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BRIEF REPORT

Memory for affectively valenced and neutral stimuli in depression: Evidence from a novel matching task

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Depressed persons have better memory for affectively negative than positive stimuli, a pattern generally not exhibited by non-depressed individuals. The mechanisms underlying this differential memory are not clear. In this study we examined memory for valenced and neutral stimuli in depressed and non-depressed individuals under conditions of relatively unconstrained encoding. We developed a novel task based on the game, *Concentration*, in which participants tried to match pairs of positive and negative words, and pairs of neutral words, hidden under squares in as few turns as possible. Whereas non-depressed participants selected and turned over positive squares more frequently than they did negative squares, depressed participants selected and turned over positive and negative squares equally often. Depressed participants also matched fewer positive word pairs within the first five minutes of the task than did non-depressed participants, and they exhibited poorer learning of positive words. Depressed and non-depressed participants did not differ in their matching of neutral words. These findings add to a growing literature indicating that depression is characterised by difficulties in the processing of positive stimuli.

Keywords: Depression; Memory; Encoding; Retrieval; Valenced stimuli.

Major depressive disorder (MDD) is among the most prevalent of all psychiatric conditions. Recent estimates indicate that almost 20% of the American population, or more than 30 million adults, will experience a clinically significant episode of depression at some point in their lives (Kessler & Wang, 2009). MDD is characterised by a constellation of behavioural, emotional, and cognitive symptoms, including psychomotor agitation or retardation, marked weight loss, insomnia or hypersomnia, decreased appetite, fatigue, extreme feelings of guilt or worthlessness, concentration difficulties,

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and suicidal ideation. Most consistently, perhaps, and in contrast to their non-depressed counterparts, individuals diagnosed with MDD have been found to have better memory for negative than for positive or neutral information; in addition, several investigators have found depressed individuals to have poorer memory for positive stimuli than do non-depressed persons (see Gotlib & Joormann, 2010, for a review).

Traditional cognitive theories of depression (e.g., Beck, 1976) posit that individuals diagnosed with MDD have negative schemas or expectancies that lead them to attend to and remember information relevant to those schemas. In most of these studies, non-depressed and depressed participants are presented with a list of positive, neutral, and negative words, one at a time, that they have to encode (often by making a self-referential judgement about each word) and are then asked, typically in an incidental memory task, to recall the words (e.g., Derry & Kuiper, 1981; Lim & Kim, 2005). Given the limitations of this paradigm, it is not clear precisely why depressed individuals exhibit better memory for negative stimuli than they do for positive stimuli, and poorer memory for positive information than do non-depressed persons. One possibility is that depressed individuals devote more resources to encoding negative stimuli and fewer resources to encoding positive stimuli and, consequently, have better memory for negative and poorer memory for positive stimuli. This formulation does not require that the encoding of negative items be *absolutely* greater than the encoding of positive items, only that the *relatively* stronger encoding of negative versus positive items will be greater among depressed than among non-depressed individuals. Thus, for example, if non-depressed individuals are characterised by a bias to encode positive stimuli more strongly than they do negative stimuli, this bias could be either reduced or reversed in depressed individuals, a prediction that we test in the present study.

A second possibility is that depressed individuals differ from non-depressed persons not in their relative encoding of positive and negative stimuli, but instead, in their retrieval of positive and negative stimuli. For example, depressed individuals may have increased accessibility to negative information and/or decreased accessibility to positive information; they may also have privileged immunity from forgetting negative stimuli. Although some investigators have demonstrated that depressed individuals attend preferentially to negative over neutral stimuli (Eizenman et al., 2003; Gotlib, Krasnoperova, Yue, & Joormann, 2004), few studies have assessed memory for negative and positive stimuli as a function of experimental exposure to those categories of stimuli.

