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BRIEF REPORT

Memory for novel positive information in major depressive disorder

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Major depressive disorder (MDD) is associated with biases in memory, including poor memory for positive stimuli. It is unclear, however, if this impaired memory for positive stimuli in MDD is related to difficulties in the initial processing of stimuli, or alternatively, reflects a decreased ability to draw on memories of positive stimuli after they have been formed. Using two versions of a word-matching task that featured a mixture of novel and practiced emotionally valenced words, we found that depressed individuals experienced greater difficulty learning positively valenced information than did their nondepressed peers. This difficulty seemed to be specific to initial encounters with the novel, but not the practiced, positive stimuli. These findings suggest that memory deficits for positive information associated with depression are related to how this information is initially processed. Implications of these findings for interventions are discussed and directions for future research are advanced.

Keywords: Depression; Memory; Learning; Valenced stimuli; Novelty.

Major depressive disorder (MDD) is a debilitating disorder characterised by prolonged bouts of sad mood and/or loss of pleasure or interest in previously enjoyable activities. In addition to these cardinal disturbances, MDD also involves disruptions in many areas of daily functioning, including sleeping, eating and psychomotor activity. Abnormalities in cognitive functioning are an important aspect of MDD and have been found to be related not only to the course of depression, but to the risk of developing the disorder as well (Gotlib & Joormann, 2010). Thus, it is critical that we gain a better understanding of aberrant cognitive processes that characterise MDD.

Depressed individuals have been found to consistently exhibit anomalous patterns of memory for emotionally valenced information. In addition to demonstrating better memory for negative than for positive or neutral information, depressed individuals also fail to show the pattern of better recall of

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positive compared to neutral or negative material documented in healthy individuals (Gotlib & Joormann, 2010; Matt, Vázquez, & Campbell, 1992). Understanding abnormalities of memory for positive material in MDD is particularly important given the formulation that depression is distinguished from other forms of psychopathology by a lack of positive affect (e.g., Clark & Watson, 1991).

Depressed individuals exhibit a broad range of difficulties related to memory for positive information. Early work examining depressed individuals' memory for affectively valenced stimuli found that in some contexts, such as cued-recall of words encoded during a self-referential rating task, depressed individuals recalled fewer positive words than did their nondepressed counterparts (Denny & Hunt, 1992). Indeed, a meta-analysis of early work on episodic recall of words and images in MDD revealed that poor recall of positively valenced information was the memory process most consistently associated with MDD (Burt, Zembar, & Niederehe, 1995). More recently, investigators have demonstrated that this effect extends beyond memory for valenced items: depressed individuals have also been found to be impaired in their learning of goal-relevant spatial stimuli that are associated with positively valenced information (Gotlib, Jonides, Buschkuehl, & Joormann, 2011). Gotlib et al. (2011) found that, on a word-matching task that required participants to remember the locations of hidden valenced words, depressed individuals learned the locations of fewer positive (but not negative) words than did nondepressed participants, an effect that was independent of the number of times that participants had viewed the words. Depressed individuals also have difficulty forming clear and distinct memories of positive information. Using a recency-probes task, which requires participants to indicate whether or not words were presented immediately prior as a target set, Levens and Gotlib (2010) found that depressed individuals showed greater interference than did nondepressed participants for positive, but not for negative or neutral, words. Finally, depressed individuals are unable to use positive memories to improve their mood following a sad mood induction (Joormann, Siemer, & Gotlib, 2007). Unlike their never-depressed counterparts, who report more positive mood after recalling a happy memory, depressed individuals report more negative mood, suggesting that recalling positive memories in MDD does not have the same restorative effect as it does in healthy controls.

At this point, we do not know why depressed individuals have such broad difficulties remembering positive information and events. In healthy individuals, emotion often enhances memory for emotional stimuli and events (Kensinger, 2009; LaBar & Cabeza, 2006). While emotion and memory can interact at all stages of the memory process (encoding, consolidation and recall; Hamann, 2001; Kensinger, 2009), cognitive factors may be especially important in understanding enhanced memory for emotional stimuli (Talmi & McGarry, 2012). For instance, cognitive factors are posited to influence memory for emotional stimuli by affecting how these stimuli are initially perceived and encoded (Kensinger, 2009). In healthy individuals, divided attention during encoding of emotional images has been found to fully mediate the effect of valence on memory for positive images (Talmi, Schimmack, Paterson, & Moscovitch, 2007), indicating that normative facilitated memory for positive stimuli depends on attention-based initial processing of these stimuli.

