Shorter communication

Selective attention and threat: Quick orienting versus slow disengagement and two versions of the dot probe task

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Received 15 June 2005; received in revised form 13 April 2006; accepted 21 April 2006

Abstract

The dot probe task is often used to assess attentional bias in anxiety, but some aspects need clarification. First, the results, which are traditionally summarized in an attentional bias index, do not allow for distinguishing between different selective attention processes; orienting and disengagement. Second, different versions of the dot probe task have been used with unknown relative merits. Participants \(N = 133\) completed two versions of the dot probe task: the detection task (i.e. is there a probe?) and the differentiation task (i.e. what sort of probe is it?). The analysis carried out allowed for a differentiation between orienting and disengagement. The main finding was that trait anxiety is related to disengagement difficulties and not to speed of orienting. Concerning the relative merits of the two dot probe task versions, the results suggest that the detection task may be superior to the differentiation task. Implications for past and future research are discussed.

Keywords: Anxiety; Attentional bias; Disengagement; Dot probe task

Introduction

Attentional bias in anxiety has been studied extensively with the dot probe task (e.g. (MacLeod, Mathews, & Tata, 1986; Mansell, Clark, Ehlers, & Chen, 1999; Mogg, Bradley, Dixon et al., 2000). Surprisingly, however, it is not exactly clear what attentional processes this dot probe task reflects and what aspects of attention are measured. A second striking feature is the use of different versions of the dot probe task, with unknown relative merits. The present paper addresses both the issues.

Relative to healthy participants, anxious patients attend more to threatening information than to neutral information. This “attentional bias” was originally demonstrated with the emotional Stroop task (Williams, Mathews, & MacLeod, 1996). However, there is considerable doubt whether the results reflect a bias in the allocation of attentional resources. De Ruiter and Brosschot (1994) suggested cognitive avoidance as a potential alternative explanation for the Stroop results. It has been suggested that a more straightforward way

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of assessing attentional bias for threatening information is the dot probe task (MacLeod et al., 1986). In this paradigm, two words are simultaneously presented on a computer screen and occasionally a small dot appears in one of the two screen locations previously occupied by one of the words. Participants are required to detect the dot as quickly as possible and to respond by pressing a button. Visual attention to particular words results in quick detection of dots appearing in a same region of the computer screen and slow detection of dots appearing in a different region. Attentional bias in anxious patients is inferred from relatively faster detection of dots replacing anxiety-related stimuli than neutral stimuli (Bradley, Mogg, White, Groom, & de Bono, 1999; Mathews, Ridgeway, & Williamson, 1996).

However, two remarks may be made. First, not only with respect to the emotional Stroop task, but also with respect to the visual dot probe task it is not exactly clear what the task measures. Posner and Petersen (1990) divide the human attention system into several subsystems, two of which are relevant in the present context: orienting toward stimuli and disengaging from stimuli. Note that in the dot probe literature the attentional bias measure is a compound score made up of orienting toward and disengaging from a stimulus. That is, the traditional attentional bias “index” is calculated by subtracting the mean reaction times (RT) to dots replacing threat stimuli, from the mean RT to dots replacing neutral stimuli in a threat–neutral stimulus pair. In equation: attentional bias index = “RT dot at neutral location”−“RT dot at threat location” (Bradley, Mogg, Falla, & Hamilton, 1998; MacLeod et al., 1986; Mogg, Bradley, & Hallowell, 1994). A positive index score may result from either a small “RT threat” component, reflecting fast responses to dots replacing threat stimuli (e.g. orienting toward threat), and/or a large “RT neutral” component, reflecting slow responses to dots replacing neutral stimuli, presumably due to slow disengagement from threat words. Thus, high attentional bias scores of anxious individuals could be due to greater orientation toward threat or to more difficulty in disengaging attention from threat or to both.

To disentangle the selective attention processes in anxiety, Amir, Elias, Klumpp, and Przeworski (2003), Fox, Russo, Bowles, and Dutton (2001), and Yiend and Mathews (2001) used an exogenous cueing paradigm, in which participants were required to respond to a neutral target, which was sometimes cued by an emotional or neutral stimulus. Yiend and Mathews used threatening and neutral pictures as cues and reported that, relative to low-trait anxious students (n = 19), high-trait anxious students (n = 20) had more difficulty in disengaging their attention from threatening pictures, but there was no between group difference in orientation toward threatening cues. Angry, happy and neutral faces were used as cues by Fox et al. and they found that there was a delay in disengaging attention from threat in high-state anxious participants relative to low-state anxious participants. Amir et al. used words as cues and reported the same pattern in patients with social phobia (n = 18) compared to non-anxious controls (n = 20). Thus, results from the cueing paradigm indicate that the main attentional peculiarity of anxious individuals is to delay attentional disengagement in case of threatening stimuli.