The present study was designed to address these issues. We used a novel, relatively unconstrained, task in which participants selected, viewed (often repeatedly), and tried to remember the content and location of positive, negative, and neutral stimuli. Depressed and non-depressed individuals were presented with an 8 by 8 grid on a computer screen. Under the 64 squares were, for one set of depressed and non-depressed participants, 16 pairs of positive words and 16 pairs of negative words; for another set of depressed and non-depressed participants, the 64 squares were 32 pairs of words that were neutral in valence. As in the game *Concentration*, participants were instructed to try to match all of the pairs of words by turning over two squares at a time, in as few turns as possible, until they had matched all the words on the entire board. Examining the frequencies and sequences of positive and negative squares turned over, as well as when they were matched, we were able to assess differential exposure to positive and negative stimuli by depressed and non-depressed participants (i.e., the number of positive and negative squares they turn over) and memory for positive and negative material as a function of exposure to those stimuli (i.e., the ratio of successful matches of negative and positive stimuli to the number of positive and negative squares turned over). In addition, by including a group of depressed and non-depressed participants who solved a board consisting only of pairs of neutral words (it was not feasible to include positive, negative, and neutral words all on a single board), we were able to examine the specificity to valenced stimuli of depression-associated difficulties to the processing of these words. We generated three hypotheses for this study:

1. Compared to non-depressed participants, depressed participants would turn over (i.e., seek), in total, a greater number of negative squares and fewer positive squares in their attempts to match the word pairs.
2. The ratio of negative to positive pairs matched within the same time frame and within the same number of "turns" would be higher in depressed than in non-depressed participants.
3. Depressed and non-depressed participants would not differ in their viewing of, or memory for, neutral stimuli.

METHOD

Participants

Participants were solicited from two out-patient psychiatry clinics as well as through advertisements posted within the community. We excluded individuals if they were not fluent in English, were not between 18–60 years of age, or if they reported severe head trauma or learning disabilities, psychotic symptoms, bipolar disorder, or alcohol or substance abuse within the past six months. Trained interviewers administered the Structured Clinical Interview for the DSM (First, Spitzer, Gibbon, & Williams, 1997) to eligible individuals during their first study session. Inter-rater reliability was high: $\kappa = .93$ for the MDD diagnosis, and .92 for the "non-psychiatric control" diagnosis (i.e., the absence of current or lifetime psychiatric diagnoses, according to the DSM-IV criteria; American Psychiatric Association, 1994).

Participants were included in the depressed groups if they met the DSM-IV criteria for MDD. The never-disordered control groups consisted of individuals with no current diagnosis and no history of any Axis I disorder. Participants also completed the Beck Depression Inventory – II (BDI; Beck, Steer, & Brown, 1996), a 21-item, self-report measure of the severity of depressive symptoms. Eligible participants were asked to return to the lab within a week after the SCID to complete the modified *Concentration* task. Fifty participants (25 MDD, 25 never-disordered controls) completed the task with pairs of positive and negative words, and an independent sample of 20 MDDs and 20 never-disordered controls completed the task with pairs of neutral words.

Stimuli

Sixteen negative words, 16 positive words, and 32 neutral words from the Affective Norms for English Words (ANEW) battery developed by Bradley and Lang (1999) were selected as stimuli. As expected, the three types of words differed significantly in valence, $F(2, 61) = 146.08$, $p < .01$; they also differed in arousal, $F(2, 61) = 44.22$, $p < .01$, but not in either frequency, $F(2, 61) = 1.82$, $p = .17$, or length, $F(2, 61) < 1$. Positive and negative words differed in valence (negative: $M = 1.98$, $SD = 0.35$; positive: $M = 8.02$, $SD = 0.33$), $t(30) = 50.32$, $p < .01$, but not in arousal (negative: $M = 5.47$, $SD = 0.93$; positive: $M = 5.67$, $SD = 0.98$), $t(30) < 1$, frequency (negative: $M = 23.62$, $SD = 31.79$; positive: $M = 40.31$, $SD = 30.05$), $t(30) = 1.39$, $p = .18$, or length (negative: $M = 6.12$, $SD = 0.80$; positive: $M = 6.37$, $SD = 0.80$), $t(30) < 1$. The neutral words had a mean valence rating of 4.97 ($SD = 0.30$), a mean arousal rating of 3.84 ($SD = 0.44$), a mean word frequency of 57.33 ($SD = 75.05$), and a mean word length of 6 ($SD = 1.30$). The neutral words differed from the negative words in valence, $t(46) = 30.83$, $p < .01$, and arousal, $t(46) = 8.31$, $p < .01$. No significant differences were found between the neutral and negative words in frequency, $t(46) = 1.71$, $p > .05$, or length, $t(46) < 1$. The neutral words differed from the positive words in valence, $t(46) = 32.28$, $p < .01$, and arousal, $t(46) = 9.01$, $p < .01$, but not in frequency or length, both ts$(46) < 1$.