Importantly, depressed individuals have been found to exhibit aberrant initial processing of positive stimuli in a variety of contexts, typically showing a reduced attentional bias for, and poorer detection of positive stimuli relative to their nondepressed peers. In contrast to their nondepressed peers, depressed individuals fail to show an attentional bias towards happy faces in a dot-probe task (Joormann & Gotlib, 2007), are impaired in correctly labelling the emotion of happy faces (Surguladze et al., 2004), and are less able to use an initial happy face to prime the detection of the emotion of a subsequent happy face (LeMoult, Yoon, & Joormann, 2012). Thus, we hypothesised that depressed individuals' poor memory for positive information is driven by difficulties in the initial processing and encoding of this material.

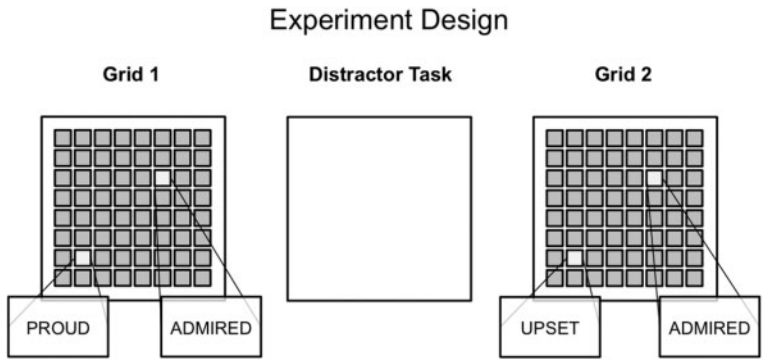

Figure 1. *Schematic representation of experiment design; two word-matching tasks separated by a brief, nonverbal distractor task. (Grid 1): 64-square grid composed of 16 positive word pairs and 16 negative word pairs. (Grid 2): 64-square grid composed of 16 novel word pairs (8 positive, 8 negative) and 16 practiced word pairs (8 positive, 8 negative) presented in the identical location as they were in Grid 1.*

To examine this prediction, we modified Gotlib et al.'s (2011) word-matching task to create a two-task paradigm that contrasted the learning of novel and previously seen valenced stimuli (see Figure 1). In the first task, participants searched for pairs of positively and negatively valenced words hidden under squares in a grid. The second task was identical to the first except that the grid was composed both of positive and negative words that were presented in the first task (in the same locations as in the first task) and of novel positive and negative words. This second grid allowed us to examine differences between depressed and nondepressed individuals as they learned the locations of novel versus previously learned emotional stimuli.

Thus, our experimental design allowed us to test two central predictions. First, based on Gotlib et al.'s (2011) findings, we hypothesised that in the first word-matching task, depressed participants would have greater difficulty than would their nondepressed peers learning the locations of positive (but not of negative) words. Second, including both practiced and novel words in the second grid allowed us to examine, for the first time, whether depressed individuals exhibit poorer memory for positive information in general, or alternatively, whether this difficulty is specific to the initial processing of positive information, that is, to the processing of novel positive stimuli. Because we posit that performance on the word-matching task is related to the effectiveness with which individuals initially engage with positive information, we hypothesised that during the second word-matching task, depressed individuals would be slower than would nondepressed controls to learn the locations of novel, but not of practised, positive words, and would match fewer of these words in the early phase of the task while the novel positive words were still novel.

METHOD

Participants

Participants were 25 currently depressed and 25 nondepressed individuals between the ages of 18 and 60 years who were recruited from the San Francisco Bay Area community using online advertisements. Participants were prescreened to exclude nonfluent English speakers, as well as individuals with previous head trauma, learning difficulties, history of psychotic symptoms, bipolar disorder, or alcohol or substance abuse in the past six months. Individuals who met the prescreening criteria were invited to come to the laboratory session where they were administered the Structured Clinical Interview for DSM-IV-TR (SCID, First, Spitzer, Gibbon, & Williams, 2002) by trained interviewers to determine study eligibility. Participants were included in the depressed group if they met DSM-IV criteria for current MDD;

participants were included in the control (CTL) group if they did not meet DSM-IV criteria for a current or past Axis-I disorder. In previous studies conducted by our laboratory with similar samples of participants, our interviewers have achieved excellent reliability with the SCID (inter-rater reliability for MDD diagnosis: K = 0.93; CTL diagnosis: K = 0.92; Levens & Gotlib, 2010). Participants also completed the Beck Depression Inventory-II (BDI), a well validated self-report measure of depressive symptoms (Beck, Steer, & Brown, 1996), and the verbal scale from the Shipley Institute of Living Scale, a self-report measure of verbal ability (Weiss & Schell, 1991). One depressed and one nondepressed participant were later excluded from the analyses for being 2 SD slower or faster, respectively, than all other participants to complete both grids, yielding a total of 24 MDD and 24 CTL participants.

