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Title

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Permalink

<https://escholarship.org/uc/item/18h2h3r1>

Journal

Visual Cognition, 22(8)

ISSN

1350-6285

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Publication Date

2014-09-14

DOI

10.1080/13506285.2014.960666

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Peer reviewed



Published in final edited form as:

Vis cogn. 2014 ; 22(8): 1014–1017. doi:10.1080/13506285.2014.960.

The Attribution of Value-Based Attentional Priority in Individuals with Depressive Symptoms

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Attention guides thought and behavior. Information that is attended becomes available to higher-order cognitive processes such as working memory and decision-making. In order to promote wellbeing, it is important that attention selects stimuli associated with rewarding outcomes (Anderson, 2013). Consistent with this idea, stimuli associated with high reward are preferentially attended in healthy individuals (e.g., Della Libera & Chelazzi, 2009; Hickey et al., 2010; Raymond & O'Brien, 2009). Such value-based attentional selection becomes automatic and persistent following associative learning between a stimulus and reward outcome, suggesting that the reward history of a stimulus can modify its attentional priority (e.g., Anderson et al., 2011, 2013).

Value-driven attentional capture has only been assessed in healthy individuals obtained through general recruitment methods, with the exception of one study showing elevated value-driven attentional capture in a drug-dependent sample (Anderson et al., 2013). It is unclear whether reward-associated stimuli can fail to acquire value-based attentional priority for certain types of individuals, and identifying the characteristics of such individuals would provide insights into the psychological and underlying neurobiological processes that play an important role in value-driven attention.

One case in which there appears to be a deficit in the processing of reward information is depression. Clinically, depression often presents with decreased pleasure from and reduced interest in activities that were previously experienced as enjoyable (Eshel & Roiser, 2010). Depression is also associated with increased focus on negative thoughts and events, at the expense of more positive alternatives that tend to be ignored or overlooked (Mathews & MacLeod, 2005). Experimental evidence demonstrates decreased sensitivity to reward information in depression (Henriques & Davidson, 2000; Shankman et al., 2007). We hypothesized that symptoms of depression are accompanied by a blunted influence of prior reward on attentional selection compared to that observed in non-depressed individuals, such that previously high-value stimuli that are normally attention capturing are more readily ignored in depression.

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Methods

College undergraduates experiencing symptoms of depression performed a visual search task involving a *training phase* and a *test phase* that was identical to the task originally used to demonstrate value-driven attentional capture (Anderson et al., 2011, Experiment 3). Performance for this depressed sample was compared to that of a control sample drawn from the general undergraduate population. In a training phase, each of two color-defined targets was associated with a monetary reward when correctly reported, with one target color yielding higher reward than the other on average (Figure 1A). In a subsequent test phase, targets were defined by shape while color was irrelevant to the task; on a subset of the trials, one of the nontargets was rendered in the color of a previously reward-associated target (Figure 1B). Depressive symptomology was quantified for all participants using the Beck Depression Inventory (BDI-II).

Results

Mean BDI-II score was 29.3 for the depressed group and 5.4 for the control group, $t(56) = 12.23, p < .001$. While the mean BDI-II score for the control group fell well within the bottom range defined as *minimal depression* by the measure, the mean for the depressed group fell within the range of *severe depression*.

An ANOVA on mean RTs in the test phase with distractor condition (absent, low-value, high-value) as a within-subjects factor and depressed status (depressed vs control) as a between-subjects factor revealed no main effect of either variable, F 's < 1 . However, distractor condition interacted linearly with depressed status, $F(1,56) = 8.26, p = .006$ (Figure 1C). We defined value-driven attentional capture as the difference in RT on high-value distractor trials compared to distractor absent trials, as we have done in prior studies (e.g., Anderson et al., 2011, 2013). While value-driven attentional capture was evident in the control participants, $t(29) = 3.05, p = .005$, replicating previous findings, the depressed participants showed no evidence of value-driven attentional capture, $t(27) = -0.97, p = .342$. On a continuous level, BDIII score was significantly correlated with the magnitude of value-driven capture, $r = -.311, p = .018$ (Figure 1D). An ANOVA on accuracy with distractor condition and depressed status as factors revealed no main effects or interaction, F 's $< 1.09, p$'s $> .34$.

