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# Electrophysiological indicators of emotion processing biases in depressed undergraduates[☆]

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ABSTRACT

It has been proposed that depressed individuals are biased towards and have more difficulty disengaging from negative information once it has been made salient (e.g. Joormann, J., 2004. Attentional bias in dysphoria: the role of inhibitory processes. Cognition & Emotion 18 (1), 125–147). The current study examined whether attention- and inhibition-related brain potentials were sensitive to both of these phenomena in depression using an affective go/no-go paradigm. Eighteen undergraduates who scored high on the Inventory to Diagnose Depression (IDD; Zimmerman, M., Coryell, W., 1987. The inventory to diagnose depression (IDD): a self-report scale to diagnose major depressive disorder. Journal of Consulting and Clinical Psychology 55 (1), 55–59) and 19 who scored low on the IDD completed the experiment. Results indicated that across all trials, subjects high on depressive symptomatology exhibited larger P3s in response to negative compared to positive stimuli. Examination of ERPs on trials uncontaminated by task-switching effects revealed larger N2s on "no-go" than "go" trials, and, specific to the depressive group, larger N2s in response to positive compared to negative stimuli. These data provide electrophysiological evidence that depressive subjects differentially categorize positive and negative emotional pictures. The P3 valence effect may help to explain difficulties inhibiting negative information seen in depression.

The classic conceptualization of depression put forth by Beck (1967; among others) identifies the over-incorporation of negative information as an overarching theme, such that depressed individuals cast themselves, their immediate surroundings, and their future in a negative light. Recent laboratory research has produced evidence for this maladaptive cognitive set in the form of several important findings which indicate that depression is concomitant with negative biases in attribution and judgment (cf. Davidson, 2000; Forgas et al., 1990), implicit memory (for a review, see Barry et al., 2004) and autobiographical memory (for a review, see Williams et al., 2007). However with regards to negative *attentional* biases in depression, the data have been ambiguous. Early behavioral studies utilizing a dot-probe paradigm and rapidly presented (500 ms or fewer) emotional words indicated that clinical levels of anxiety, but not depression, were associated with a rapid attentional shift towards threatening words (MacLeod et al., 1986). Findings such as this gave rise to other studies which considered additional conceptualizations of depressive information processing biases, including the possibility that insufficient information is paid to positive stimuli (e.g. Mogg et al., 1991) or that depression is associated with an "even handed" approach to the self-relevance of emotional stimuli (Gilboa et al., 1997). Other evidence suggests that depression might also be associated with a general unresponsiveness to any emotional content (be it positive or negative) compared to normals (Rottenberg et al., 2005), a view that is consistent with depression being, perhaps at early stages in human evolution, an adaptive mechanism which shelters the individual from excessive environmental stressors.

This is not to say that a negative attentional bias in depression cannot be observed in an experimental context. More recently, some studies were able to observe negative attentional biases in depressed subjects by manipulating key components of the dot-probe procedure, including the extension of stimulus presentation time to 1000 ms and the use of more emotionally evocative and depression-relevant stimuli (e.g. faces; Gotlib et al., 2004; Bradley et al., 1997). These results initiated a shift in the discussion of depressive attentional biases from that of whether or not one exists to focusing on its specific time course and suggests that while depression is not characterized by the rapid negative attentional bias characteristic of threat detection in anxiety, it

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[☆] 1. The numbers of the IAPS pictures used were the following: Positive: 2050,2057,2070,2080,2150,2340,4599,4601,4603,4608,4610,4606,4614,4640,4641,4660,5621,5830,5831,8030,8080,8190,8200,8370,8470,8490,8496. Negative: 2205,2710,2800,2810,2900,3180,3220,3230,3530,6243,6250,6560,6570,9001,9220,9290,9421,9530,9600,9620,9622,9630,9800,9810,2100,2110,2120.

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might be associated with a subsequent over-elaboration of negative information and inability to disengage from the emotion evoked by the negative stimulus once it has been appraised. This perspective is consistent with the idea that those with depression display a ruminative response style, such that encounters with mood-congruent information lead to a maladaptive and unproductive focus on such stimuli (Nolen-Hoeksema, 1991) and that resulting emotions cannot be inhibited through typical means, e.g. distraction.

That depression is associated with particular difficulty in inhibiting negative information is a testable hypothesis. From a general cognitive functioning perspective, depression has been linked to deficits in executive functioning, i.e. cognitive control (e.g. Austin et al., 2001; Trichard et al., 1995), a process which serves to assist in tasks such as selecting among numerous response options and inhibiting irrelevant or distracting information (Botvinick et al., 2001). Because increasing evidence indicates that cognitive control mechanisms are highly involved in emotion processing and regulation (cf. Ochsner and Gross, 2005), it is reasonable to believe that cognitive manipulation of emotional, specifically negative, material would be in some way compromised in depression. To directly test this possibility, experimenters from the Gotlib/Joormann group have utilized adapted information processing tasks that examine interference and inhibition of emotional stimuli in depressive subjects (Joormann, 2004; Gotlib et al., 2005; Joormann, 2006; Joormann and Gotlib, 2007; Joormann and Gotlib, 2008). These experiments have shown that depressive subjects fail to inhibit negative stimuli in these behavioral contexts. The inability of depressive subjects to properly disengage from negative information demonstrated in these studies fits with the "affective interference" hypothesis put forth by Siegle et al. (2002a,b), indicating that depression is associated with facilitated performance in tasks that emphasized attention to emotional aspects of negative stimuli, but performance deficits when depressed subjects are asked to perform a task that requires shifting attention away from negative information. These data indicate that the negative attentional bias and inhibitory deficits are two closely intertwined phenomena; it appears that problems inhibiting negative information are a result of, at least in part, a tendency to initially afford negative stimuli excessive attention.