Design and procedure

In our version of the *Concentration* task, participants were presented with an 8×8 grid of solid blue squares on a computer monitor. Under the 64 squares were either 16 pairs of positive words and 16 pairs of negative words for one set of participants, or 32 pairs of neutral words for another set of participants, which were randomly assigned to the squares at the beginning of the task. Participants were instructed to try to match all of the pairs of words in as few turns as possible. For each turn, participants clicked on two squares, one at a time. Clicking on a square turned it over to reveal the word underneath. If the two words participants turned over in a single turn matched (i.e., were the same word), the two squares turned black and were no longer in play; if the two words did not match, the two squares returned to solid blue two seconds after the second square was clicked; the participants then began the next trial. This procedure was repeated until the participants matched all 32 word pairs.

RESULTS

Participant characteristics

The 25 depressed and 25 non-depressed participants who completed the valenced board (MDD: 21 female; CTL: 22 female) did not differ significantly in age (MDD: $M = 40.64$ years, $SD = 14.55$; CTL: $M = 39.88$ years, $SD = 11.94$), $t(48) < 1$, or education (college degree: MDD = 47%; CTL = 48%), $\chi^2(1, 50) < 1$; as expected, MDD participants had significantly higher BDI scores than did CTL participants (MDD: $M = 32.08$, $SD = 9.92$; CTL: $M = 1.04$, $SD = 1.57$), $t(48) = 15.45$, $p < .01$. The 20 depressed and 20 non-depressed participants who completed the neutral board (MDD: 12 female; CTL: 9 female) also did not differ significantly in age (MDD: $M = 29.85$ years, $SD = 11.06$; CTL: $M = 36.10$ years, $SD = 12.43$), $t(36) = 1.68$, $p = .10$, or education (college degree: MDD = 65%; CTL = 55%), $\chi^2(1, 37) < 1$; again, as expected, MDD participants had significantly higher BDI scores than did CTL participants, with completely non-overlapping distributions (MDD: $M = 27.11$, $SD = 10.64$, range = 15–49; CTL: $M = 1.80$, $SD = 1.96$, range = 0–6), $t(36) = 10.46$, $p < .01$.

Valenced board: Number of turns before completely solving the board

Depressed and non-depressed participants differed significantly both in the total number of turns they took before completely solving the board and in the time they took to solve the board. Depressed participants took more total turns than did non-depressed participants (Depressed: $M = 338.56$, $SD = 110.59$; Non-depressed: $M = 268$, $SD = 75.43$), $t(48) = 2.64$, $p < .05$; $d = 0.75$, and took longer to solve the board (Depressed: $M = 12.72$ min, $SD = 4.58$; Non-depressed: $M = 9.86$ min, $SD = 3.36$), $t(48) = 2.52$, $p < .05$; $d = 0.71$.

Valenced board: Number of positive and negative squares turned over

The quickest participants solved the entire board in about six minutes. Consequently, we restricted our primary data analyses to the first five minutes of the task to ensure that all participants were still engaged in solving the board. A two-way (Group repeated over Valence) analysis of variance (ANOVA) conducted on the number of positive and negative squares turned over by MDD and CTL participants within the first five minutes did not yield significant main effects of Group or Valence, both $Fs(1, 48) < 1$, but did yield a significant interaction of Group and Valence, $F(1, 48) = 5.03$, $p < .03$. Within the first five minutes of the task, the CTL participants turned over more positive ($M = 68.96$, $SD = 12.14$) than negative ($M = 63.84$, $SD = 15.91$) squares, $t(24) = 2.01$, $p < .05$; in contrast, the MDD participants did not differ in the number of positive ($M = 62.52$, $SD = 12.53$) and negative ($M = 65.24$, $SD = 10.81$) squares they turned over, $t(24) = 1.13$, $p = .27$, nor did they differ from their non-depressed counterparts in the number of times they turned over either positive,

$t(48) = 1.85$, $p = .07$, or negative, $t(48) = 0.36$, $p = .72$, squares.

