The Indirect Effect of Attention Bias on Memory via Interpretation Bias: Evidence for the Combined Cognitive Bias Hypothesis in Subclinical Depression.

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Abstract

Little research has investigated functional relations among attention, interpretation, and memory biases in depressed samples. The present study tested the indirect effect of attention bias on memory through interpretation bias as an intervening variable in a mixed sample of non-depressed and subclinically depressed individuals. Subclinically depressed and non-depressed individuals completed a spatial cueing task (to measure attention bias), followed by a scrambled sentences test (to measure interpretation bias), and an incidental free recall task (to measure memory bias). Bias-corrected bootstrapping yielded evidence for the hypothesized indirect effect model, in that an emotional bias in attention is related to a congruent bias in interpretative choices which are in turn reflected in memory. These findings extend previous research and add further support for the combined cognitive bias hypothesis in depression. Theoretical and clinical implications of our findings are discussed.

Keywords: depression, cognitive processing, combined cognitive bias hypothesis, attention, interpretation, memory.

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The scientific understanding of underlying mechanisms in depression has markedly increased in the past decades. Various cognitive variables at the content (e.g., dysfunctional attitudes) as well as at the process (e.g., memory) level that play a detrimental role in the onset and maintenance of depressive symptoms have been identified. At the process level, considerable empirical research has shown that both subclinically and clinically depressed individuals selectively attend to negative information, tend to interpret ambiguous information in a negative manner, and recall disproportionately more negative memories (for reviews, see De Raedt & Koster, 2010; Gotlib & Joormann, 2010). Although there is extensive evidence supporting attention, interpretation, and memory biases in depression, the interplay between these cognitive mechanisms is not well understood.

In recent years, there is a growing consensus that cognitive biases should be studied in an integrative manner to augment understanding of each particular process as well as disordered cognitive functioning (see Everaert, Koster, & Derakshan, 2012; Hertel & Brozovich, 2010; Hirsch, Clark, & Mathews, 2006). It has been advocated that biased cognitive processes influence each other in that a bias at one stage (e.g., attention) affects the processing of this information at the other stages (e.g., interpretation). This notion has been labeled as the *combined cognitive bias hypothesis* (Hirsch et al., 2006). Indeed, there is increasing empirical study on such functional relations or the dependence between cognitive biases in healthy, at-risk, and depressed samples.

Relations Between Cognitive Biases

Some studies have examined memory in relation to emotional biases in attention. A study in a subclinically depressed sample found that a negative bias in attention at the elaborative stages, as indexed by a spatial cueing task, predicted later recall of negative words that were presented during the prior attention task (Koster, De Raedt, Leyman, & De Lissnyder, 2010). These findings were extended by the observation that the absence of attention bias for positive words, as displayed by subclinically depressed participants, was associated with less accurate recognition of these stimuli (Ellis, Beevers, & Wells, 2011). This research on functional relations between attention biases at elaborative stages and memory suggests that emotional biases in attention explain congruent biases in recall and recognition.

Memory has also been studied in relation to interpretation. Two cognitive bias modification studies (i.e., manipulation of cognitive processes through experimental procedures; Koster, Fox, & MacLeod, 2009) examined effects of interpretation bias on memory through induction of either a positive or a negative interpretative bias in an unselected undergraduate sample. A first study found that participants trained to interpret ambiguous information negatively exhibited improved recall of negative endings of ambiguous scenarios that were presented before the interpretation training, and vice versa for positive information (Salemink, Hertel, & Mackintosh, 2010). In addition, a second training study demonstrated that trained interpretation biases, either positive or negative, can also affect memory for subsequently encountered ambiguous scenarios in a bias congruent manner (Tran, Hertel, & Joormann, 2011). In line with these findings, Hertel and El-Messidi (2006) observed that, under conditions of experimentally heightened self-focused attention, subclinically depressed individuals interpret homographs (e.g., dump, blue) more often as personal and subsequently recall these interpretations to an increased extent. In sum, data on the dependence of memory on interpretation bias indicates that individuals recall events in the way they have previously interpreted it or congruent with their current interpretative bias.

Previous research linking attention and interpretation to memory provides some indication about cognitive processes that influence memory for emotional information.