There are also neuroimaging data that complements these behavioral studies, showing that depressed individuals have difficulty in the disposal of negative information either when specifically directed to do so or when such information becomes irrelevant to the task at hand. Imaging work by Siegle et al. (2002b) examined amygdala activity in depressed individuals during performance of both affective and non-affective tasks, indicating that depressed subjects displayed an unusually prolonged amygdala response following the presentation of negative words, an effect that persisted into a subsequent non-emotional Sternberg task. More recently, Johnstone et al. (2007) instructed depressed subjects to cognitively regulate emotional responses to arousing pictures while undergoing functional MRI. Results indicated that during active emotion regulation, depressed individuals exhibited inefficient processing by recruiting areas of the prefrontal cortex not accessed by controls. Also, patients showed an abnormal relationship between frontal regions recruited during regulation and sub-cortical regions (i.e. amygdala) that index emotional arousal: ventromedial prefrontal cortex (VMPFC) activation during regulation was negatively related to amygdala activation in controls, where depressed patients showed a positive relationship between these two regions. (Johnstone et al., 2007). Taken together, these studies provide some neurobiological evidence for difficulty inhibiting and, to an extent, excessive attention for negative information in depressed individuals.

As mentioned above, there is not universal support for the existence of negative attentional biases in depression as they manifest in laboratory paradigms. Gotlib et al. (2004) postulated that they were able to observe the bias in their depressed sample, in part, because they used stimulus presentations of 1000 ms. They stated that this allowed time for both initial orienting and maintenance of attention to the affective stimulus. However, because human beings have the ability to separate affective and non-affective stimuli at stages that precede consciousness and can appraise emotional content on the order of milliseconds (see LeDoux, 1996), it is puzzling that, should an attentional bias for negative stimuli exist in depression, it would take a full second to emerge. Part of the issue might be that the methods typically employed in this type of study are not able to reveal the subtle changes that take place at various stages in the information processing stream associated with the presentation of an emotional stimulus. It is possible that depressed subjects are devoting more attentional resources to negative stimuli even using these faster presentation times, but the effect is not evident in a behavioral response given that it is an end-result of many processes that lead up to its production. Indeed, there have been a handful of studies that have observed *some* indication of a negative attentional bias in depression using stimuli presented as quickly as 300 ms, though results using primarily behavioral responses in this context have been inconsistent (Murphy et al., 1999; Erickson et al., 2005).

Furthermore, the time-course of the mechanisms that underlie the appraisal and inhibition of emotional information remain somewhat unclear. Joormann and colleagues interpret the lack of significantly slowed responses to a negatively primed target as indicative of a difficulty inhibiting the preceding negative distracter, but this inference is based on a comparison between two reaction times and not a specific measure of inhibition collected at the presentation of the distracter. Regarding specific brain activation, recent fMRI studies offer evidence to suggest that frontal brain regions that are typically involved in inhibition are compromised in depression using both affective and non-affective tasks (Elliott et al., 2002; Langenecker et al., 2007). Using an affective go/no-go procedure, Elliott and colleagues discovered that depressed individuals showed – relative to controls – enhanced neural responses to emotional distracters at the orbitofrontal cortex, and specifically enhanced responses to negative distracters. This result suggests that cortical regions that subserve inhibition operate inefficiently in depression—a phenomenon reflected in other contexts that require cognitive control, even in the *absence* of emotional influence, such as in a standard go/no-go or Stroop procedure (Langenecker et al., 2007; Wagner et al., 2006). However, due to the nature of fMRI data, which exhibits relatively poor temporal resolution, it cannot be said for certain at what stage in stimulus processing these difficulties emerge.

To improve upon the methodology used in these prior investigations, the employment of event-related brain potentials (ERPs; "The reaction time for the 21st century" in Luck et al., 2000; Luck, 2005) is a useful means of examining both the devotion of attentional resources and the extent to which cognitive control is being exerted (e.g. Donchin and Coles, 1988; Van Veen and Carter, 2002). There has been a wealth of research examining the relationship between ERP responses and affective stimulus processing. Specifically, experimenters have targeted components emerging in the late stages of the P3 "family" – known as the P3B and late positive potential (LPP) – as being especially sensitive to motivationally relevant stimuli (e.g. Schupp et al., 2000; Carretié et al., 2001; Schupp et al., 2004; Delplanque et al., 2006; Bradley et al., 2007). Studies have consistently shown that these late components are enhanced for emotional versus neutral pictorial