Valenced board: Positive and negative matches

The number of negative and positive matches made by depressed and non-depressed participants, cumulatively over each one-minute interval for the first five minutes, is presented in Figure 1. A three-way (Group repeated over Valence repeated over Time) ANOVA conducted on the number of matches yielded significant main effects of Group, $F(1, 48) = 4.86$, $p < .05$, and Time, $F(4, 192) = 161.50$, $p < .01$, and significant two-way interactions of Group and Time, $F(4, 192) = 3.81$, $p < .05$, and Valence and Time, $F(4, 192) = 2.87$, $p < .05$, all of which were qualified by a significant three-way interaction of Group, Valence, and Time, $F(4, 192) = 2.67$, $p < .05$. We conducted follow-up tests with an adjusted significance level of .03. These tests indicated that, compared with non-depressed participants, depressed participants matched significantly fewer negative words during the first minute, $t(48) = 2.45$, $p < .02$, $d = 0.69$ (Figure 1, left); they also matched significantly fewer positive words during the fourth and fifth minutes, $t(48) = 2.38$, $p < .03$, $d = 0.67$, and $t(48) = 2.81$, $p < .01$, $d = 1.04$, respectively (Figure 1, right), indicating that they had a lower rate of positive word matches over time than did their non-depressed counterparts.

Valenced board: Ratio of matches to squares turned over

Figure 2 presents the ratio, or proportion, of the number of negative and positive matches to the number of negative and positive squares turned over, respectively, for each minute over the first five minutes of the task. A three-way (Group repeated over Valence repeated over Time) ANOVA conducted on these ratios yielded a significant main effect of Time, $F(4, 192) = 3.31$, $p < .02$, which was qualified by a significant three-way interaction for the linear trend, $F(1, 48) = 7.14$, $p < .01$. It is clear from Figure 2 (right) that whereas non-depressed participants made an increasing number of matches to the positive squares turned over from the third through the fifth minutes, depressed participants did not demonstrate this effect of learning positive words. Follow-up tests, conducted again with an adjusted significance level of .03, indicated that, compared with the non-depressed participants, depressed participants matched significantly fewer positive words during the fourth, $t(48) = 3.0$, $p < .01$, $d = 0.86$, and fifth, $t(48) = 2.50$, $p < .02$, $d = 0.77$, minutes; no other group differences were significant.

Neutral board

As predicted, depressed and non-depressed participants did not differ significantly in the total number of turns they took before completely solving the neutral board, in the time they took

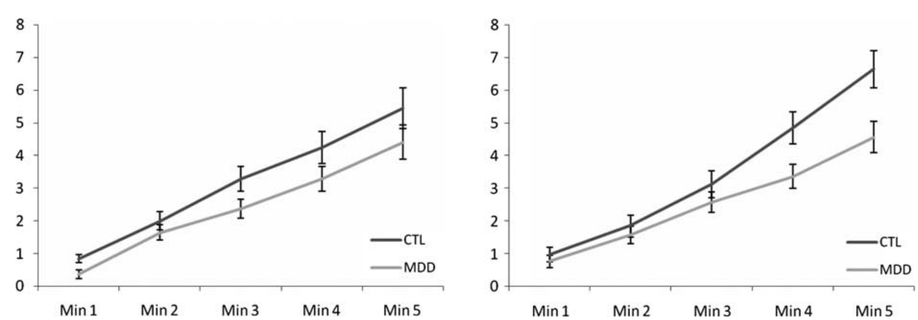
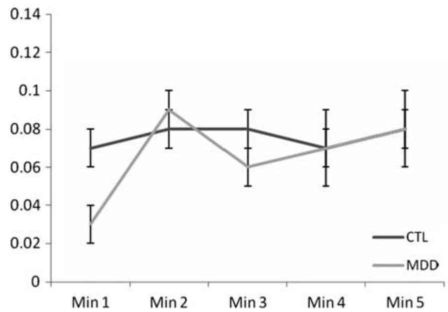