However, current research is limited in that it fails to consider the influence of attention *and* interpretive bias on memory in a single study. Therefore, in a recent study, we investigated how memory depends on biases in attention and interpretation in subclinically depressed and non-depressed individuals (Everaert, Duyck, & Koster, submitted). All participants performed a computerized version of the scrambled sentences test (measure of interpretation bias) while their eye movements were registered online (measure of attention biases). Next, they completed an incidental free recall test probing previously endorsed interpretations (measure of memory bias). Based on predictions by cognitive models of depression we build complementary path models. The path analyses revealed a good fit for a model in which selective orienting of attention is associated with interpretation bias, which in turn is associated with a congruent bias in memory. Also, a good fit was observed for a path model in which depression-related biases in both sustained attention at encoding and interpretation are associated with memory bias. This first integrative study further improves our understanding of how exactly different components of attention and interpretation bias are related and operate together to influence recall of emotional information.

Research on the dependence between cognitive biases in depression has clearly progressed in the recent years. To date, however, there is still a paucity of integrative research examining how attention and interpretation might regulate memory for emotional information.

The Present Study

Following up on the basic demonstration of links between attention, interpretation and memory bias (Everaert et al., submitted), the present study sought to test specific theoretical predictions regarding functional relations among attention, interpretation, and memory biases. A central tenet within cognitive models of depression is that biased cognitive processes are interdependent (Clark, Beck, & Alford, 1999; Joormann, Yoon, & Zetsche, 2007; Williams, Watts, MacLeod, & Mathews, 1988). In theorizing about specific functional relations, cognitive models posit that biased attention has an indirect effect on memory through its impact on interpretation. That is, once negative information has entered the focus of attention, depressed individuals have difficulties disengaging their attention from it which results in extensive elaboration and biased interpretation. The attributed meaning is then likely to be stored into long-term memory setting the stage for negative biases in memory. This study was specifically designed to provide a direct test of this *indirect effect hypothesis*.

In contrast to prior studies investigating relations between cognitive biases within groups of subclinically depressed individuals, this study examined pathways between emotional biases in a mixed sample of non-depressed and subclinically depressed individuals. This is because cognitive models (e.g., Clark et al., 1999) assume a linear relation between the extent to which a process is biased toward negative information and depressive symptom severity, indicating that processing biases are involved in both normal and clinical cognition. A test of the combined cognitive bias hypothesis should consider relations between biases among a broad range of depression levels.

We administered a sequence of well-established cognitive tasks to measure biases at different processing levels (see below) and used similar stimulus materials across cognitive tasks. This enables an optimal test of how encountered information is processed through the several stages and also reduces the error variance associated with different experimental tasks which may diminish chances to find existing relationships between biases. As such, we attempted to provide a rigorous test of the combined cognitive bias hypothesis.

Method

Participants

Sixty-four undergraduates (56 women and 8 men; age range: 17-48; mean age 19.79 years) were recruited. Participants were selected on self-reported levels of depressive symptom severity assessed by the Beck Depression Inventory – II (BDI-II; Beck, Steer, &

Brown, 1996; Dutch version: Van der Does, 2002). The BDI-II scores were obtained in a screening which resulted in a broad range of symptom severity levels at the moment of testing (see below). Participants received course credits in return for their participation.

Depressive Symptom Levels

The BDI-II measures depressive symptom severity through 21 items. The questionnaire has good reliability and validity in both healthy and subclinically depressed samples (Beck et al., 1996; Van der Does, 2002). The internal consistency was α=.86 in this study. At testing, BDI-II scores ranged from 0 to 40, with 31 individuals reporting minimal (BDI-II cut off range: 0-13), 15 mild (BDI-II cut off range: 14–19), 14 moderate (BDI-II cut off range: 20-28), and 4 severe symptom levels (BDI-II cut off range: 29-63).

Assessment of Cognitive Biases

Attention bias. Selective attention was indexed by a spatial cueing task modeled after Koster et al. (2010). Previous research with this task observed individual differences in attention related to depression (see De Raedt & Koster, 2010). The task was programmed and presented using the Inquisit 3 Millisecond software package. On each trial of the task, participants focus on a black fixation cross presented for 500ms in the middle of the screen (white background), flanked by two black rectangles (3.0 cm high by 8.0 cm wide). The middle of these rectangles was 8 cm from the fixation cross. Next, a cue word (positive, neutral, or negative in valence) appeared for 1500ms in the middle of one of the rectangles. Then, a dot appeared 50ms after cue offset (CTOA=1550) in the same (i.e., valid trials) or opposite (i.e., invalid trials) rectangle where the cue word was previously displayed. Participants had to detect the position of the target, as fast and accurately as possible, by pressing one of two keys on a standard AZERTY keyboard. The target remained on the screen until a response was made. The following trial started immediately after responding.

