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BRIEF REPORT

Enhanced Attentional Capture in Trait Anxiety

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Attentional Control Theory (ACT) proposes that anxiety is specifically associated with more attentional distraction by salient stimuli. Moreover, there is some suggestion that worry is one mechanism whereby anxiety impairs attentional control. However, direct evidence for these hypotheses is lacking. In the current study we addressed limitations of previous work by examining the relationships between trait anxiety and worry and attentional distraction by a salient, task-irrelevant color singleton in a visual search task. Results revealed that trait anxiety, but not worry, was related to increased attentional distraction (i.e., capture) by the color singleton. The current results suggest that anxiety is associated with a general enhancement of bottom-up processes involved in motivational significance detection.

Keywords: anxiety, attentional capture, attentional control theory

Eysenck, Derakshan, Santos, and Calvo's (2007) Attentional Control Theory (ACT) suggests that distractibility is a key component of anxiety that results from the bottom-up attentional selection mechanism overpowering the volitional, top-down control system. The theory draws on decades of research suggesting that attentional selection is determined by the interaction of two attentional systems: a stimulus-driven system and a goal-driven system (Posner & Petersen, 1990; Corbetta & Shulman, 2002); that is, by the interplay of early exogenous (e.g., stimulus saliency) and later endogenous (e.g., expectations) processes, respectively (Theeuwes & Van Der Burg, 2007; van Zoest, Donk, & Theeuwes, 2004).

Although ample research has documented that threatening stimuli are distracting to anxious people (for a review see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007), Eysenck and colleagues (2007) suggest that a better test of the general theory would demonstrate that salient, nonthreatening stimuli are also effective distractors. Most research that has used nonthreatening stimuli to investigate this issue has employed fairly complex tasks (e.g., reading comprehension; Calvo & Carreiras, 1993; Calvo, Eysenck, Ramos, & Jiménez, 1994) that involve several types of processes (e.g., memory storage and retrieval), thus making it difficult to determine whether attention is the specific process most affected by anxiety (Derakshan & Eysenck, 2009).

To address this limitation, Eysenck and colleagues (Derakshan, Ansari, Hansard, Shoker, & Eysenck, 2009) have used the antisaccade task as a process pure measure of attention. In this task, one must inhibit the prepotent response to look at a suddenly appearing cue and execute a volitional eye movement in the opposite direction. Although the antisaccade task provides a good measure of behavioral or saccadic inhibition, it is not ideal for investigating how the initial capture of attention is influenced by the interaction between top-down and bottom-up mechanisms. In the antisaccade task the cue is always task-relevant. As such, the top-down attention system should be set to detect the cue. Both systems should therefore initially be driven by the cue making it difficult to compare the relative contribution of the top-down and bottom-up attention systems to the initial allocation of covert attention.

Theeuwes' (1991, 1992) irrelevant singleton method may be a more appropriate way to investigate whether the bottom-up system is more dominant than the top-down system during the initial competition for attention. In this method, subjects search for a target that is embedded in a unique shape among an array of like objects (e.g., a green diamond among an array of green circles). Color is irrelevant to the task; however, on half of the trials one of the nontarget objects appears in a novel color (e.g., a red circle), making it a highly salient color singleton. To the extent that the top-down attention system is dominant, individuals should detect the unique shape rapidly, regardless of whether a color-singleton appears or not. To the extent that the bottom-up system is dominant, attention should be captured by the highly salient color-singleton, delaying subjects' ability to identify the target. Thus, the slowing caused by an irrelevant color-singleton indexes the amount of attentional "capture" via the bottom-up system (Theeuwes, 2010). This method therefore provides an ideal measure to investigate the interaction of the top-down and bottom-up attention systems and investigate ACT's hypothesis that individuals high in anxiety should experience more capture of attention by an irrelevant stimulus.

In the current study, we examined the relationship between trait anxiety and irrelevant singleton task performance. Based on the predictions of ACT, we expected that higher trait anxiety would be

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associated with increased attentional capture as indexed by slower RT on color-singleton present trials. As a secondary aim, we also examined the relationship between worry and attentional capture. It has been proposed that the worry aspect of anxiety may deplete resources available for the top-down control of attention, thereby disrupting the balance between the top-down and bottom-up attentional systems (Eysenck & Calvo, 1992; Eysenck et al., 2007). However, little work has directly investigated the extent to which worry plays a role in the relationship between anxiety and distractibility.