Figure 1. *Left: Negative word pairs solved cumulatively each minute during the first five minutes. Right: Positive word pairs solved cumulatively each minute during the first five minutes. CTL = Non-depressed controls; MDD = Participants with Major Depressive Disorder; Min = minutes of the task.*



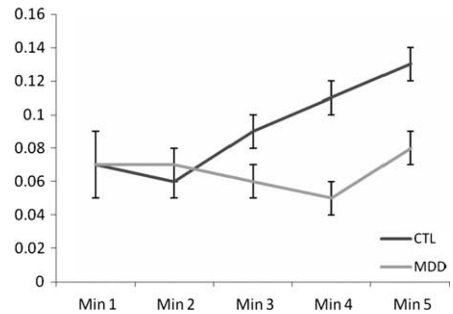


Figure 2. *Left: Ratio of negative matches to negative squares turned over during the first 5 minutes. Right: Ratio of positive matches to positive squares turned over during the first 5 minutes. CTL = Non-depressed controls; MDD = Participants with Major Depressive Disorder; Min = minutes of the task.*

to solve the board, or in the number of squares turned over within the first five minutes, all ts(38) < 1, all ps > .05. A two-way (Group repeated over Time) ANOVA conducted on the number of matches made by depressed and non-depressed participants, cumulatively over each one-minute interval for the first five minutes, yielded a significant effect only of Time, $F(4, 152) = 146.67$, $p < .001$; neither the main effect of Group, $F(1, 38) < 1$, nor the interaction of Group and Time, $F(4, 152) < 1$, was significant, both ps > .05. As expected, participants in both groups cumulatively solved more neutral pairs with increasing time. Finally, a two-way (Group repeated over Time) ANOVA conducted on the ratio of the number of matches to the number of squares turned over for each minute over the first five minutes of the task also yielded a significant effect only of Time, $F(4, 152) = 4.99$, $p < .001$; neither the main effect of Group, $F(1, 38) = 1.71$, nor the interaction of Group and Time, $F(4, 152) = 1.55$, was significant, both ps > .05. Again, as expected, all participants exhibited a higher ratio of matches to cards turned over with increasing time.

DISCUSSION

The present study was designed to examine memory for positive, negative, and neutral stimuli in diagnosed depressed and non-depressed participants under conditions of relatively unconstrained encoding. In previous investigations in which participants were presented with a list of words to encode and recall, depressed individuals typically recalled more negative words and fewer positive words than did their non-depressed counterparts. This procedure, however, artificially constrains encoding of the stimuli and precludes an examination of the relation between encoding (or exposure to stimuli) and memory. To address these shortcomings, we developed a task in which participants are exposed repeatedly to positive, negative, and neutral stimuli that allows us to examine the relation between exposure to emotional and neutral stimuli and memory for these stimuli in depression.

We found that, compared to non-depressed participants, depressed individuals took more turns and more time to match 16 positive and 16 negative word pairs in a 64-square grid. More important, however, during the first five minutes of the task, while all participants were still attempting to solve the board, non-depressed participants selected and turned over positive squares more frequently than they did negative squares; in contrast, depressed participants selected and turned over positive and negative squares equally often. Depressed participants also matched fewer positive word pairs within the first five minutes of the task than did non-depressed participants, particularly as the task progressed during the fourth and fifth minutes. Indeed, whereas non-depressed participants exhibited a linear increase over the first five minutes of the task in the number of positive word pairs they matched relative to the number of positive squares they turned over, depressed participants did not demonstrate this level of learning of positive words. Thus, depressed participants did not reap the same memory benefit as did non-depressed participants from exposure to positive words. Finally, in contrast to the findings obtained with the participants who completed the valenced board, the depressed and non-depressed participants who completed the neutral board did not differ significantly from each other on any of these metrics, indicating that depressed participants do not differ from their non-depressed counterparts in their encoding of, and memory for, neutral stimuli. In short, therefore, depressed and non-depressed individuals are not distinguished by their encoding and memory in general, but by their encoding and memory for positively valenced information.