Discussion

Stimuli previously associated with reward have been consistently shown to involuntarily capture attention in healthy individuals (e.g., Anderson et al., 2011, 2013). In the present study, we show that individuals experiencing depressive symptoms largely ignore previously high-value stimuli, suggesting that such stimuli are less attention-grabbing in depression. This sharp contrast to the pattern of performance observed in prior studies and replicated here in the control participants indicates that depression is accompanied by changes in how the attention system is shaped by reward information.

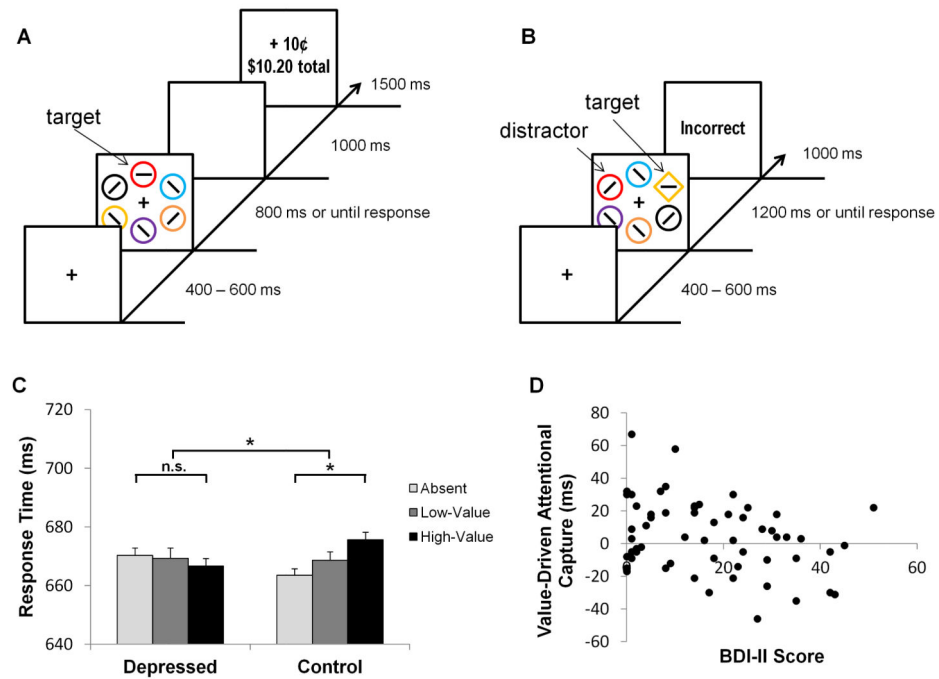
Reduced automatic attention to previously reward-associated stimuli could play a role in the experience of symptoms of depression. By failing to orient to reward-associated stimuli,

potentially enjoyable or otherwise beneficial opportunities may become less salient. This reduced salience could then, in turn, decrease the extent to which an individual pursues rewarding opportunities and thinks about rewarding outcomes, with implications for overall mood. Reduced attention to reward-related stimuli could represent a risk factor for the development of depressive symptoms, or it could reflect depression-related changes in how the brain processes information. To the extent that reduced automatic attention to reward-related stimuli follows the development of depressive symptoms, it could serve to facilitate the maintenance of a depressed state by biasing subsequent information processing.

The findings of the present study demonstrate a link between depressive symptoms and value-based attention. The attention system of depressed individuals exhibits an apparent hyposensitivity to the reward history of visual objects. Our findings provide further insight into how cognitive processes are affected in depression. The present study also indicates a direct relationship between value-based attention and the normal processing of reward information, as predicted by a distinctly value-driven mechanism of attentional control (Anderson, 2013).

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**Figure 1.**

(A-B) Sequence and time course of events for a trial in the training phase (A) and test phase (B). (C) Mean response time by distractor condition in the test phase. Error bars reflect the within-subjects SEM for each participant group. (D) Relationship between value-driven attentional capture and BDI-II score.