Procedure

Within one week of the interview session, participants returned to the lab for an experimental session. Participants completed a word-matching task composed of positive and negative words, a five-minute filler activity based on the WAIS-IV Digit Symbol Task (Wechsler, 1955), and a second word-matching task composed of positive and negative words, half of which were repeated from the first task (and presented in their original locations) and half of which were novel positive and negative words.

Stimuli

Stimuli were 24 positive and 24 negative adjectives taken from the Affective Norms for English Words list (ANEW; Bradley & Lang, 1999). Positive words differed significantly from negative words with respect to valence (negative: M = 2.42, SD = 0.51; positive: M = 7.65, SD = 0.43; $t(46)$ = 38.45, p < .001), but not with respect to arousal (negative: M = 5.33, SD = 0.94; positive: M = 5.29, SD = 1.01; $t(46)$ = 0.52, p = .60), frequency (negative: M = 20.71, SD = 16.21; positive: M = 30.63, SD = 23.43; $t(46)$ = −1.71 p = .09), or length (negative: M = 6.63 letters, SD = 1.17; positive: M = 6.21, SD = 1.06; $t(46)$ = 1.29 p = .20).

Word-matching task

The tasks were similar to that developed by Gotlib et al. (2011). Participants were presented with 8 × 8 grid of solid blue squares on a computer monitor behind which were 16 pairs of positive words and 16 pairs of negative words, and 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, or "selecting", a square revealed the word behind it. If participants selected two identical words in a single turn, 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 and the participants began the next turn. Participants selected words until they had matched all 32 word pairs.

For the second word-matching task, the grids were constructed by replacing half of the positive and negative words on the first grid with novel words. Thus, participants solved a grid containing eight practiced (i.e., repeated) positive and eight practiced negative word pairs, and eight novel positive and eight novel negative word pairs. Practiced positive and negative word pairs were presented in the same locations on the second grid as they were on the first grid; novel positive and negative word pairs were placed randomly in the remaining locations. All participants solved the same grid in the first word-matching task. Two versions of the second grid were counterbalanced across participants with respect to which practiced words were repeated from the original grid. Two equivalent subsets of positive and negative words from the original grid were created, and were each presented to half of the participants in each group. The two subsets did not differ with respect to valence, arousal, frequency or word length.

Analytic strategy

The behaviour of interest in the word-matching task is participants' ability to find word matches.

Because every participant will eventually match every word, it is uninformative to analyse the total number of words matched by participants over the entire task. The total amount of time or the total number of turns participants took to complete each task were also not appropriate measures of performance on the word-matching tasks; our hypotheses involved specific predictions about how depressed and nondepressed individuals would perform during the initial portions of the word-matching tasks, not about how many turns or how much time they took to match every word pair. Thus, we assessed the ability to find word matches by using a cut-off, analysing the total number of words matched before this cut-off. To ensure that our measure of the number of words matched by each participant before the cut-off was not biased by the total number of words viewed by the participants, we used cut-offs expressed in terms of turns. Further, we used different cut-offs for our analyses of the two grids because each grid had a different composition and was used to test a different hypothesis.

The first grid was used to test our first hypothesis: that in the context of the word-matching task, depressed participants would have greater difficulty learning the location of positive words than would their nondepressed peers. Because we expected to replicate Gotlib et al.'s (2011) findings, we used a cut-off that was analogous to that used by Gotlib et al. (a cut-off of five minutes). In that study the fifth minute was the last in which all participants were still working on solving the grid; in the current study, the 90th turn was the last turn in which all participants were still working on the first grid.

The analysis of the second grid provided the critical test of our hypothesis that depressed individuals would be slower than their nondepressed peers to learn the locations of novel, but not of practiced, positive words. Because we were most interested in the comparison between learning practiced words and learning novel words, we restricted our analysis to participants' performance during the first half of the second grid, before the novel words became practiced. Specifically, for each participant, we established a cut-off of the mid-point of the task in terms of number of turns, and calculated the total number of words the participant had solved for each category and valence. Thus, for a participant who took 100 turns to solve the second grid, we examined how many words of each type she/he had matched by turn 50. Additionally, because we had hypothesised that depressed individuals are impaired specifically in their ability to initially process positive stimuli, we conducted a priori analyses comparing depressed and nondepressed participants' learning of novel and practiced positive stimuli.

