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Attentional Bias in Depressive Patients and the Moderating Effect of Concurrent Anxiety

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Key Words
Emotional Stroop · Attentional bias · Anxiety · Depression

Abstract

Background: Most previous studies finding positive results in the emotional Stroop test did not control for concurrent anxiety symptoms. This study investigated depressive patients without comorbid anxiety disorders in order to clarify existing inconsistent findings. Furthermore, we examined the relationship between anxiety level and the emotional Stroop effect in patients and healthy subjects. Subjects and Methods: Twenty-three depressive patients without comorbid anxiety disorder and 27 healthy subjects performed a mixed computerized version of the emotional Stroop test (attentional bias test). We assessed the state and trait anxiety and examined its correlation with the emotional Stroop effect. Results: We failed to find evidence for attentional bias in the patients as measured by longer reaction times to the emotional stimuli. However, there was a positive correlation between state anxiety and attentional bias in depressed patients. On the other hand, in healthy subjects the trait anxiety correlated negatively with attentional bias. Conclusions: Attentional bias is not found in depressed patients if only patients without comorbid anxiety disorders are included. Furthermore, healthy subjects with high trait anxiety levels may be vulnerable to affective disorders because they use avoidance strategies when encountering negative information.

Introduction

Cognitive theories of depression emphasize the importance of cognitive processes in the etiology, maintenance and treatment of depression. According to these theories, biased information processing towards negative information elevates the risk for depression [1, 2]. However, empirical research concerning biased information processing only partly supports this assumption [3]. There is strong evidence for biased memory processes in depression (see also contradictory findings, e.g. [4]), but conclusive evidence for biased attention is missing. Therefore, Williams et al. [3] proposed an alternative interpretation that anxiety and depression are characterized by different patterns of biased information processing. According to their model, in anxiety, information process-
ing is biased at an early stage resulting in attentional biases. In depression on the other hand, the biased processing occurs at the level of strategic elaboration resulting in memory biases. Because the depressive and anxiety disorders are very likely to have different biases of information processing, it is important to investigate depressive patients without comorbid anxiety disorder. According to the US National Comorbidity Survey, 58% of the patients with major depressive disorder had a comorbid anxiety disorder [5]. We hypothesized that the high occurrence of anxiety disorders among depressive patients accounts for the inconsistent results related to attentional bias in depression.

A modified version of the Stroop task, the emotional Stroop task, has been widely used to investigate attentional biases in anxiety and depression [6, 7]. In this task, the subjects are presented with emotional words in different colors and are asked to identify the ink color of the emotional words. If the subjects have difficulties ignoring the meaning of emotional words, the reaction times (RTs) increase. We refer to this effect as the emotional Stroop effect in the rest of the paper. In earlier studies, depressive subjects showed greater emotional Stroop effect in naming negative or depressed-content words than healthy subjects [8–11]. A recent study also reported that depressed patients exhibited greater interference for naming the colors of negative words than did controls [12]. However, it should be noted that these authors calculated the interference score by subtracting RTs of the nonlexical characters from the negative words, which renders the comparison with other studies difficult.

However, other studies did not find the emotional Stroop effect for negative stimuli [13–17], including some recent research [18–20]. Bradley et al. [21] suggested that the duration of stimulus exposure could explain the inconsistent findings. Attentional biases have tended to occur in tasks using relatively long exposure durations of ≥1 s [8, 9, 21, 22]. One possible explanation for this finding is that when depressed individuals focus their attention on negative information, they have greater difficulty in disengaging their attention from it. However, it should be noted that there are also studies which have found attentional bias for stimulus exposure durations <1 s [11, 12]. Furthermore, a recent study using an exposure duration of 1.5 s did not find attentional bias in dysphoric participants [19]. These results suggest that other factors may account for the inconsistency in previous results.

Because patients with depressive disorder are a highly heterogeneous group, the specific participants selected for study merit attention. In particular, attention must be paid to anxiety symptoms because an influence of anxiety on the emotional Stroop effect has been well established (see meta-analysis by Bar-Haim et al. [23]). Because more than half of the depressed patients concomitantly experience anxiety symptoms, this can lead to important confounding effects. However, most former studies investigating the emotional Stroop effect in depression neither reported nor controlled for the level of anxiety. To control for this factor, we excluded patients with a comorbid anxiety disorder and furthermore assessed anxiety in the depressive patients included in the study.