We had hypothesised that depressed participants would select and encode negative stimuli more frequently, and positive words less frequently, than would non-depressed participants, and that they would consequently match negative words more quickly and positive words more slowly than would their non-depressed counterparts. We hypothesised further that depressed and non-depressed participants would not differ in their matching of neutral words. We did not find group differences in the selection and matching of either neutral or negative words. That we did not find depression-associated effects in the selection or recall of negative information may be due to the fact that participants were not asked explicitly to process the words on the board self-referentially. In a recent review, Wisco (2009) concluded that depressive thought is more negative for self-relevant than for externally focused content. It is possible, therefore, that replicating this study with instructions that make the stimuli self-referential would yield differences between depressed and non-depressed participants in the encoding and recall of negative stimuli.

Importantly, the present findings add to a growing literature indicating that depression is characterised by difficulties in the processing of positive stimuli, perhaps to an even greater extent than it is by biases in the processing of negative material. For example, Canli et al. (2004), Henriques and Davidson (2000), Pizzagalli, Iosifescu, Hallett, Ratner, and Fava (2008), and Sloan, Strauss, and Wisner (2001) all found depressed individuals to be less responsive than were non-depressed controls to a range of positive stimuli. Suslow, Junghanns, and Arolt (2001) found that although depressed and non-depressed participants did not differ in their latencies to detect sad faces in a display of schematic faces, depressed participants were significantly slower than were their non-depressed counterparts to detect happy faces. Similarly, Joormann and Gotlib (2006) found that depressed individuals required a greater intensity of facial expression to identify happiness than did non-depressed participants. Consistent with these findings, Gilboa-Schechtman, Erhard-Weiss, and Jeczemien (2002) found that depressed participants had poorer memory for happy facial expressions than did non-depressed controls, and Deldin, Deveney, Kim, Casas, and Best (2001) found evidence for lower N200 event-related brain potential (ERP) in response to positive faces in depressed than in non-depressed individuals, potentially reflecting decreased resource allocation to the encoding of positive stimuli. Indeed, the finding in the present study that depressed individuals are slower than are non-depressed controls to learn the locations of positive stimuli is consistent with this formulation, both underscoring the difficulty experienced by depressed persons in encoding and remembering positive stimuli and supporting Clark and Watson's (1991) tripartite model that focuses on the importance of low levels of positive affect in this disorder.

One of the advantages of the task developed for this study is that it permits an examination of the relation between exposure and memory for both emotional and neutral stimuli. For example, non-depressed participants selected, turned over, and viewed more positive squares than they did negative squares. Importantly, they also showed evidence of stronger learning for the positive stimuli than for the negative stimuli, both matching more positive stimuli than did depressed participants and exhibiting a higher ratio of positive matches to positive squares turned over as the task progressed. Although depressed participants did not differ from non-depressed participants in the number of positive squares they viewed, they failed to learn these stimuli as quickly, both making fewer positive matches during the fourth and fifth minutes of the task and exhibiting a lower ratio of positive matches to positive squares turned over.

It is noteworthy that although non-depressed participants showed clear learning of positive and of neutral stimuli over time, they did not exhibit this level of learning for negative material. Although it is possible that this pattern reflects a greater salience of the positive than the negative stimuli for the non-depressed participants (e.g., Tomaszczyk, Fernandes, & MacLeod, 2008), by this explanation we would have seen the opposite pattern in the clinically depressed participants for whom the negative stimuli were likely more salient than the positive stimuli; MDD participants, however, did not exhibit differential learning of positive and negative material. Investigators can address this formulation more explicitly by obtaining idiographic ratings from the participants of the salience of the stimuli. Even with the standardised valence ratings of the ANEW, however, we were able to use a novel task to document a deficit in memory for positive stimuli in clinically depressed participants that does not appear to be a simple function of their selection and viewing of these stimuli. It remains for future research to elucidate the parameters of this deficit, to examine more explicitly the relation between encoding of and memory for valenced stimuli in depression, and to ascertain the temporal relation between diminished memory for positive stimuli and episodes of MDD.

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