Participants completed a total of 15 practice trials and 2 test blocks. Each test block contained 120 test trials and 6 catch trials. On the test trials there was a 50/50 ratio of valid (left cue/left target and right cue/right target) and invalid (left cue/right target and right cue/left target) trials was programmed. The words were presented at random at the left or right hemifield with an equal number of presentations for each word and emotion category. On the catch trials, a digit varying from 1 to 3 appeared at the center of the screen for 100ms. Participants were required to report the presented digit using the numerical keypad. These trails were included to encourage participants to fixate the middle of the screen at the beginning of each trial. Similar to Baert, De Raedt, and Koster (2010), a bias index from the cue validity scores (Cue validity: $RT_{invalid\ cue} - RT_{valid\ cue}$) was calculated by subtracting the cue validity of neutral trials from the cue validity from negative trails ($CV_{negative} - CV_{neutral}$).

Stimulus materials. Cues consisted of 20 negative (e.g., loser, sad), 20 positive (e.g., winner, happy), and 20 neutral words (e.g., central, weekly) that were written in uppercase letters (Times New Roman, size 35). To use similar stimulus materials across cognitive tasks, the emotional cue words in the spatial cueing task were selected from the interpretation bias task (i.e., the emotional words in the scrambled sentences test; see below). Neutral cue words were retrieved from Koster et al. (2010). Targets were black squares (0.7 by 0.7 cm). All word types were matched on word length (in number of letters; negative words: $M = 7.6$, $SD = 1.60$; neutral words: M=8.00, SD=1.49; positive words: $M = 8.30$, $SD = 1.42$) as indicated by non-significant t-tests (all p's>.05).

Interpretation bias. A scrambled sentences test (SST; Wenzlaff & Bates, 1998) assessed emotional biases in the individual's tendency to interpret ambiguous information. Prior studies with the SST revealed differences in interpretative tendencies between depressed and non-depressed samples (e.g., Rude, Wenzlaff, Gibbs, Vane, & Whitney, 2002). In this test, participants unscramble sentences using five of the six displayed words to form grammatically correct and meaningful statements (e.g., looks the future bright very dismal). By reporting the unscrambled sentence that first comes to mind, every sentence is resolved in either a positive (e.g., the future looks very *bright*) or negative (e.g., the future looks very *dismal*) manner. Twenty unscrambled sentences designed to tap into depression-relevant themes were retrieved from a previous study (Everaert et al., submitted). Participants received 2.5 minutes to complete the task.

As in previous research with the SST (e.g., Rude et al., 2002), a cognitive load procedure was added. This procedure aims to prevent deliberate (e.g., social desirable) report strategies. At start, all participants memorized a 6-digit-number to be recalled at the end of the test. A negative bias in interpretation was indexed by the ratio of negatively unscrambled sentences over the total correctly completed emotional sentences.

Memory bias. In the incidental free recall test, participants were asked to recall the sentences they had previously constructed during the SST as accurately as possible. A maximum of 5 minutes was allowed for this task. An unscrambled sentence was coded as a correctly recalled if it matched the sentence reported during the interpretation task in terms of valence (i.e., positive or negative), target word (e.g., bright, dismal), quantifier (e.g., very), and topic (e.g., future). Negative biases in memory were calculated by dividing the number of recalled negatively unscrambled sentences by the total number of emotional (i.e., positive and negative) unscrambled sentences recalled.

Procedure

Participants were tested in groups of 20 students in a computer room designed for testing large groups. They were seated at approximately 60 cm from the monitor. All participants started with the spatial cueing task which was immediately followed by the scrambled sentences task. After a short break (to reduce primacy and recency effects on recall), participants completed an incidental free recall test. Finally, participants filled in the BDI-II**.** The experimental session lasted approximately 60 min.

Data Preparation and Data Analysis

Data from the spatial cueing task were first trimmed by discarding trials with errors, removing participants (n=3) who exhibited a high level of erroneous responding on catch trials (>3*SD* from *M*=.04%.). Also responses reflecting anticipatory (RTs < 200ms) and delayed (RT > 750ms) responding were removed (Baert et al., 2010) as well as outliers (RTs deviating more than 3*SD* from the *M* of each trial type). Analyses were performed on 96.42% of the data.