Moreover, these effects of anxiety on the emotional Stroop are not limited to clinical populations. The meta-analysis by Bar-Haim et al. [23] shows that attentional bias is reliably demonstrated for high-anxious nonclinical individuals and is not observed in nonanxious subjects. In addition, the results indicate that nonanxious individuals show avoidance of threat-related stimuli by shifting attention away from them. However, it remains unclear whether the attentional bias in high-anxious subjects is mediated by stable personality traits (trait anxiety) or a transient mood state (state anxiety). To address this issue we assessed the differences in state and trait anxiety in healthy subjects and their influence on RTs in the emotional Stroop test.

To summarize, the main goals of this study were:
– to investigate attentional bias in healthy subjects and depressive patients in a mixed emotional Stroop task;
– to assess the level of state and trait anxiety and examine its correlation with the emotional Stroop effect.

**Methods**

**Subjects**

Twenty-three patients with unipolar major depression according to DSM-IV (age = 41 ± 11.4 years, range = 19–59) and 27 healthy subjects (age = 41 ± 7.3 years, range = 28–54) participated in the study (for demographic data see table 1). The groups did not differ according to gender, age and years of school education. Exclusion criteria were a history of neurological or major medical disorders which may affect cognitive or brain functions. Handedness was assessed by a German version of the Edinburgh Handedness Inventory [24] and only right-handed subjects were included in the study. All subjects had normal or corrected-to-normal vision, normal color vision as assessed by the test of Velhagen and Broschmann [25] and were native German speakers.

Patients were recruited from the wards of the University of Heidelberg Psychiatric Hospital. The clinical diagnosis was confirmed by Structured Clinical Interviews for DSM-IV. All patients with a history of an axis I disorder other than unipolar depression were excluded from the study. Severity of depression was assessed
was a short break (10 min) between the emotional Stroop task and the classical Stroop task. Before the tests were performed, the subjects filled in the questionnaires and the color vision test was conducted.

The study protocol was approved by the local ethics committee and all subjects gave written informed consent (Declaration of Helsinki) after the experiment had been fully explained.

### Data Analysis

#### Emotional Stroop Test

The subjects’ RTs and error rates were recorded using the Stim software. For statistical analysis of the behavioral data, 2 separate ANOVAs with RTs and error rates as dependent measures were performed with condition (neutral, positive, and negative) and run (first and second) as within-subject factors and group as a between-subject factor. Greenhouse-Geisser correction was applied where appropriate. The Newman-Keuls test was used for post hoc comparisons. Furthermore, RTs of the neutral condition were subtracted from those of the positive (happy Stroop) and negative (sad Stroop) condition.

### Correlations

Pearson correlations were calculated between clinical data and the ‘sad’/‘happy’ Stroop effect. We calculated the correlations for different test measures and psychometric data separately for the patients and controls because there is evidence for categorically
different processes in healthy subjects and emotional disorders [34]. Furthermore, in order to minimize the correlations calculated, we only calculated them for the emotional Stroop effect of the first run. Depressive symptoms of controls could not be investigated because they had very low scores on the BDI and HRSD.

**Results**

Table 2 contains the mean RTs and number of errors for healthy subjects and patients. The ANOVA for RTs revealed a trend towards a main effect of group [F(1, 48) = 3.2, p = 0.08], patients having slower RTs than healthy subjects. A main effect of run [F(1, 48) = 14.5, p < 0.001] revealed that all subjects were faster in the second run. There was no significant main effect of condition [F(2, 96) = 0.1, NS]. The group × condition interaction was not found to be significant.

According to the t test there were no significant differences between the depressive patients and the controls for any of the the emotional Stroop effects: negative-neutral and positive-neutral.

The analysis of error percentages yielded a main effect of condition [F(2, 96) = 13.9, p < 0.001] indicating that all subjects committed more errors in the negative condition compared to the positive (p < 0.001) and neutral (p < 0.001) ones. A trend level main effect of run [F(1, 48) = 2.7, p = 0.10] revealed that all subjects committed more errors in the first than in the second run. Furthermore, a trend level interaction group × run × condition was found [F(2, 96) = 2.9, p = 0.06]. The patients committed more errors in the negative than in the positive condition in the second run (p < 0.07). The healthy subjects committed as many errors in the negative as in the positive conditions in the second run.