Recently Koster, Crombez, Verschuere, and De Houwer (2004) adapted the dot probe task to allow for a differentiation between the two aspects of attention, by adding trials with only neutral stimuli. Fast orienting toward threat will result in faster responses to dots replacing the location of the threat stimuli compared to dots replacing neutral stimuli. Difficulties in disengaging from threat will result in slower responses to dots replacing neutral stimuli, when a threat stimulus is in the other location, compared to when a neutral stimulus is in the other location. In a student sample (N = 44), Koster et al. found no evidence of enhanced orienting. However, they did find that all participants had difficulty disengaging attention from threat. A significant correlation (r = .42) between the traditional attentional bias index and trait anxiety was found, but the investigators did not report correlations between the new indices of selective attention and anxiety. Taken together, these results seem to suggest that dot probe results reflect difficulty in disengaging attention from threat.

A second point of concern relates to the precise nature of the dot probe task, which has been subjected to major changes, adaptations, and developments through the years, leading to various forms of the task being used at the moment. Two forms of the dot probe task are most frequently used. The first is the simple probe detection task of Macleod et al. (1986), in which high and low anxious participants are required to respond to a dot that occasionally replaces either a threatening or a neutral stimulus (Brosschot, de Ruiter, & Kindt, 1999; Dalgleish, Moradi, Taghavi, Neshat Doost, & Yule, 2001; Mansell, Clark, & Ehlers, 2003;

In a second version of the dot probe task, participants are required to detect a probe and to differentiate between two types of probes (‘:’ versus ‘…’ or ‘E’ versus ‘F’ or ‘↑’ versus ‘↓’) or, in a different sort of computer version, between locations of the probe (left versus right or top versus bottom) (see for attentional research in anxiety: Bradley, Mogg, Falla et al., 1998; Bradley, Mogg, Millar, Bonham Carter et al., 1997; Bradley, Mogg, & Millar, 2000; Bradley, Mogg, White et al., 1999; Chen, Ehlers, Clark, & Mansell, 2002; Fox, 2002; Keogh, Dillon, Georgiou, & Hunt, 2001; Mansell et al., 1999; Mansell, Ehlers, Clark, & Chen, 2002; Mogg & Bradley, 1999; Mogg, Bradley, De Bono, & Painter, 1997; Mogg, Bradley, Dixon et al., 2000; Mogg et al., 1994; Mogg, McNamara, et al., 2000; Mogg, Millar, & Bradley, 2000).

It is unclear whether the two versions measure the same phenomena. Mogg and Bradley (1999) compared two differentiation tasks (type of probe versus location of the probe) in a non-clinical student population. No difference in the pattern of selective attention and in effect sizes was found between the two tasks. However, these tasks were not compared within one study and the original detection task was not administered. Another relevant indistinctness is whether the task results are differentially influenced by existing differences between the detection and differentiation task, such as the influence of differentiating between types of probes in addition to the detection of them and the influence of increased stimulus variation in the differentiation task. Therefore, it was decided to compare the dot probe detection task and probe differentiation task in one study.

In sum, we tried to disentangle the selective attention processes of orienting toward threat and disengaging from threat in a dot probe task and to test whether anxious individuals differ in these respects from controls. Based on previous studies using different paradigms, we predicted that in a dot probe task, relative to non-anxious participants, anxious participants would differ in disengagement from threat, but not in orienting toward threat. Secondly, we decided to compare two versions of the dot probe task (detection versus differentiation), by investigating the relationship between the traditional attentional bias indices of both the tasks and its relationship with anxiety.

Methods

Study design

The present study employed a mixed between–within subjects factorial design. Level of anxiety was investigated as a between-subjects factor and selective attention and version of dot probe task as within-subject factors.

Participants

A total of 133 students of Maastricht University participated in the experiment in exchange for a small remunerative reward. Their age ranged from 18 to 40 years (mean = 21.6 years); 111 participants were female.