RESULTS

All analyses were conducted using the "R" statistical computing language (R Core Team, 2012) using the package "ez" (Lawrence, 2013).

Participant characteristics

The depressed and nondepressed participants did not differ in age, $t(46) = 0.40$, $p = .65$, or verbal ability (Shipley scores), $t(45) = 0.26$, $p > .1$. The depressed and nondepressed groups also did not differ in the proportion of males and females (MDD: 14 female; CTL: 13 female; $X^2(1,48) = 0.03$, $p > .1$), in their distribution of ethnicity, $X^2(4,48) = 2.33$, $p > .1$, or in the number of participants who had completed a degree at a four-year college or university, $X^2(1,48) = 1.5$, $p = .22$. As expected, the depressed participants obtained higher scores on the BDI than did the nondepressed participants (MDD: $M = 30.33$, $SD = 8.08$; CTL: $M = 2.50$, $SD = 3.31$; $t(46) = 15.61$; $p < .001$).

Overall task performance

Depressed and nondepressed participants did not differ in the number of turns (MDD: $M = 155.79$, $SD = 34.02$; CTL: $M = 156.83$, $SD = 44.35$; $t(46) = 0.09$, $p = .93$) or the number of minutes (MDD: $M = 11.43$, $SD = 3.25$; CTL: $M = 11.35$, $SD = 3.64$; $t(46) = 0.08$, $p = .94$) required to compete the first word-matching task. The two groups of participants also did not differ in the number of turns

(MDD: M = 140.58, SD = 28.16; CTL: M = 142.46, SD = 42.24; $t(46) = 0.18$, $p = .86$) or the number of minutes (MDD: M = 9.35, SD = 2.25; CTL: M = 9.59, SD = 3.17; t(46) = 0.29, $p = .77$) required to complete the second grid. Perhaps not surprisingly given that the second grid included practiced words, participants took fewer minutes (grid 1: M = 11.39, SD = 3.41; grid 2: M = 9.47, SD = 2.72; $t(47) = 6.75$, $p < .001$) and fewer turns (grid 1: M = 156.31, SD = 39.11; grid 2: M = 141.52, SD = 35.53; $t(47) = 4.39$, $p < .001$) to solve the second grid than they did to complete the first grid.

Performance on the first grid

To assess performance on the first word-matching grid, we conducted a two-way (group: [MDD, CTL] repeated over valence: [positive, negative]) analysis of variance (ANOVA) on the number of words matched in the first 90 turns of the task. There were no significant main effects of group, $F(1,46) = 0.13$, $p = .73$, or valence, $F(1,46) =2\ .48$, $p = .12$; as predicted, however, there was a significant interaction of group and valence, $F(1,46) = 4.41$, $p < .05$. Follow-up paired t-tests indicated that whereas depressed participants matched significantly fewer positive than negative words (positive: M = 6.08, SD = 2.62; negative: M = 7.54, SD = 3.92; $t(23) = 2.98$, $p < .01$), nondepressed participants did not show this effect (positive: M = 7.21, SD = 3.54; negative: M = 7.00, SD = 3.53; $t(23) = 0.33$, $p > .1$). Importantly, this difference was not due to differential selection of positive and negative words: depressed and nondepressed participants did not differ in the ratio of positive to negative words selected in the first 90 turns of the word-matching task (MDD: M = 1.01, SD = 0.173; CTL: M = 1.01, SD = 0.168; $t(23) = 0.01$, $p = .99$).

Performance on the second grid

To analyse performance on the second grid, we established the cut-off as the mid-point of the task in terms of number of turns for each participant, and calculated the total number of words the participant had solved for each category. Depressed and nondepressed participants did not differ with respect to this mid-point cut-off in terms of either the number of turns prior to the mid-point (MDD: M = 70.79, SD = 14.08; CTL: M = 71.73, SD = 21.12; $t(46) = 0.18$; $p = .86$) or the total number of words participants solved by the mid-point (MDD: M = 10.46, SD = 2.13; CTL: M = 10.42, SD = 1.84; $t(46) = 0.08$; $p > .1$).