**Correlations of the Emotional Stroop Effect with Age, Education and Duration of Depression**

There was no significant correlation between the ‘sad’ Stroop effect and age or years of education (all subjects included). Neither the length of the illness (months from the time first depressive episode started) nor the length of the hospitalization (weeks) correlated with the ‘sad’ Stroop effect.

**Correlations of the Emotional Stroop Effect with Anxiety and Depression Symptoms**

In the patients, the STAI-State (State-Trait Anxiety Inventory) and the ‘sad’ Stroop effect correlated significantly (r = 0.46, p < 0.05; table 3). This indicated that the higher the STAI-State score, the longer the RT in the negative condition compared to the neutral condition. There was no correlation between depressive symptoms (BDI and HRSD) and the ‘sad’ Stroop effect in the patients. The number of depressive episodes so far correlated with the ‘happy’ Stroop effect (r = 0.50, p < 0.02), showing that the higher the number of the episodes so far, the longer the

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**Table 2. Summary of behavioral data of the emotional Stroop test**

| Condition: | Neutral | | Positive | | Negative |
|-----------|---------| |---------| |---------|
| Run: 1    | 2       | | 1       | 2       | 1       |
| Group: C  | P       | | C       | P       | C       |
| C         | P       | | C       | P       | C       |
| RT, ms    | 695     | 765 | 673     | 727     | 697     | 755 | 672     | 732     | 697     | 764 | 674     | 732     |
| SD, ms    | 123     | 117 | 114     | 135     | 130     | 118 | 118     | 137     | 129     | 122 | 115     | 140     |
| Error, %  | 2.9     | 2.0 | 1.6     | 2.1     | 2.0     | 2.5 | 2.1     | 1.6     | 3.2     | 2.9  | 2.6     | 3.5     |
| SD, %     | 2.3     | 2.5 | 1.8     | 2.7     | 1.9     | 2.7 | 2.3     | 2.0     | 2.5     | 2.7  | 1.9     | 3.1     |

Means and standard deviations (SD) for RTs (milliseconds) and error percentages for different emotional Stroop task conditions, runs (1 and 2) and groups (healthy controls = C and patients = P).

**Table 3. Summary of the correlations between the anxiety/depressive symptoms and the emotional Stroop effect in depressed patients**

<table>
<thead>
<tr>
<th></th>
<th>BDI</th>
<th>STAI-state</th>
<th>STAI-trait</th>
<th>Depressive episodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sad Stroop</td>
<td>0.19</td>
<td>0.46*</td>
<td>0.26</td>
<td>0.22</td>
</tr>
<tr>
<td>Happy Stroop</td>
<td>0.17</td>
<td>0.29</td>
<td>0.20</td>
<td>0.50*</td>
</tr>
</tbody>
</table>

* p < 0.05.
RTs in the positive condition compared to the neutral condition. In the healthy subjects on the other hand there was a negative correlation between the STAI-Trait score and the ‘sad’ Stroop effect \( r = -0.39, p < 0.05 \), showing that the higher the STAI-Trait score, the faster the RTs in the negative condition compared to the neutral condition.

**Carryover Effects**

Because recent studies have shown that negative words can interfere with the processing of subsequent words, we addressed these carryover effects in an exploratory analysis. Three separate ANOVAs with RTs as the dependent measures were performed with condition (preceding stimuli were neutral, positive or negative) and run (first and second) as within-subject factors and group as a between-subject factor. The analysis of the neutral words as the target stimuli revealed an insignificant main effect of condition \( F(2, 96) = 2.1, \text{NS} \). The emotional stimuli as the target stimuli also yielded insignificant results; negative stimuli \( F(2, 96) = 1.7, \text{NS} \) and positive stimuli \( F(2, 96) = 1.4, \text{NS} \). The group \( \times \) condition (neutral stimuli as the target stimuli) interaction revealed a trend effect \( F(2, 96) = 2.9, p = 0.06 \). The post hoc tests show that the depressive patients were slower when responding to the neutral words preceded by a neutral word \( (p < 0.05) \) than when the preceding word was negative or positive (NS).

