of interpretation bias between attentional bias and depression, we conducted regression analysis with total gaze duration bias, relative interpretation bias, and their interaction term as predictors, and BDI- scores as the outcome variable. As shown in Table 5 , total gaze duration bias positively predicted BDI- scores (P<0.01), with higher bias scores associated with higher depression scores. Relative interpretation bias negatively predicted BDI- scores (P<0.01), with higher interpretation bias associated with lower depression scores. The interaction between total gaze duration bias and relative interpretation bias negatively predicted BDI- scores (β=-3.479, P<0.05), indicating that relative interpretation bias negatively moderated the relationship between total gaze duration bias and depression. To further verify this moderating effect, we generated a simple slope plot. The slope for low relative interpretation bias was steeper than for high relative interpretation bias, indicating that when relative interpretation bias was low, total gaze duration bias

had a stronger effect on BDI- scores. Thus, relative interpretation bias negatively moderated the impact of attentional bias on depression (Figure 3 [Figure 3: see original paper]).

Table 5 The moderating effect of interpretation bias on attention bias and depression

Variable	Model 1	Model 2	Model 3
Total Gaze Duration Bias	—	4.244b	5.633b
Relative Interpretation Bias	—	-4.312b	-4.269b
Total Gaze Duration Bias × Relative Interpretation Bias	—	—	-3.479a
BDI- Score	17.147b	19.192b	—
R^2	0.123	0.456	0.521

Note: a indicates P<0.05, b indicates P<0.01, —indicates no data. BDI- score served as the dependent variable. Model 1 included demographic control variables (gender, only-child status, residence, family structure). Model 2 added main effects (total gaze duration bias and relative interpretation bias). Model 3 added the interaction term.

Discussion

3.1 Impact of Attention Bias on Depression

This study found that attentional bias was positively correlated with depression and could positively predict depressive symptoms. The attentional narrowing theory suggests that depressed individuals tend to allocate attention toward depression-related stimuli [28], causing them to receive and process more negative information. As this negative attentional bias becomes progressively reinforced, attentional focus narrows to negative stimuli, undoubtedly exacerbating depressive symptoms. Thus, improving negative attentional bias represents an important pathway for alleviating depression. Research indicates that attention bias training is more effective than conventional medication for improving depressive symptoms in patients [29], and positive attention training can ameliorate negative attentional bias and subsequently relieve depressive emotions [30].

3.2 Mediating Effect of Interpretation Bias

This study revealed that interpretation bias partially mediated the relationship between total gaze duration bias and depression. Total gaze duration bias could

both directly affect depression and indirectly influence it through interpretation bias. The depression reinforcement feedback cycle model posits that individuals with negative attentional bias are more likely to develop negative interpretation bias, thereby increasing depressive emotions [16]. According to information processing models, when individuals show attentional bias toward negative information, their understanding of social information also tends to be negative, ultimately activating depressive networks [31]. Negative interpretation bias not only increases depression risk but also predicts future depression onset.

3.3 Moderating Effect of Interpretation Bias

The innovation of this study lies in examining both the mediating and moderating roles of interpretation bias. We found that when relative interpretation bias was high, it weakened the effect of total gaze duration bias on depression; when relative interpretation bias was low, it strengthened this effect. Positive interpretation bias can mitigate the impact of negative attentional bias on adverse emotions [32-33]. Since attentional bias and interpretation bias belong to the same cognitive process, when individuals tend to interpret negative stimuli with positive attitudes, it increases the positivity of cognitive processing and consequently alleviates depressive emotions.

In conclusion, individuals' depressive emotions are simultaneously influenced by negative attentional bias and interpretation bias. The combined cognitive biases hypothesis suggests that cognitive biases do not exist in isolation but interact with each other, and their combined effects on disorders may be greater than single bias effects [34]. Beck' s negative cognitive schema theory posits that negative schemas in depressed patients are stable and enduring; improving only one component of the cognitive system may not change the overall nature of the cognitive schema. Therefore, to significantly improve depressive symptoms, we should focus on the impact of the entire cognitive process on depression, particularly by correcting negative interpretation bias to reduce the influence of negative attentional bias on depression. This study not only provides theoretical support for the combined cognitive biases hypothesis but also offers insights for cognitive therapy of depression.

Limitations and Conclusions

This study has several limitations. First, the sample size was relatively small, and participants were not professionally diagnosed, so clinical generalization should be approached cautiously. Future research should include clinically diagnosed depressed patients to enhance generalizability. Second, this study only examined delayed interpretation bias without measuring immediate interpretation bias. Future studies should incorporate both immediate and delayed interpretation bias measures to more comprehensively examine their mediating or moderating roles. Finally, this study only explored the effects of attentional bias and interpretation bias on depression without including other cognitive processes such as memory bias. Future research should incorporate additional

cognitive processes to more comprehensively analyze cognitive influences on depression.

In summary, this study concludes that: (1) Attentional bias, interpretation bias, and depression are significantly interrelated, with individuals scoring higher on depression showing more negative attentional bias and negative interpretation bias. (2) Interpretation bias mediates the relationship between attentional bias and depression, with attentional bias influencing depression both directly and indirectly through interpretation bias. (3) Interpretation bias moderates the relationship between attentional bias and depression, with positive interpretation bias weakening and negative interpretation bias strengthening the impact of attentional bias on depression.

Author Contributions

XU Xiliang conceptualized the study, designed the research, supervised implementation, and wrote the manuscript; CHENG Guo conducted experimental operations, collected and organized data, performed statistical analysis, and prepared figures and tables; LIU Mingfan was responsible for quality control, manuscript review, and revision; YANG Lihao contributed to experimental operations, statistical analysis, and manuscript writing and revision.

Conflict of Interest

The authors declare no conflict of interest.

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Note: Figure translations are in progress. See original paper for figures.