A three-way ANOVA (group [MDD, CTL] repeated over word type [practiced, novel] repeated over valence [positive, negative]) conducted on the number of matches by the mid-point yielded a significant interaction of valence and word type $F(1,46) = 19.18$, $p < .0001$; the predicted three-way interaction of group, valence and word type was not significant, $F(1,46) = 2.36$, $p = .13$. Follow-up paired tests revealed a practice effect for negative words: participants matched more practiced than novel negative words (practiced: M = 2.92, SD = 1.15; novel: M = 2.17, SD = 1.17; $t(47) = 2.86$, $p < .001$). Interestingly, positive words showed the opposite pattern: participants matched fewer practiced than novel positive words (practiced: M = 2.25, SD = 1.14; novel: M = 3.10, SD = 1.12; $t(47) = 2.86$, $p < .001$; see Figure 2).

To test our a priori hypothesis that depressed individuals would solve fewer novel positive words than would their nondepressed peers, for each set of positive and negative words, we conducted a two-way ANOVA (group [MDD, CTL] repeated over word type [practiced, novel]) on the total number of these words solved by the mid-point of the second grid. For negative words, the ANOVA yielded a significant main effect of word type, $F(1,46) = 8.01$, $p < .01$, but no main effect of group, $F(1,46) = 0.64$, $p = .43$, or interaction of group and word type $F(1,46) = 0.00$ $p = .99$. Thus, depressed and nondepressed participants did not differ in the matching of practiced and novel negative words.

For positive words, there was again no significant main effect of group, $F(1,46) = 0.36$, $p = .55$; there was, however, a significant main effect of word type, $F(1,46) = 17.36$, $p < .001$, as well as a significant interaction of group and word type, $F(1,46) = 7.53$, $p < .01$. Follow-up t-tests

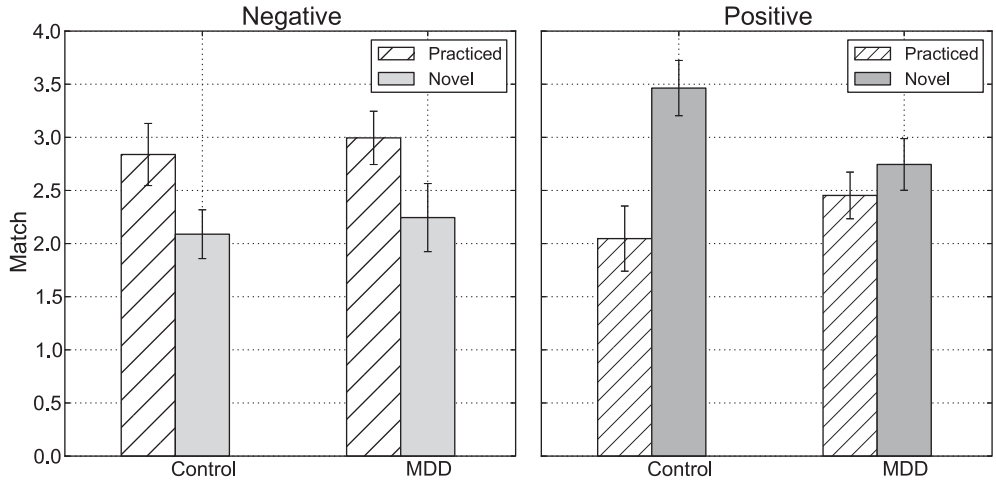

Figure 2. *Mean number of words matched in the first half of the second grid, split by valence and type of word. CTL = Nondepressed controls; MDD = Participants with major depressive disorder.*

revealed that whereas depressed and nondepressed participants did not differ in the total number of practiced positive words solved in the first half of the second grid (MDD: M = 2.45, SD = 0.93; CTL: M = 2.04, SD = 1.30; $t(46)$ = 1.28; p > .1), depressed individuals solved significantly fewer novel positive words than did their nondepressed peers (MDD: M = 2.75, SD = 1.03; CTL: M = 3.46, SD = 1.10; $t(46)$ = 2.30; p < .05). In addition, post hoc paired t-tests showed that nondepressed individuals matched more novel than practiced positive words (novel: M = 3.46, SD = 1.10; practiced: M = 2.04, SD = 1.30; $t(23)$ = 4.10, p < .001), a difference not shown by depressed participants (novel: M = 2.75, SD = 1.03; practiced: M = 2.45, SD = 0.93; $t(23)$ = 1.30, p > .1.