**Discussion**

The main goal of this study was to investigate attentional bias for depression-related stimuli in depressive patients without comorbid anxiety disorders in order to clarify the existing inconsistent findings. In addition, we investigated the influence of trait and state anxiety on emotional interference in healthy subjects and depressive patients.

Our study failed to find attentional bias in the emotional Stroop task in depressed patients compared to healthy controls. This is in line with other findings investigating the emotional Stroop task \([13–17]\), including recent studies \([18–20]\). In considering possible reasons for the absence of the Stroop effect \([23]\), we first discuss the patient characteristics in our group. In the present study, we particularly excluded patients with comorbid anxiety disorders. This was warranted because of the well-established impact of anxiety on the emotional Stroop effect. In contrast, most previous studies did not exclude patients with comorbid anxiety disorders. Comparison with these studies is difficult because neither the number of patients with comorbid anxiety disorders nor the current level of anxiety symptoms were reported in these studies. Our results suggest that on a group level attentional bias cannot be demonstrated in depressive patients without comorbid anxiety. We further explored the dimensional relationship between state and trait anxiety and attentional bias. We found a correlation between state anxiety and the emotional Stroop effect in depressed patients. Patients with higher state anxiety scores showed longer RTs in the negative condition compared to the neutral condition. This supports the impact of anxiety on attentional bias in depressive patients, even when excluding the most extreme cases (i.e., those fulfilling the criteria for an anxiety disorder). The only previous study addressing this issue did not find any significant correlation between the biases in the emotional Stroop task and anxiety measures. However, they employed a different psychometric instrument to measure anxiety as compared to the present study \([35]\).

Secondly, the stimulus content used in experiments is also considered to play an important role in investigating the emotional Stroop test. Beck \([2, 36]\) postulated in his theory that depressed individuals attend to negative information which is congruent with, and relevant to, their negative schemata (content-specificity). Gotlib et al. \([35]\) tested this content-specificity perspective and they demonstrated in the emotion face dot-probe task attentional bias in depressed patients only for depression-relevant stimuli and not for threat-related stimuli \([35]\). However, they found no differences in the emotional Stroop task between depression- and threat-related stimuli. In order to be sure that our null finding was not due to the stimuli used, we afterwards asked 6 clinical psychologists with experience in the treatment of depression to rate the words according to their relevance to depression and happiness. They rated on a 5-point scale how relevant each word used in the experiment was to depression and happiness \((1 = \text{not relevant at all and } 5 = \text{very relevant})\). The mean rating for depression-related words was a relevance of 4.7 to depression and 1.3 to happiness. We also checked for the relevance ratings for happiness-related words and found that the ratings were equally good – the mean rating of happiness-related words was a relevance of 4.3 for happiness and 1.4 for depression.

Finally, a further aspect which should be considered involves the test used. Instead of blocking conditions, the computerized mixed Stroop test was employed. The mixed version produces lower interference effects than blocking conditions \([6]\). Further, recent studies show that
negative words can interfere with the processing of any subsequent words (carryover effects) [37–39]. This means that the patients could be slower to respond to the words which follow the emotional words related to their psychopathology. Afterwards, we reanalyzed our data concerning the carryover effects (also called slow component). We found no overall carryover effect. The results show that the depressive patients were slower when responding to the neutral words preceded by a neutral word than when the preceding word was negative or positive. This is very likely due to the probabilities; the proportion of consecutive trials that are from different emotional categories is greater than that of consecutive trials that are from the same emotional categories [37]. Thus, we found no carryover effect, i.e. no interference of the negative stimuli with the subsequent stimuli.

Therefore, we summarize that the null results found in this study are not due to the test version employed. In contrast, anxiety symptoms seem to be the most important confounding factor when investigating attentional bias in depressive patients. Further studies should report the level of concurrent anxiety symptoms.