The main analysis is an *indirect effect model* with attention bias as an independent variable, interpretation bias as an intervening variable, and memory bias entered as a dependent variable. Figure 1 depicts the tested model. To test whether the conditions of an indirect effect model were met, we examined the significance of the indirect effect (path *a* x *b*), the total effect (i.e., effect of attention bias on memory bias without taking interpretation bias into account; path *c*) and the direct effect (i.e., effect of attention bias on memory bias variable after controlling for interpretation bias; path *c'*). Following decision rules proposed by Mathieu and Taylor (2006), evidence for an indirect effect hypothesis is provided by a significant indirect effect and both non-significant total and direct effects. Recall that there are theoretical reasons to expect that both paths *c* and *c'* would be non-significant. That is, cognitive models do not postulate a direct influence of attention bias on memory bias (see introduction).

The indirect effect was directly tested using a bootstrapping approach (Preacher & Hayes, 2008). By relying on confidence intervals to determine the significance of the indirect effect, this powerful statistical method avoids problems associated with traditional approaches (e.g., unrealistic assumptions regarding multivariate normality; see Hayes, 2009). In this study, we estimated 5000 bias-corrected bootstrap 95% confidence intervals which should not contain 0 for the indirect effect to be significant.

Results

Sample characteristics

No differences occurred between subclinically depressed and non-depressed participants on age, $F(1,59)=1.06$, $p=.30$, or gender distribution ($\chi^2 < 1$). By design, significant group differences were found on the BDI-II. Table 1 provides statistics per group for gender ratio, BDI-II scores, and all cognitive biases.

(Table 1 about here)

Test of the Indirect Effect Model

Correlational Analysis. We observed a significant correlation between attention bias and interpretation bias, $r=.25$, $p<.05$, and between interpretation bias and memory bias, $r=.73$, $p<.001$. The correlation between attention bias and memory bias, $r=.01$, $p>.05$, was not significant. Moreover, we found that depressive symptom severity scores correlated with interpretation, $r=.77$, $p<.001$, and with memory bias, $r=.51$, $p<.001$, but not with attention bias, $r=.19$, $p>.05$.

Importantly, skewness and kurtosis statistics (z-scores) indicated no substantial deviations from normality for the critical variables when applying a criterion of 2.58 recommended for larger sample sizes: depression levels, *skewness*= 1.87, *kurtosis*=0.58, emotional biases in attention, *skewness*=1.28, *kurtosis*=0.54, interpretation, *skewness*=1.98, *kurtosis*=-0.73, and memory, *skewness*=1.42, *kurtosis*=-1.71.

Bias-Corrected Bootstrapping Analysis. Results of the bias-corrected bootstrapping procedure revealed that the indirect effect of attention bias on memory bias via interpretation bias was positive (indirect effect coefficient = .12) and statistically different from zero ($p<.05$). The bias-corrected bootstrap confidence interval was entirely above zero, 95% CI =

[.004, .270]. Both the total effect, c=.06, t=0.77, p=.44, and the direct effect, c'_1=-.06, t=-1.02, p=.31, were not significant. These results are consistent with the hypothesis of an indirect effect of attention on memory bias through interpretation bias as an intervening variable.

Discussion

Negative biases in attention, interpretation, and memory are viewed as critical cognitive mechanisms underlying depression. Although a wide range of empirical studies supports these cognitive biases in different depressed samples, the interplay between them received little empirical consideration. Starting from predictions by cognitive models of depression, the present study tested specific functional relations between negative biases in attention, interpretation, and memory. Non-depressed and subclinically depressed participants completed a sequence of cognitive tasks measuring biases at these different levels of processing. The main finding of this study is that a negative bias in attention has an indirect effect on memory via a negative bias in interpretation.