Materials

Pairs of words, derived from Hermans & De Houwer (1994), were used as emotional stimuli. The threat words (e.g., death, tumor) were evaluated as very negative and modestly negative. Paired words were matched on lexical frequency and number of syllables. In the detection task, 48 threat–neutral and 48 neutral–neutral word pairs were used and followed by a probe, consisting of a single dot. Following the threat–neutral word pair the probe could appear, with equal probability, in either the position of the threat or the neutral word. The probe remained on the screen until the subject responded by pressing a response-box button. Another 192 neutral-neutral pairs were used as fillers without probes and on those trials the next word was presented after 1 s.

The differentiation task differed in two main respects from the detection task: in the first place, in this task the probe consisted of a single or a double dot ( . versus ..) and participants had two buttons to indicate their differentiation. Second, in this task no neutral–neutral word pairs were used. Only the 48 threat–neutral word
pairs, which were repeated across the two tasks, were presented. This task could not be used for calculating the orientation and disengagement aspects of attention, since it had no neutral–neutral word pairs.

**Experimental software**

The dot probe tasks were programmed and presented using Micro Experimental Laboratory (MEL Version 2) software (Schneider, 1988) on an Intel 200 MHz computer with a high-resolution monitor (refresh rate 60 Hz). Responses in the dot probe tasks were obtained through a MEL parallel response box.

**Procedure**

Participants were tested individually and the procedure was explained to them in sufficient detail. Written informed consent was obtained. Each trial started with a fixation cross-displayed for 500 ms in the middle of the computer screen. This was followed by a random word pair with one word above the other, vertically separated by 3 cm. Word pairs were presented in lower-case, white letters against a black background for 500 ms. Both dot probe tasks consisted of 16 practice trials. Participants were asked to respond as quickly and as accurately as possible. The sequence of both tasks was randomized, with 50% of the participants starting with the detection task and 50% starting with the differentiation task. Participants rested for 3 min between the two tasks. At the end of the dot probe tasks, all participants completed the state and trait version of the Spielberger State and Trait Anxiety Inventory (STAI: Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). During debriefing, participants were asked whether they were acquainted with the computer task and then thanked for their participation.

**Results**

**Preparation of reaction time data**

The trials with errors were discarded (1.8% in the detection task and 4.8% in the differentiation task). RT less than 200 ms were excluded in order to eliminate anticipatory responses (0.2% in the detection task and none in the differentiation task). To reduce the influence of outliers, RT, which were more than three standard deviations above each individual mean, were eliminated (1.3% in the detection task and 0.7% in the differentiation task).

Concerning the order of administration of the dot probe task, there was neither a main effect of order nor interaction effects. During the debriefing, it was asked whether participants knew the computer task. Participants with knowledge \( (n = 17) \) did not differ from participants without knowledge \( (n = 116) \) \( (p > .20) \).

**Attentional bias: orienting toward and disengagement from threat**

The results of the detection task were used to test whether anxiety is related to differences in orienting toward threat and/or disengaging from threat (see Table 1 for mean response latencies and standard deviations). The group of participants was split into two subgroups, one group with the highest STAI-trait