Method

Participants

Fifty-one female undergraduates with normal or corrected-to-normal vision participated in the current study for course credit.

Stimuli and Materials

The search task was a variant of Theeuwes's irrelevant singleton paradigm (Theeuwes, 1991) and was programmed in E-Prime (Psychology Software Tools, Sharpsburg, PA). Search arrays consisted of 10 geometric shapes equally spaced around an imaginary circle (11° radius), presented against a black background on 19 in. computer monitors running at 100 Hz. Shape stimuli consisted of green and red unfilled diamonds (4.5° × 4.5°) and circles (3.4° diameter) with gray line segments (1.5° × .2°) presented in the middle of each shape. In half of the trials a single diamond target appeared among nine circles. In the other half a single circle target appeared among nine diamonds. The lines within the nine identical shapes was randomly selected to be tilted 22.5° to the left or right of the horizontal or vertical plane. The line segment in the unique target-shape was a similar gray line oriented either horizontally or vertically. In no-distractor trials (half of all trials), all 10 items were either red or green. The distractor trials were identical to the no-distractor trials except that one of the nonunique shapes, chosen at random, appeared in the opposite color as the other nine shapes (e.g., if nine shapes were red, the distractor was green).

The State-Trait Anxiety Inventory–Trait Version (STAI-T; Spielberger & Gorsuch, 1983) was used to assess participant's trait anxiety. The STAI-T is a self-report measure comprised of 20 items that are rated on a Likert scale ranging from 1 (*Almost never*) to 4 (*Almost always*). Higher scores indicate more severe trait anxiety. The Penn State Worry Questionnaire (PSWQ: Meyer, Miller, Metzger, & Borkovec, 1990) was administered to assess chronic worry. The PSWQ is a self-report measure comprised of 16 items that are rated on a Likert scale ranging from 1 (*Not at all typical of me*) to 5 (*Very typical of me*). Higher scores indicate more severe worry.

Procedure

Participants received task instructions and then were run individually in dimly light, sound attenuated data collection booths. The subject's task was to make a speeded button press (via an E-Prime button box) to indicate whether the line segment in the unique shape was horizontally or vertically oriented. Participants performed 320 trials in two blocks of 160 trials that were separated by a participant-terminated rest break. The 160 trials in each block were comprised of the complete counterbalancing of the 10 target locations × 2 target line orientations × 2 target shape colors × 2 target shape × 2 distractor conditions. The order of trials within a block was randomized.

Each trial began with a centrally presented fixation point that appeared for a randomly selected time ranging from 600–1200 ms in 100 ms increments. Following the fixation point, a search array appeared and remained on the screen until subjects responded. Auditory feedback was presented for erroneous responses. After a 1 second blank frame, the next trial began with a fixation point.

After completing all 320 trials, subjects completed computer based versions of the STAI-T and the PSWQ.

Data Preparation and Analysis Strategy

Data from four participants were eliminated due to poor overall accuracy (<60%). The remaining 47 participants all performed at better than 88% accuracy ($M = 96.7\%$, $SE = .42\%$). Trials with RTs less than 250 ms or greater than 3000 ms were eliminated as outliers (5.2% of trials). Then each subject's mean RT on correct trials was calculated separately for distractor and no-distractor trials.

A repeated measures analysis of variance (ANOVA), including one two-level factor Trial (no distractor vs. distractor), was conducted on behavioral measures without regard to individual difference scores on the STAI-T and PSWQ in order to establish baseline experimental effects. To test the principal predictions of the current study, blocked regression analyses were then conducted wherein accuracy and RT measures of distractor cost (distractor–no distractor) were entered into separate regressions as the dependent variables. The main effects of STAI-T and PSWQ scores were entered in first, followed by the STAI-T × PSWQ interaction term.

Results

Anxiety Measures

The average STAI-T score was 40.70 ($SD = 10.08$; range = 22–61) and the average PSWQ score was 52.49 ($SD = 12.74$; range = 22–79). As expected, higher STAI-T scores were significantly associated with higher PSWQ scores ($r = .53$, $p < .001$).