The reported evidence for the indirect effect model lends support for predictions by cognitive models of depression (Clark et al., 1999; Joormann et al., 2007; Williams et al., 1988). These models postulate that cognitive biases emerge at different levels of processing and influence each other in that a negative bias at one level affects the further processing of this information at other levels. In line with this *combined cognitive bias hypothesis,* our data indicates that how emotional information is attended is related to congruent biases in subsequent interpretation which in turn improves memory for this information. As such, memory bias reflects interpretative choices in that when depressed individuals make more negative interpretations of an event, they are more likely to recall these negative interpretations. Also, interpretation bias reflects biased attention allocation in that only the selected (negative) information is processed. These findings connect observations by prior research linking memory to interpretation biases (Hertel & El-Messidi, 2006; Salemink et al., 2010; Tran et al., 2011) and memory to attention biases (Ellis et al., 2011; Koster et al., 2010) by suggesting that interpretation/elaboration processes determine how attention regulates memory for emotional information. Moreover, our findings converge with the results of our previous study in which a good fit was observed for the path model including a link between depressive symptom levels tied to biases in attention, in particular the selection component, predicted interpretation biases which in turn were related congruent memory biases (Everaert et al., submitted). Although we did not observe a correlation between depression scores and attention bias in this study, the presented data replicates the indirect effect of attention on memory via interpretation, using a different cognitive task to measure attention bias. This also provides further support for the role of attention bias in accounting for emotional biases in interpretation. As such, the explicit test of the indirect effect hypothesis in the present study further substantiates the modeled interplay between cognitive biases.

A finding that needs to be addressed is that we did not find a relation between depressive symptom severity and attention bias, though the predicted relations emerged in interpretation and memory processes. This is not in line with the majority of previous studies (for a review, see De Raedt & Koster, 2010), despite that some researchers failed to find attention bias in relation to depression using the spatial cueing task (e.g., Koster, Leyman, De Raedt, & Crombez, 2006). Although depressive symptom severity scores were not related to attention bias, the bias index of this cognitive process was related to congruent biases in interpretation which showed a relation with depression scores. This indicates that, even when not related to depression in this study, an emotional bias in attention (which is the gate of all incoming information) is of importance through its influence on other cognitive processes involved in depression.

In addition to the theoretical relevance of our findings, the present results have also clinical implications. Our findings suggest that a cognitive bias at one level of processing can maintain dysfunctional attitudes through the impact on the later processing stages. For example, in attending to negative instead of positive information (e.g., frowned eyebrows of one of the assessors during a job interview), individuals might subsequently endorse more negative interpretations of this information (e.g., “I am making a bad impression”, “they think I am not capable for the job”). These negative interpretations might consolidate maladaptive beliefs (e.g., “I am worthless”) and further activate mood-congruent memories (e.g., broken relationship). Similarly, our findings also suggests that reducing a cognitive bias (e.g., through cognitive bias modification techniques) at an early processing level (e.g., attention) may alter the further processing of this information and, eventually, might make dysfunctional beliefs more adaptive.

Some limitations of the present investigation should be noted. First, the design of this study does not allow conclusions regarding the causal direction of the modeled relations between cognitive biases. Although features of our study design (i.e., temporal precedence of processes and tasks, similar stimulus materials across tasks) optimized conditions to test the indirect effect hypothesis and allow some confidence in the predicted chain of relations between cognitive biases, experimental manipulation is required to stringently test the direction of the effects. In this regard, cognitive bias modification techniques provide the tools to test the postulated causal relations (see Koster et al., 2009). For example, to investigate the causal influence of attention bias on interpretation, investigators could manipulate attention allocation (e.g., either by training healthy individuals to attend to positive or negative information, or by training depressed individuals to attend away from negative and toward positive information) and examine differences between the conditions in interpretative tendencies. The data reported here suggests that training an emotional bias in attention would result in congruent biases in interpretation. Our results may provide an impetus for future research to test the direction of the relations through experimental manipulation.

Other limitations involve the low number of men in this sample. Although the gender distribution was representative for an undergraduate university college, it may limit the generalizability of the findings to men. Given gender differences in the risk of depression (see Nolen-Hoeksema & Hilt, 2009), future research could investigate gender differences in the interplay between vulnerability mechanisms underlying the disorder (e.g., how cognitive biases are involved in gender differences in rumination). Moreover, this study was conducted in a subclinically depressed sample and thus caution is warranted in drawing conclusions about clinical symptom levels of depression. Nevertheless, the reported findings remain of importance because individuals with subclinical symptom levels experience significant suffering and are at risk to develop clinical depression. The emotional biases in attention, interpretation, and memory are likely to contribute to this pathogenesis (Gotlib & Joormann, 2010). Finally, the tasks were presented in a fixed order and we cannot fully exclude the possibility of demand effects in remembering. That is, it could be that individuals try to deliberately try to recall the sentences they have formed during the SST to make a consistent impression.

