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BRIEF REPORT

Delighted and Distracted: Positive Affect Increases Priming for Irrelevant Information

Renée K. Biss and Lynn Hasher
University of Toronto and Rotman Research Institute of Baycrest Centre

Emotional states are known to influence how people process relevant information. Here, we address the impact of emotional state on irrelevant information. In this experiment, participants were randomly assigned to a neutral or positive mood induction, and then completed a task that involved viewing a sequence of overlapping pictures and words. They were instructed to attend to the pictures and ignore the distracting words. Following a filled interval, implicit memory for the distracting words was tested using a word fragment completion task. Individuals in the positive mood group showed increased implicit memory for previously irrelevant information compared to those in the neutral mood group. These findings are consistent with the view that positive mood broadens attention to include encoding of irrelevant information in the environment, and this can impact subsequent performance.

Keywords: positive affect, attention, inhibition, transfer, implicit memory

Our emotional context influences what we attend to and remember. For example, positive affect is theorized to broaden attention and lead to more flexible cognition (Fredrickson, 2001; Isen, 1999). Positive affect expands the visual field of view (Schmitz, De Rosa, & Anderson, 2009) and enhances autobiographical memory for peripheral details (Talarico, Bernsten, & Rubin, 2009). Positive states also facilitate creative problem solving and the ability to make connections between divergent materials (Isen, Daubman, & Nowicki, 1987; Rowe, Hirsh, & Anderson, 2007). In contrast, negative affect coupled with high arousal is hypothesized to induce rigid thinking and a narrow attentional focus on central cues instead of peripheral information (Derryberry & Tucker, 1994; Easterbrook, 1959).

The broad and flexible processing style observed under positive affect may be a result of loosened inhibitory attentional control. Inhibitory control regulates the contents of consciousness by suppressing information that is irrelevant to current goals (Hasher, Zacks, & May, 1999). In support of this idea, positive affect decreases performance on tasks gauging inhibitory control, including negative affective priming (Goeleven, De Raedt, & Koster, 2007), directed forgetting of previously relevant information (Bäuml & Kuhbandner, 2009), and the classic flanker task (Fenske & Eastwood, 2003; Rowe et al., 2007). Reduced inhibitory control associated with a positive mood may be directly related to increased cognitive flexibility: Individual differences in semantic access are associated with reduced selectivity in visual attention (Rowe et al., 2007).

Reduced inhibitory control is also known to have some counterintuitive benefits. When previously irrelevant information becomes useful, individuals with reduced inhibitory control, such as older adults and individuals tested at a nonoptimal time of day, show a selective benefit in performance for the irrelevant information (Campbell, Hasher, & Thomas, 2010; Kim, Hasher, & Zacks, 2007; Rowe, Valderrama, Hasher, & Lenartowicz, 2006). In the Rowe et al. (2006) study, younger and older adults performed a 1-back task on pictures that were superimposed with irrelevant words. When subsequently given an implicit word fragment task in which some of the fragments could be solved using the previously irrelevant words, older adults showed greater priming. The extent of priming was amplified for both older and younger adults when they were tested at their nonoptimal time of day, when inhibitory control is more likely to be weak or disengaged (May & Hasher, 1998). There is also evidence that individual differences in pleasant mood are associated with greater implicit memory for distraction (Biss, Hasher, & Thomas, 2010).

Taken together, these findings suggest that if positive affect relaxes inhibitory control over irrelevant information, individuals in a positive mood should encode more distraction and demonstrate greater subsequent use of that distraction. Our previous evidence (Biss et al., 2010) showed a correlation between naturally occurring positive mood among students and their subsequent implicit use of distraction. The purpose of the present study was to determine whether positive affect has a causal effect on the broad-

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Renée K. Biss and Lynn Hasher, Department of Psychology, University of Toronto, Toronto, Ontario, Canada and Rotman Research Institute of Baycrest Centre, Toronto, Ontario, Canada.

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Correspondence concerning this article should be addressed to Renée K. Biss, Department of Psychology, University of Toronto, 100 St. George Street, Toronto, Ontario, M5S 3G3 Canada. E-mail: renee.biss@utoronto.ca

ening of attention to distracting information, ultimately resulting in facilitated transfer of this information to a later task. To this end, we induced positive and neutral moods in younger adults before they performed a version of Rowe and colleagues' (2006) 1-back and fragment tasks. We predicted that the positive mood group would show greater priming for distraction than the neutral mood group.