<table>
<thead>
<tr>
<th>Word pair</th>
<th>Probe position</th>
<th>High trait anxious ( (n = 20) )</th>
<th>Low trait anxious ( (n = 20) )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>( M )</td>
<td>( SD )</td>
</tr>
<tr>
<td>(a) Neutral–neutral</td>
<td>Neutral</td>
<td>411.16</td>
<td>74.6</td>
</tr>
<tr>
<td>(b) Threat–neutral</td>
<td>Threat</td>
<td>411.94</td>
<td>65.3</td>
</tr>
<tr>
<td>(c) Threat–neutral</td>
<td>Neutral</td>
<td>421.19</td>
<td>76.7</td>
</tr>
</tbody>
</table>
scores \((n = 20, \ M = 51.65, \ SD = 4.2)\) and the other group with the lowest \((n = 20, \ M = 25.55, \ SD = 2.5)\) scores. First, a 2 \times 2 repeated measures ANOVA was performed on the threat–neutral trials with group (high versus low anxious individuals) as the between-subjects factor and congruency as the within-subject factor (congruent = dot appears at threatening location versus incongruent = dot appears at neutral location). This analysis revealed a main effect of group, \(F(1,38) = 6.8, \ p < .05\), due to high-trait anxious participants being slower and the group \(\times\) congruency interaction effect was not significant, \(F(1,38) = 2.3, \ p = .14\). Secondly, to specifically examine the selective attention processes, neutral–neutral trials were incorporated. While, orienting toward threatening information should result from faster responding to congruent trials (dot after threat) compared to neutral trials in high anxious individuals, the 2 (group) \(\times\) 2 (orienting) repeated measures ANOVA only revealed a significant main effect of group, \(F(1,38) = 5.0, \ p < .05\). Difficulty to disengage attention from threat should be reflected in slower responding to incongruent trials (in threat–neutral trial, dot after neutral word) compared to neutral trials in high anxious individuals and this was confirmed. In addition to a main effect of group, \(F(1,38) = 6.3, \ p < .05\), the 2 (group) \(\times\) 2 (disengaging) repeated measures ANOVA revealed a significant group \(\times\) disengaging interaction effect, \(F(1,38) = 5.1, \ p < .05\). While low anxious individuals reacted similarly to incongruent and neutral trials, high anxious individuals’ responses were delayed on incongruent trials compared to neutral trials.

To further test the relationship between anxiety and selective attention, indices for both components of selective attention were calculated. The orienting index was calculated by subtracting the mean RT for threatenng stimuli from the mean RT for neutral stimuli:

\[
\text{orienting index} = dN, N - dT, N,
\]

where \(dN, N\) stands for dots replacing neutral words in the presence of other neutral words and \(dT, N\) for dots replacing threat words in the presence of neutral words. A positive score on the orienting index indicates faster response to dots appearing after threat as compared to neutral words. To calculate the ease of disengaging attention from threat, the mean RT for neutral stimuli in the presence of neutral stimuli was subtracted from the mean RT for neutral stimuli in the presence of threat stimuli. In equation:

\[
\text{disengaging index} = dN, T - dN, N,
\]

where \(dN, T\) stands for dots replacing neutral words in the presence of threat words. A positive score on the disengaging index indicates slower responses to neutral words in the presence of threat compared to neutral words in the presence of other neutral words.

In the total sample, there was no significant Pearson product moment correlation between the orienting index and trait anxiety, \(r = -.01, \ ns\), but a significant, yet small, correlation between the disengaging index and trait anxiety, \(r = .21, \ p < .05\).

Analyses of the anxious subgroups revealed that high anxious individuals had higher disengaging scores compared to low anxious individuals, \(t(38) = -2.25, \ p < .05\) (\(M = 10.02, \ SD = 17.63\) versus \(M = -2.54, \ SD = 17.66\)). Furthermore, while the disengaging index did not differ from zero in low anxious individuals, \(t(19) = -0.64\), it did in high anxious individuals, \(t(19) = 2.54, \ p < .05\), indicating that the latter group had difficulties disengaging attention from threat. No difference between high and low anxious individuals was found on the orienting index, \(t(38) = -0.14, \ ns\) (\(M = -0.78, \ SD = 34.6\) versus \(M = -2.04, \ SD = 18.7\)). In addition, the orienting index did not differ significantly from zero in high anxious individuals, \(t(19) = -0.10\), and also in low anxious individuals, \(t(19) = -0.49\). Fig. 1 represents the orienting and disengaging indices of both groups.

**Relative merits of two dot probe versions**

To compare the detection and differentiation dot probe task on selective processing of threat, the traditional index of attentional bias (MacLeod et al., 1986) was calculated for both the tasks by subtracting the mean RT to dots replacing threat stimuli, from the mean RT to dots replacing neutral stimuli, in threat–neutral trials (see Tables 1 and 2). There was a small yet significant correlation between trait anxiety and attentional bias in the detection task, \(r = .17, \ p < .05\), but no correlation in the differentiation task, \(r = -.03, \ ns\).
Independent samples $t$-tests were carried out to compare high and low anxious individuals. In the detection task, a trend for differences in attentional bias scores between high and low anxious individuals, $t(38) = -1.53$, $p = .07$ (one-tailed) was revealed. High anxious individuals tended to have higher attentional bias scores ($M = 9.24$) compared to low anxious individuals ($M = -4.58$). In the differentiation task, no
difference in attentional bias scores were found between high and low anxious individuals, \( t(38) = 0.82, ns \). These results are depicted in Fig. 2.