In our study both groups committed more errors in the negative than in the positive and neutral conditions. This finding provides evidence for the attentional bias toward negative words in all subjects because the subjects were distracted from the given task generating more errors. Because the error rates were quite low, further studies are needed to investigate error rates in the emotional Stroop test. Most studies investigating the emotional Stroop effect did not report error rates. Studies in healthy subjects found no significant difference in error rates between conditions [40, 41]. McKenna and Sharma [40] investigated the role of intrusive cognitions using the emotional Stroop task. According to them, negative stimuli command processing independently of the person’s explicit goals. This disruptive effect of negative stimuli decreased with repetition because repetition results in habituation. When analyzing the RTs, we did not find any habituation effect (there was no significant condition and run effect). However, when analyzing the error rates, the main effect of run reached trend level significance revealing that all subjects committed more errors in the first run than in the second run. Furthermore, the patients committed as many errors in the negative, positive and neutral conditions in the first run but not in the second run; the patients committed more errors in the negative condition compared to the positive condition in the second run. There was no significant difference in the first run between the conditions in the patients. Therefore, we conclude that healthy subjects habituate in the negative condition but patients do not.

In the healthy subjects the trait anxiety score and the emotional Stroop effect (negative-neutral) correlated negatively. This indicated that the nonclinical subjects with high trait anxiety reacted faster in the negative condition compared to the neutral condition. This pattern supports the theory that vulnerable individuals, who score high in trait anxiety, use controlled avoidance strategies when encountering negative or threatening stimuli [34]. Because these avoidance strategies are thought to be controlled, they are resource limited. When the person faces severe or prolonged stress, these strategies are likely to fail. According to Mathews and MacLeod [34] such failure of control may correspond to the onset of emotional disorders. Bar-Haim et al. [23] put forward a new theoretical model about cognitive mechanisms underlying the attentional bias in anxiety, and it relates in an interesting manner to our results in healthy subjects. According to the model, anxious subjects may display abnormal processing at different stages of processing: at the preattentive threat evaluation system, resource allocation system, guided threat evaluation system and goal engagement system. At the stage of the guided threat evaluation system, strategic processing takes place. If the outcome of this evaluation is estimated as a low-threat situation, the overriding of the automatic threat evaluation takes place. As a result, the minor negative stimuli are ignored and could therefore result in faster reactions to negative stimuli in tasks like the emotional Stroop task. This was very likely the case in healthy subjects in our study. In contrast, the patients could estimate the experimental situation as more threatening and in such a high-threat situation, a high state of anxiety is likely to proceed [23]. This may result in a higher state anxiety and longer RTs to negative words as shown by our patients.

A major limitation of our study is that all patients were medicated with antidepressants. Few studies have investigated the effects of medication on cognitive tests. Killian et al. [42] found that antidepressant medication did not influence performance on the Stroop test. Another study showed that the cognitive deficits of depressive patients are not likely to be caused by the continuous antidepressant medication [43]. One recent study found that a single dose of an antidepressant can increase the processing of positively valenced material in nondepressed subjects [44]. However, Munafo et al. [45] found that the patients with a history of depression currently not on antidepressant medication did not show any difference in emotional Stroop task after acute tryptophan depletion. In con-
The patients with a history of depression currently on antidepressant medication showed an attentional bias towards social threat material. Because they found the differing vulnerability to compromised serotonin function, we could conclude that our results were not related to medication. The fact that all emotional Stroop studies so far investigated medicated depressive patients also supports this view. Furthermore, one has to be careful interpreting the results of the studies investigating performance in healthy subjects after receiving a single-dose antidepressant [46]. Considering the effects of benzodiazepines on cognitive functions, meta-analyses found that cognitive dysfunction did occur in patients on long-term treatment with benzodiazepines [47]. However, our patients were not treated with benzodiazepines as a long-term medication. Regarding acute effects of benzodiazepine administration we took care that the patients did not receive benzodiazepines before testing. Furthermore, in our study only 4 patients out of 23 received benzodiazepines and therefore it is not likely that our results are confounded by effects of benzodiazepines.

We conclude that attentional bias for depression-related stimuli is not likely to occur in depressed patients without comorbid anxiety disorders. Because we found a relationship between anxiety level and the emotional Stroop effect in depressed patients and healthy subjects, anxiety symptoms may be the most important confounding factor that should be controlled in future studies. In addition, we suggest that the high-anxious healthy subjects are vulnerable to affective disorders because of a tendency to avoid negative information reflected in the faster RTs to negative words. It is important to identify such risk factors in healthy subjects in order to prevent the development of affective disorders, and therefore attention should be paid by clinicians to subclinical anxiety symptoms.

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References