Method

Participants

Sixty-four students (43 female, 21 male) from the University of Toronto who were native English speakers participated in the study. Participants had a mean age of 19.4 years ($SD = 2.7$; range 17 to 33), and 12.9 years of education ($SD = 1.2$). They received course credit or monetary compensation. Participants were randomly assigned to the positive ($n = 32$) and neutral ($n = 32$) mood induction groups.

Materials

For the mood induction, 146 pictures were selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) using the IAPS norms. Pictures used for the neutral condition had valence ratings between 4.5 and 5.5 ($M = 5.1$, $SD = 0.3$). Those used in the positive mood induction had valence ratings greater than seven ($M = 7.5$, $SD = 0.3$). Arousal ratings did not differ between neutral ($M = 4.1$, $SD = 0.9$) and positive pictures ($M = 4.2$, $SD = 0.5$), $t(144) < 1$. Sound clips devoid of verbal material were also selected for use in the mood induction. In the neutral condition, participants listened to ambient street noise, while in the positive mood condition, participants listened to a jazzed up version of Bach's *Brandenberg Concerto No. 3*, which has previously been found to induce positive mood (e.g., Rowe et al., 2007). Mood pleasantness was assessed using a 9-point scale adapted from Rowe et al. (2007) that ranged from 1 ("not at all pleasant") to 9 ("extremely pleasant"). Arousal was also assessed using a scale that ranged from 1 ("very calm") to 9 ("very aroused").

Fifty-five line drawings, selected from Snodgrass and Vanderwart (1980) and colored red, were used as target pictures for the 1-back task. Fifty drawings were superimposed with distracting information: 30 with random letter strings, 10 with filler words, and 10 with critical primed words. The filler words were included to reduce awareness of the connection between tasks.

Twenty critical words and their corresponding fragments were selected and divided into two lists. The critical words were five to eight letters long ($M = 6.0$, $SD = 1.1$). Lists were counterbalanced such that each participant was exposed to one list in the 1-back task (the primed list) and solved fragments from both lists in the fragment completion task. Completion from the list not seen in the 1-back task (the control list) was used to calculate baseline fragment completion. All fragments could be solved using multiple English words, only one of which was presented in the experiment. Ten easy filler fragments were also used in the fragment completion task to limit awareness of the connection between the study and test phases. These fragments all had high completion rates ($M = 68\%$, $SD = 14\%$), to ensure that participants felt successful during the task.

Procedure

After participants gave informed consent, they rated their current mood pleasantness and arousal. For the 6 min mood induction, participants viewed the IAPS pictures on the computer screen and listened to the corresponding sound clip using headphones. The pictures appeared one at time on the screen for 5 s each. Participants were instructed to relax and think about the pictures and music. Participants then rated mood pleasantness and arousal a second time to determine the effectiveness of the mood induction.

For the 1-back task, participants viewed a sequence of overlapping pictures and letter strings and were instructed to press the spacebar whenever consecutive pictures were identical. They were instructed to ignore the superimposed words or nonwords and attend to the pictures only. Overlapping pictures and words were presented in the center of the computer screen for 1000 ms, with an ISI of 500 ms. There were 10 consecutive picture pairs, which were randomly placed amid novel pictures. Accuracy and latency for these 10 responses were used to determine 1-back task performance. The sequence proceeded as follows: Five trials of only pictures, followed by eight with nonwords, 34 critical trials with a mixture of nonwords, filler words, and target words, then eight trials with nonwords.

A nonverbal filler task lasting between 8 and 10 min was used to minimize awareness of the connection between the two critical tasks. Participants rated their mood pleasantness and arousal at the end of this filled interval.

For the fragment completion task, participants viewed 30 word fragments, each presented on the screen for 3,000 ms. Participants responded out loud with the first word that came to mind. No reference to the 1-back task was made. Of the presented fragments, 10 were easy filler fragments, 10 were from the control list not seen by the participant, and 10 could be completed using the superimposed target words from the study phase (i.e., primed fragments). Following this task, participants rated mood pleasantness and arousal a final time. To ensure that participants did not intentionally complete the word fragments with words that they remembered from earlier in the study, participants were given an awareness questionnaire.

Finally, participants filled out a background questionnaire and were debriefed. As a mood reinstatement, all participants watched a brief comedic video clip before leaving.

