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Focus on the positive: Anxiety modulates the effects of emotional stimuli on hemispheric attention

Caroline Crump [a,*], S. Aakash Kishore [a], Eran Zaidel [a,b]

[a] Department of Psychology, University of California, Los Angeles, CA, USA
[b] Brain Research Institute, University of California, Los Angeles, CA, USA

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ABSTRACT

People with high levels of trait anxiety are said to orient attention selectively to threatening stimuli (Bradley, Mogg, White, Groom, & de Bono, 1999; MacLeod, Mathews, & Tata, 1986), but this effect is sometimes difficult to replicate. We suggest a reason for this difficulty is that typical tests of the spatial attention bias in anxiety failed to consider together: (1) the differential effects of positive and threatening stimuli on attention in anxiety, (2) the separate contributions of each hemisphere to the attention bias, and (3) whether the attention bias in anxiety is restricted to orienting or can be observed more strongly in the conflict or alerting networks of attention. We compared the effects of schematic angry, happy, and neutral face cues using a lateralized version of Posner's Attention Network Task (Lateralized Attention Network Test) which distinguishes spatial Orienting Cost (due to an invalid cue; disengagement) from spatial Orienting Benefit (due to a valid cue; hypervigilance), and which considers executive Conflict resolution and Alerting in addition to spatial Orienting in each hemisphere separately. We tested participants with high and low trait anxiety measured by the STAI-TA (Spielberger, Gorsuch, & Lushene, 1983). Surprisingly, happy face cues rather than angry face cues interacted with target visual field and participant level of anxiety. Happy face cues presented to participants with low anxiety elicited maximal Orienting Benefit and minimal Orienting Cost for targets presented to the left visual field. Anxious individuals failed to benefit from happy cues in the left visual field. We suggest that lateralized positive cues can provide a more sensitive index of attention changes in anxiety than is provided by centrally-presented threatening cues.

1. Introduction

Despite the growing body of research on anxiety disorders, to date there is no comprehensive account of the cognitive consequences of anxiety. One of the best-documented correlates of anxiety is an attention bias toward threatening stimuli (Bradley et al., 1999; MacLeod et al., 1986). This bias is explained as a lowered threshold to detect threat in the environment (e.g., Bishop, Duncan, Brett, & Lawrence, 2004) and contrasts with an attention bias toward positive stimuli in individuals with low anxiety (Waters, Nitz, Craske, & Johnson, 2007). However, individuals with high anxiety sometimes show a bias toward positive stimuli instead of threatening stimuli. Researchers suggest that individuals with high anxiety sometimes develop this bias toward positive stimuli as a coping strategy to redirect attention to stimuli that are more likely to signal safety than threat (attentional control theory: Derryberry & Reed, 2002; Eysenck, Derakshan, Santos, & Calvo, 2007).

Attention to threat in anxiety has been investigated extensively using the Emotional Stroop task (see Williams, Mathews, & MacLeod, 1996 for a review), the Visual Probe task (MacLeod et al., 1986), and tasks of covert orienting of spatial attention (i.e., Fox, Russo, Bowles, & Dutton, 2001). These tasks attempt to differentiate two possible mechanisms underlying the attention bias: hypervigilance toward stimuli and difficulty disengaging from stimuli. Previous studies have shown conflicting evidence, alternately supporting hypervigilance (Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006), difficulty with disengagement (Yiend & Mathews, 2001; Salemink, van den Hout, & Kindt, 2007), or both (Koster, Crombez, Verschuere, & de Houwer, 2004; for a review of evidence, see Cisler & Koster, 2010). Indeed, opposite conclusions are sometimes reached from the same data using different analyses (Fox et al., 2001; Mogg, Holmes, Garner, & Bradley, 2008). We propose that some of these inconsistencies may be due to the fact that the traditional tests of the attention bias (1) have focused on threat stimuli rather than positive stimuli, (2) ignore the hemispheric basis of attention to emotional stimuli, and (3) measure only overall visual orienting, and do not consider other components of attention, such as Conflict and Alerting.

* Corresponding author. Address: 1285 Franz Hall, Box 951563, Los Angeles, CA 90095-1563, USA. Fax: +1 (310) 206 5895.
E-mail address: ccrump@ucla.edu (C. Crump).

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1.1. The role of the right hemisphere in anxiety

We presuppose that each hemisphere can independently process the information projected to it (Zaidel, Clarke, & Suyenbou, 1990) resulting in a dissociation between the two visual fields and the visual stimulus (*cf.* the "processing dissociation" criterion of independent hemispheric processing in the normal brain; Zaidel, 1983). There is by now compelling evidence that the two cerebral hemispheres constitute two separate cognitive systems that can process diverse stimuli in many perceptual–motor–cognitive tasks (e.g., Zaidel et al., 1990). We believe that lateralized presentations best tap the limits of independent competence of the two cerebral hemispheres in a given task (Zaidel, Iacoboni, Zaidel, & Bogen, 2003). This contrasts with central presentations which may involve variable degrees of interhemispheric interactions.