Error Rate

The ANOVA conducted on error rate revealed a significant effect of Trial such that participants committed more errors on distractor ($M = 1.99\%$ error; $SD = 1.80$) compared to no-distractor trials ($M = 1.34\%$ error; $SD = 1.39$; $F(1, 46) = 9.24$, $p = .004$, $\eta_p^2 = .17$). Regression analysis revealed no significant effects involving STAI-T, PSWQ, or their interaction on accuracy distractor cost (Fs < 1.14, ts < 1.23, ps $> .22$).

Reaction Time

The ANOVA conducted on RT revealed the typical distractor effect such that participants responded more slowly on distractor ($M = 1394.75$; $SD = 213.23$) compared to no distractor trials

(M = 1223.50; SD = 193.54; $F(1, 46) = 207.91$, $p < .001$, $\eta_p^2 =$ .82).

Regression analysis predicting RT distractor cost revealed that the first block containing the main effects of STAI-T and PSWQ scores was significant ($F(2, 44) = 5.61$, $p = .007$, $R^2_{adj} = .17$). STAI-T was a significant predictor ($t = 3.22$, $p = .002$, $\beta = .51$), whereas PSWQ was unrelated to distractor RT cost ($t < 1$, $p = .35$, $\beta = -.15$). Consistent with our prediction, STAI-*T* scores were positively correlated with attentional capture by the irrelevant singleton ($r = .43$, $p = .002$; see Figure 1). Figure 2 shows distractor costs for high- and low-STAI-T groups created based on a median split procedure (for illustrative purposes only). The second block containing the STAI-T X PSWQ interaction term was not significant ($F(1, 43) < 1$, $p = .52$, $R^2_{change} = .1$).

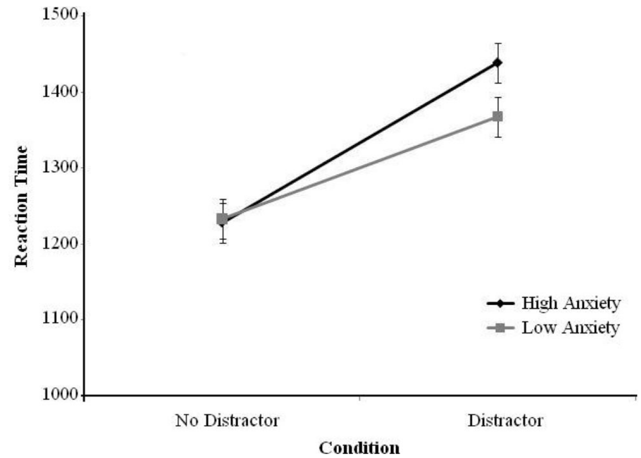

Figure 2. Mean reactions times for search with and without a distractor graphed as a function of anxiety.

Discussion

Here we used an attentional capture task that directly pits the top-down and bottom-up attention systems against one another to determine which one dominated the initial guidance of attention in anxiety. By doing so, we were able to demonstrate that anxiety was associated with more bottom-up control of attention, even when the salient stimuli were emotionally neutral. This main finding provides strong evidence for ACT's claim that increased distractibility associated with anxiety results from a general shift in the relative strength of the bottom-up and top-down attention systems, with the bottom-up being relatively more potent (Eysenck et al., 2007). At the same time, we failed to find evidence that worry was related to attentional capture. This secondary finding is inconsistent with some suggestions that the worry component of anxiety depletes resources required for the effective use of the top-down attentional system, thereby contributing to the shift toward bottom-up processing (Eysenck & Calvo, 1992; Eysenck et al., 2007).

Our finding that trait anxiety is associated with enhanced attentional capture by an irrelevant singleton is consistent with previous research demonstrating greater distraction by salient, distractor stimuli in anxious individuals (for a review see Derakshan & Eysenck, 2009). However, our method extends previous findings in at least three important ways. First, the irrelevant singleton task used here provides a more direct measure of attention than previous studies that have employed more complex tasks tapping later processes such as memory (e.g., Calvo et al., 1994). Second, the singleton task does not involve cue processing, as does the antisaccade task (Derakshan et al., 2009), and thus provides a more direct measure of competition between the top-down and bottom-up systems in the initial allocation of attention. Last, the singleton task involves searching for a target in an array of stimuli spread out in space, unlike the Stroop and Flanker tasks that involve centrally presented sparse stimulus arrays. Moreover, the Flanker task is perhaps a better measure of response competition than attentional capture by irrelevant stimuli in that "irrelevant" stimuli in the Flanker task are associated with an alternative response. Thus, results from the current study extend previous work using the Stroop (e.g., Fox, 1993) and Flanker task (Pacheco-Unguetti, Acosta, Callejas, & Lupianez, 2010) by showing selective, spatial attentional capture by an irrelevant stimulus in anxiety.