Results

Four participants reported awareness of the connection between study and test phases and their data were removed. The remaining sample included 30 participants in each mood induction group.

Figure 1 shows the mood pleasantness and arousal ratings made across the experiment. Pleasantness ratings were submitted to an ANOVA with mood group (positive, neutral) as a between-subjects factor and time of rating (baseline, postinduction, prefragment, postfragment) as a within-subjects factor. Greenhouse-Geisser corrections for degrees of freedom were

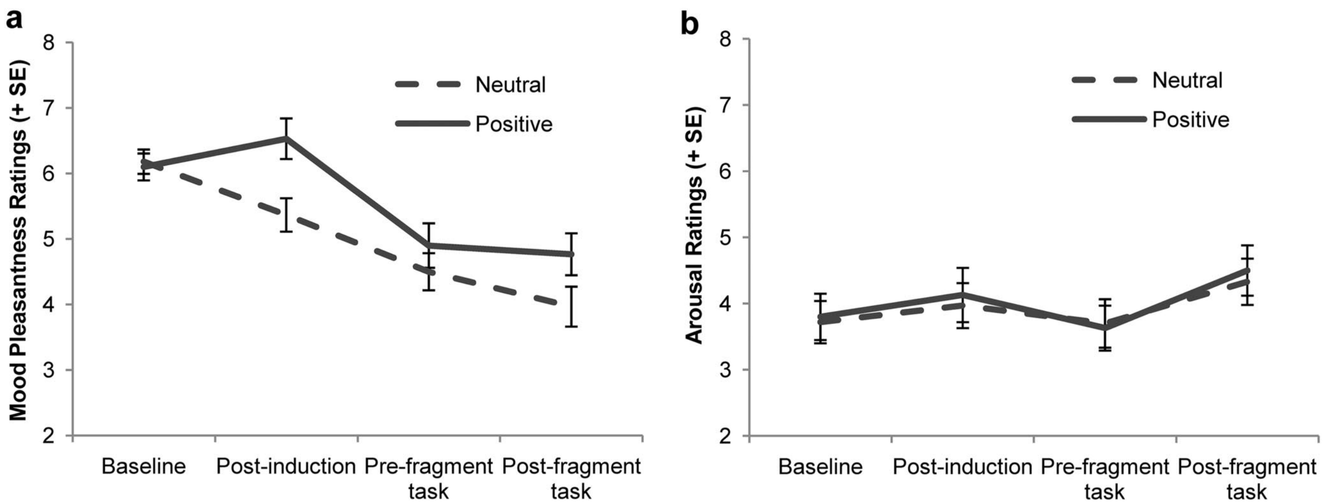

Figure 1. (a) Mood pleasantness and (b) arousal ratings for each mood induction group, made at baseline, after the mood induction, and immediately before and after the fragment completion task.

used where appropriate. There was no main effect of mood group, $F(1, 56) = 3.00$, $p = .09$, but there was a significant main effect of rating time, $F(2.6,145.6) = 29.26$, $p < .001$, $\eta_p^2 = .34$. Critically, the interaction between mood group and rating time was significant, $F(2.6,145.6) = 2.83$, $p = .048$, $\eta_p^2 = .05$. Planned comparisons indicated that the positive mood group gave higher ratings than the neutral group following the induction procedure, $t(58) = 2.90$, $p = .005$, $d = 0.75$, and there was a trend toward higher mood ratings in the positive group after completing the fragment task, $t(58) = 1.80$, $p = .08$. No other differences approached significance, *t*s < 1. Thus, the appropriate mood was engaged during the critical 1-back task, when affect was expected to influence the breadth of encoding. Arousal ratings were also submitted to a mixed ANOVA with mood group as a between subjects factor and time of rating as a within-subjects factor. There was a reliable main effect of rating, $F(2.7,151.4) = 4.71$, $p = .005$, $\eta_p^2 = .08$, with arousal ratings increasing after the fragment completion task. No other effects were significant, *Fs* < 1.

Accuracy on the 1-back task was at ceiling for both the neutral ($M = 97\%$, $SD = 7\%$) and positive ($M = 98\%$, $SD = 5\%$) mood groups. Latency on the 1-back task did not differ between the neutral ($M = 528$ ms, $SD = 72$) and positive ($M = 536$ ms, $SD = 98$) conditions, $t(58) < 1$.