A two-way ANOVA was carried out to directly compare both tasks, with one between-subjects factor, trait anxiety (high versus low), and one within-subject factor, dot probe task (detection versus differentiation). There were no significant main effects, but the anxiety \( \times \) task interaction effect was marginally significant, \( F(1, 38) = 2.98, p = .09 \), reflecting a trend for the attentional bias scores of high and low anxious individuals to differ between both the tasks.

The Pearson product moment correlation between the attentional bias indices of both the tasks was not significant in the total sample, \( r = .10, ns \).

Discussion

The present study had two aims: (1) to specify what specific selective attention process (orienting or disengaging) is responsible for the attentional bias in anxious individuals and (2) to compare two versions of the dot probe task (detection versus differentiation). Some of the results were marginally significant, falling in the 5–10% alpha range and will be interpreted cautiously.

First, the present results suggest that vulnerability to anxiety is associated with a difficulty in disengaging attention from threat rather than faster orienting toward threat: high anxious individuals differed from low anxious individuals on the disengagement index, but not on the orienting index. Furthermore, only the disengagement index had a positive and significant correlation with anxiety. These findings add to a growing body of evidence that anxiety is related to a bias in disengagement from threat and not in orienting toward threat (Amir et al., 2003; Fox et al., 2001; Yiend & Mathews, 2001).

With respect to the comparison of two dot probe tasks, the present results suggest that the detection dot probe task may be slightly superior to the differentiation task. The traditional attentional bias score was calculated in both versions of the task and revealed a significant correlation with anxiety in the detection task. The differentiation task failed to show the predicted correlation between attentional bias for threat and trait anxiety, which is consistent with some studies (Bradley, Mogg, White et al., 1999; Yiend & Mathews, 2001), but inconsistent with others (Bradley, Mogg, Falla et al., 1998; Fox, 2002). Note, that the dot probe tasks results seem to be rather inconsistent, something which was also concluded by Mogg, Bradley, Dixon et al. (2000): “the dot probe task appears to provide a relatively fragile index of anxiety-related attentional biases in non-clinical studies” (p. 1074). Our result of a non-significant correlation between both the dot probe tasks, which presumably measure the same construct, seems to corroborate such a conclusion.

High and low anxious participants were equally fast in orienting toward stimuli and there were no differences between threatening and non-threatening stimuli. However, the high anxious participants displayed difficulty in disengaging from negative stimuli. This seems to fit theories about ‘freeze’ behavior in the face of perceived threat (e.g. Lang, Bradley, & Cuthbert, 1998). Freezing behavior is considered to have a preparatory function in the phase between the detection of threat and the response to it. Difficulty to disengage attention from threat might thus be an aspect of freezing behavior, allowing the organism to allocate cognitive resources to the particular threatening stimulus.

A limitation of the present study is that no neutral word pairs were included in the differentiation task. The reason for doing so was that the aim of the present study was to compare two dot probe tasks in the format as they are regularly used. As a result, the orientating and disengaging indices could not be calculated for the differentiation task. Furthermore, it limited the comparability between the two dot probe tasks. A second limitation is that because the orienting and disengagement indices are measured at one point in time, the time frame of those indices cannot be inspected, which leaves open the possibility that e.g. orienting effects might have occurred earlier in time. For example, Mogg et al. (1994) found evidence of high-trait anxious participants shifting attention towards threat after masked exposure of 14 ms. Thirdly, the evidence of an anxiety related bias in disengaging attention from threat is derived from a comparison between threat–neutral and neutral–neutral word pairs. Note that a threat–neutral word pair not only differs in threat value from a neutral–neutral word pair, but also in interest value, novelty, etc. However, since we focussed on anxiety, it seems plausible that both anxious and non-anxious individuals are as easy influenced by interest value and
novelty and that any anxiety-related differences are due to the threat value of the stimuli. But keeping plausibility aside, this is an empirical issue that awaits testing.

There seems to be room for a reconsideration of earlier dot probe task results. The traditional attentional bias index calculated by Macleod et al. (1986) is ambiguous, in that it does not distinguish between relevant selective attention processes: orienting and disengagement. The present results add to the growing evidence on the relevance of that distinction and suggest that selective attention as observed in the dot probe task is largely due to a difficulty to disengage attention from threat.

References