The right hemisphere may be specialized for processing emotion in general and for processing negative emotion in particular (Compton et al., 2008; Schiffer et al., 2007). This is attributed to right hemisphere specialization for activating the autonomic nervous system during fight-or-flight responses (EEG: Spence, Shapiro, & Zaidel, 1996; see Hugdahl, 1996 for a review). Moreover, the right hemisphere has been strongly implicated in the orienting of attention both in the left visual field and in the right visual field (Heilman & Van Den Abell, 1980). The right hemisphere is therefore likely to mediate the attention bias in anxiety. However, aspects of a particular paradigm, such as central stimulus presentations or verbal target stimuli, may unintentionally alter the ability of the right hemisphere to exhibit the attention bias reliably (*cf.* Kinsbourne, 1970), resulting in the conflicting results seen previously.

In contrast to right hemisphere involvement in negative emotions, hemispheric competence for processing positive emotion is less understood. Three alternative models usually account for hemispheric differences in emotion processing (see Demaree, Everhart, Youngstrom, & Harrison, 2005 for a review of hypotheses on the right hemisphere's role in emotion processing). The Right Hemisphere Hypothesis states that the right hemisphere is activated for processing (both the identification and experience of) all emotions, regardless of valence. An alternate view, the Valence Hypothesis, posits that the right hemisphere is specialized for processing negative emotions and that the left hemisphere is specialized for processing positive emotions. Finally, the Motivational (approach/avoidance) Hypothesis suggests that the right hemisphere is more active than the left for emotions which elicit avoidance of stimuli, such as threat and fear, and the left hemisphere is more active than the right for emotions which elicit approach to stimuli, such as happiness. All three hypotheses predict right hemisphere involvement in processing threat stimuli. However, the three hypotheses make different predictions about hemispheric asymmetries in processing positive emotions. The results of the present study may provide support for one of these hypotheses because the study addresses the implicit effects of emotional state on hemispheric attention by examining the effects of emotional spatial cues.

1.2. An alternate measure of attention: The Lateralized Attention Network Task

The Lateralized Attention Network Task (LANT) is a modified version of the Attention Network Task (ANT) which measures separate components of automatic attention independently in each hemisphere. These components include executive Conflict Resolution (C), Alerting (A), and Orienting (O; Fan, McCandliss, Sommer, Raz, & Posner, 2002). Conflict Resolution (C) measures the ability to identify a target in spite of distracting incongruent flankers (*cf.* Eriksen & Eriksen, 1974). Alerting (A) measures overall arousal and response expectancy following a nonspatial cue. Orienting (O) is defined as the overall advantage in cognitive processing when attention is cued to the location of the impending target. These components are considered "networks" of attention to emphasize and reflect the multiple stages of processing which occur in each component of attention (see Posner & Rothbart, 2007 for a review; see Fan, McCandliss, Fossella, Flombaum, & Posner, 2005 for imaging).

The ANT has been shown to be a reliable and internally valid measure of attention, and it has been proposed as a clinical tool for assessing attention problems in psychiatric disorders (Fan et al., 2002). The LANT is identical to the ANT in all but two respects. First, the LANT differentiates between Orienting Benefit (response facilitation by a valid cue; OB) and Orienting Cost (response inhibition by an invalid cue; OC). Orienting Benefit corresponds to the traditional measure of hypervigilance and Orienting Cost corresponds to the traditional measure of disengagement in spatial orienting paradigms. Second, the cues and targets are lateralized to the left and right visual fields, rather than appearing in the upper and lower fields. The LANT has also been shown to be a reliable measure of the independent attention networks in each cerebral hemisphere (Greene et al., 2008).

1.3. Present research

The present study compared responses to happy, neutral, and angry face cues between individuals with high trait anxiety and individuals with low trait anxiety. Hemispheric processing was investigated using a lateralized tachistoscopic task of attention and was controlled by several experimental parameters, including the use of schematic faces as spatial cues. Previous research suggests that simple, schematic faces should be equally perceptible to both hemispheres (Yashar et al., 2008), thus avoiding any unintended bias toward one hemisphere within the paradigm. Spatial orienting as well as alternate attention networks (namely, C and A) were assessed using the LANT. The literature on the attention bias in anxious individuals suggests that angry face cues will increase both OB and OC in participants with high anxiety relative to participants with low anxiety and relative to neutral faces in either group (*cf.* Fox et al., 2001). Due to the right hemisphere's known role in both negative emotions and spatial attention, we predicted that effects of anxiety on attention will be selective to the right hemisphere.

2. Methods

2.1. Participants

One hundred fifteen undergraduates (54 males) at the University of California, Los Angeles participated in the experiment as part of a class assignment. Anxiety level was measured with the trait portion of the State-Trait Anxiety Inventory (Spielberger et al., 1983). Anxiety scores ranged from 24–69 with a median score of 41. Handedness scores were not available. However, the short adaptation of the Edinburgh Handedness Inventory (Oldfield, 1971) was administered for students in the same course for several different academic terms and the prevalence of non-consistent right-handedness was approximately 7%.

2.2. Apparatus

The experiment was performed on an IBM-compatible personal computer using E-Prime 1.1 presentation software (Psychology Software Tools, 2002). Stimuli were presented on a 17″ Dell monitor with a refresh rate of 60 Hz and a screen resolution of