Performance on the fragment completion task is shown in Table 1. Control fragment completion rates did not differ between the neutral and positive groups, $t(58) < 1$, and neither did performance on the easy filler fragments, $t(57) = 1.01$, $p = .32$. Priming for distraction was calculated by subtracting control completion rates for each group from each participant's primed completion. Consistent with predictions, priming for previous distraction was greater for the positive group compared to the neutral mood group, $t(46) = 2.06$, $p = .045$, $d = 0.53$.

Table 1
Means (SDs) for Fragment Task Performance

Measure	Positive mood group	Neutral mood group
Primed fragment completion	24% (17)	17% (10)
Control fragment completion	11% (10)	11% (11)
Filler fragment completion	70% (15)	67% (14)
Priming	13% (17)	6% (10)

Discussion

Participants in the positive mood group showed greater implicit memory for distraction compared to those in a neutral mood, a finding consistent with the idea that positive affect relaxes inhibitory control processes that otherwise prevent salient but irrelevant information from accessing working memory (Rowe et al., 2007).

At least two alternative interpretations of the present findings should be considered. One possibility is that the effect of positive affect occurred at retrieval, not at encoding. That is, both groups encoded the distraction but people in a positive mood were more likely to transfer or rely on previously irrelevant information when it subsequently became relevant. However, while the two groups differed on pleasant mood ratings at encoding, they did not differ before the fragment completion task. This pattern suggests that, in the present experiment, positive affect broadened attention to distraction at encoding. A second potential interpretation of the present findings is tied to a suggestion made by Driesbach and Goschke (2004): A positive mood biases people toward novel or salient stimuli. With respect to the findings in the present study, that would mean that what was novel or salient were the superimposed words as compared to the superimposed nonwords. It is not clear that this explanation can handle the range of findings that are consistent with a broadening of encoding or reduced inhibitory regulation explanation, particularly those results from tasks using repetitive materials (e.g., Fenske & Eastwood, 2003; Goeleven et al., 2007; Rowe et al., 2007). We did not test here for knowledge of the nonwords, which on their surface would appear to be more novel than the familiar words used here as distraction.

The current findings are consistent with the broaden-and-build theory (Fredrickson, 2001; Fredrickson & Branigan, 2005), which suggests that positive affect broadens the scope of attention, such that individuals in a positive mood process a wider range of information from the environment. Broadening associated with positive emotional states has previously been demonstrated by increased processing of spatially adjacent distractors (Rowe et al., 2007), and the tendency to process the big picture rather than small details (Fredrickson & Branigan, 2005; Gasper & Clore, 2002). Here, we found that attentional broadening has a mnemonic benefit in terms of improved implicit memory for nontarget information.

At a neural level, positive affect may influence recruitment of prefrontal cortex (PFC) regions that downregulate processing of information that is irrelevant to a current goal. Indeed, positive affect is known to impair several behavioral measures of executive control, including planning, updating, and switching (Mitchell & Phillips, 2007). Older adults, a population with reduced executive control abilities and functional changes in the PFC (Grady, 2008), show greater priming for previous distraction (Rowe et al., 2006), similar to the positive mood younger adults in our study. Because aging is associated with decreased negative, and sometimes increased positive affect (Gross et al., 1997; Stone, Schwartz, Broderick, & Deaton, 2010), an intriguing possibility is that older adults' more pleasant emotional states may contribute to their increased susceptibility to distraction.

In a general sense, positive affect may make it more difficult to restrict cognitive representations to those based on a current goal, resulting in more flexible and creative behavior. Indeed, positive affect harms performance when a goal needs to be maintained, but improves flexibility when a goal changes (Dreisbach & Goschke, 2004). This is consistent with the idea that positive affect engenders an openness to consider opportunities beyond the goal currently being pursued (Carver, 2003). We have demonstrated that positive affect increases the use of previously goal-irrelevant information when it becomes relevant on a subsequent implicit task. In addition to enhancing flexible selection of cognitive perspective (Ashby, Isen, & Turken, 1999; Isen, 1999), positive affect may improve implicit learning by relaxing executive control processes and allowing a greater range of information to be attended. Tacit knowledge of distraction has predictive value: Seemingly extraneous information that appeared frequently in the recent past will likely occur in the future, when it might be important. Positive moods may enable one to pick up on these environment regularities unnoted by others, thereby providing a greater scope of information available for future decision making and problem solving.

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