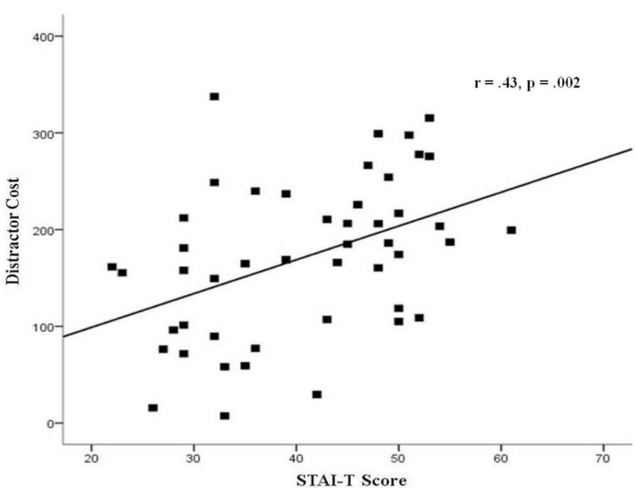

Figure 1. A scatter plot illustrating the relationship between distractor cost (ms) and STAI-T scores.

Whereas trait anxiety was associated with enhanced attentional capture in the present study, worry was not. The current findings add to a small body of literature on the effects of worry on cognitive performance (see Eysenck et al., 2007) by suggesting that the relationship between anxiety and attentional capture has little to do with worry.

Theeuwes (2010) suggests that attentional capture effects revealed in the irrelevant singleton paradigm are primarily the result of exogenous, bottom-up processes. Thus, the current results suggest that anxiety is associated with an enhanced stimulus-driven attention system dedicated to detecting salient stimuli that signal motivational significance in general. This interpretation is also in accordance with electroencephalogram (EEG) studies showing enhanced resting right posterior activity—a region linked to bottom-up arousal and vigilance processes—in anxious individuals (e.g., Nitschke, Heller, Palmieri, & Miller, 1999). Based on previous findings showing a specific relationship between enhanced right posterior activity and the anxious arousal component of anxiety—characterized by fear and panic—an interesting avenue for future research would be to examine whether anxious arousal demonstrates particularly strong links to attentional capture (Nitschke & Heller, 2005). Although the current results point to the role of an enhanced bottom-up attention mechanism in anxiety, future research should continue to examine anxiety's effects on top-down control in light of evidence demonstrating reduced frontal cortex activity in anxiety (e.g., Bishop, 2008).

Despite the strengths of the additional singleton task with regard to isolating the effect of anxiety on attentional capture, the search array chosen for the current experiment had a radius of 11 degrees, introducing the possibility that eye movements may have played a role in our findings. The current results may therefore reflect enhanced attentional capture, oculomotor capture, or both in anxious individuals. Nonetheless, there is general agreement that covert attention must be directed to an object prior to the execution of overt attention—that is, a saccade (Hoffman & Subramaniam, 1995; Deubel & Schneider, 1996; Remington, 1980)—and thus we assume that even if eye movements were involved in the current findings they were preceded by covert shifts of attention to the irrelevant singletons. Moreover, Theeuwes and colleagues (Theeuwes, Kramer, Hahn, Irwin, & Zelinsky, 1999) suggest that covert attentional capture and oculomotor capture are driven by the same bottom-up, saliency based system. Finally, we modeled our method on that used by Theeuwes and colleagues (Chisholm, Hickey, Theeuwes, & Kingstone, 2010), who also examined individual differences effects on attentional capture.

In sum, the present study provides strong evidence for an association between anxiety and enhanced attentional distraction (i.e., capture) by salient stimuli. Future work should incorporate more direct measures of attention such as event-related brain potentials in order to disentangle anxiety's effects on the time course of bottom-up and top-down mechanisms.

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