The differential matching of novel and practiced positive words occurred despite the fact that the depressed and nondepressed participants did not differ in how often they selected, or viewed, novel positive and practiced positive words. A two-way ANOVA (group repeated over word type) conducted on the number of novel and practiced positive words participants viewed in the first half of the second grid yielded no significant effects of group, $F(1,46)$ = 0.00, p = .98, word type, $F(1,46)$ = 3.69, p = .06, or interaction of group and word type, $F(1,46)$ = 0.05, p = .82.

DISCUSSION

The present study was designed to investigate a mechanism that might underlie depressed individuals' relatively poor memory for positive information. We tested the hypothesis that depressed individuals are impaired specifically in their processing of novel positive information by administering two word-matching tasks in which participants searched for pairs of concealed positively and negatively valenced words. Importantly, the second task contained both novel words and words that were repeated from the first task, allowing us to examine whether depressed participants are slower than are their nondepressed peers to learn the locations of novel positive words or whether they have difficulty processing positive information more generally.

In the first word-matching task, similar to Gotlib et al.'s (2011) findings, we found that depressed and nondepressed participants differed in how they learn the locations of valenced words. During the first 90 turns of the word-matching task, depressed individuals learned the location of

fewer positive than negative words; nondepressed individuals did not differ in their rates of matching positive and negative words. The present results are not inconsistent with Gotlib et al.'s (2011) finding that nondepressed participants matched more positive words than depressed participants; we obtained a similar interaction between group and valence, and in addition, we found that depressed participants matched fewer positive words than did nondepressed participants. Thus, across both studies, depressed individuals had more difficulty than did their nondepressed counterparts learning the locations of positive stimuli.

We created the second word-matching task to test the effects of our critical manipulation—including both novel and practiced words in the task grid. Intriguingly, this manipulation yielded an interaction of valence and novelty on the number of words matched in the early phase of the task for both groups of participants. In the first half of the task, participants matched the locations of more practiced than novel negative words, but more novel than practiced positive words. Previous work has shown that the emotional content of an item can affect individuals' memory for contextual features like the spatial location of the item (D'Argembeau & Van der Linden, 2004; Schmidt, Patnaik, & Kensinger, 2011). The current findings suggest an interesting caveat: the influence of emotional content on the encoding of contextual features of a stimulus may depend on its novelty.

The demands of the word-matching task, combined with the relative salience of novel versus previously encountered information, may be important in understanding the obtained results. During the task, participants are free to select and match any of the 64 words hidden on the grid. In effect, each of the words on the grid is in competition with the other words for the participants' memory and attention. If, on a given trial, a word is more salient, or is better able to capture a participant's attention, the word and its location will be more likely to be successfully encoded, brought back to mind on a later trial and successfully matched. Indeed, increased attentional capture has been suggested as a mechanism by which emotional content facilitates the learning of spatial context (D'Argembeau & Van der Linden, 2004). Thus, the current findings suggest that, especially in healthy individuals, novel positive (but not novel negative) words are especially salient or engaging, and, therefore, more easily remembered. Alternatively, it may be that all novel stimuli are initially salient (Bradley, 2009), but that the resultant increase in attention towards such novel stimuli facilitates the contextual learning for positive, but not negative, stimuli (Kensinger, 2009). Interestingly, although the three-way interaction was not significant, a priori comparisons showed that for negative words, neither depressed nor nondepressed individuals preferentially matched novel over practiced words, whereas for positive words, depressed individuals matched fewer *novel* positive words than their nondepressed peers. Indeed, additional post hoc tests indicated that this difference might be understood as depressed individuals not showing the normative bias towards learning novel positive information. This finding is especially interesting as it suggests that depressed individuals' poor memory for positively valenced emotional content (Gotlib et al., 2011) is driven by how they initially process this information. Specifically, it may be that for depressed individuals, novel positive information is simply less salient or attention capturing.

Together, these findings provide exciting preliminary evidence that when nondepressed individuals encounter a mixture of novel and repeated positive and negative stimuli, memories for the spatial context of repeated negative and novel positive information is especially privileged. Importantly, individuals with MDD show a normative bias towards remembering the context of repeated negative information, but lack the normative bias for remembering the spatial context of novel positive information. While these findings are tentative and warrant replication with a larger sample, they add to a growing body of work documenting aberrant memory for positive emotional information in MDD. Relative to their nondepressed peers, depressed individuals show poorer memory for positive information; however, this effect appears to be present only when information is newly encountered, suggesting

that difficulties in the initial processing of positive material drive subsequent deficits in memory for this information in MDD.

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