In conclusion, this study sought to investigate a specific hypothesis regarding the interplay among attention, interpretation, and memory biases in a mixed sample of non-depressed and subclinically depressed individuals. The findings showed that memory bias can be explained by interpretative choices and that interpretative choices in turn can be explained by biases in attention. The evidence for this indirect effect of attention bias on memory through interpretation bias as an intervening variable adds further support for the combined cognitive bias hypothesis in depression.

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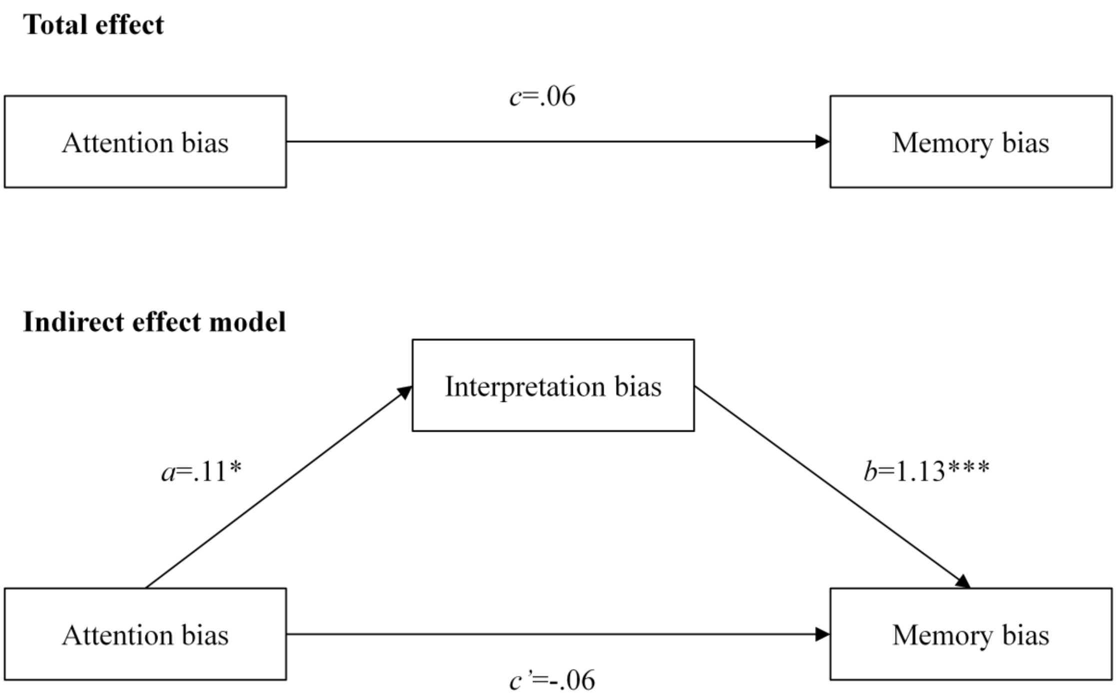
Table 1.

Group Differences

			Group			
			Non-depressed		Subclinical	
			M	*SD*	*M*	*SD*
Age			20.41	6.36	19.22	1.54
Gender ratio (m/f)			3/26		4/28	
BDI-II			8.29	4.04	21.76	6.28
Attention (ms)	Negative cues	Valid trials	381.07	56.74	372.08	48.93
		Invalid trials	365.88	47.73	363.07	42.40
	Neutral cues	Valid trials	376.55	54.48	373.83	46.13
		Invalid trials	370.24	57.16	363.92	47.37
	Positive cues	Valid trials	378.15	54.79	375.58	49.37
		Invalid trials	366.46	56.47	363.36	46.27
Interpretation	Relative bias index		20.69	16.85	46.73	21.68
	No. of positive items		9.81	3.52	6.64	3.25
	No. of negative items		2.39	1.63	5.97	3.58
Memory	Relative bias index		31.97	35.77	50.14	33.63
	No. of positive items		2.58	1.65	1.88	1.27
	No. of negative items		1.00	1.03	1.82	1.26

Note1. BDI-II = Beck Depression Inventory. *Note2*. According to established cut off criteria (Beck et al., 1996), participants were classified as either non-depressed or subclinically depressed when they reported a BDI-II total score lower than or equal to/higher than 14, respectively. *Note3*. Relative bias indexes compare positive vs. negative information. *Note4*. Age data of 4 participants was missing.

Figure 1. Indirect, total, and direct effects of attention bias on memory bias with interpretation bias as an intervening variable.



Note1. * $p < .05$, *** $p < .001$. *Note2*. Unstandardized regression coefficients are displayed.