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A Preliminary Investigation of Cognitive Flexibility for Emotional Information in Major Depressive Disorder and Non-Psychiatric Controls

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Clinical research suggests that individuals with major depressive disorder (MDD) are cognitively inflexible, exhibiting ruminative, rigid, and automatic thoughts within a negative schema. However, existing neuropsychological research on cognitive flexibility in this population has not employed emotional stimuli. Because research suggests that the performance of individuals with MDD is modulated when emotional stimuli are used, this study investigates the impact of emotional stimuli on cognitive flexibility performance through a novel emotional modification of the Wisconsin Card Sorting Test. Controls were less flexible when stimuli were positive and individuals with MDD were less flexible when stimuli were negative relative to the controls. These divergent styles of responding to emotional information may contribute to the relative risk or protection from depressed mood.

Keywords: emotion, depression, cognitive flexibility, Wisconsin Card Sorting Test

Clinical observations support the existence of restricted and inflexible cognitive processes in individuals with major depressive disorder (MDD). For example, Beck's cognitive theory of depression suggests that individuals with depression are stuck in a "negative loop," rigidly viewing themselves, the world, and the future in accordance with a negative cognitive schema (Beck, 1967). Suicidal individuals, who often suffer from MDD, demonstrate inflexible styles of thinking by generating fewer possible solutions to problems (Schotte & Clum, 1987) and in viewing death as "the only solution possible to an unendurable level of mental pain" (Jamison, 1999, p. 5).

Cognitive inflexibility may be related to neurological abnormalities in populations with depression. The prefrontal cortex, thought to be important for performing executive functioning tasks including cognitive flexibility tasks (Channon, 1996; Damasio & Anderson, 2003), has been repeatedly noted to be hypoactive in individuals with MDD (Baxter et al., 1989; Davidson, 1994; Mayberg et al., 1999). Consequently, impaired cognitive flexibility in this population may stem from hypoactivation of brain regions thought to subserve cognitive flexibility abilities.

Finally, research using neuropsychological tasks assessing cognitive flexibility indicates that depressed populations may have deficits in this area of cognitive functioning. One of the most commonly used tests to assess an individual's ability to shift sets is the Wisconsin Card Sorting Task (WCST). In this task, individuals must learn a rule to perform the task correctly and later be able to adjust their performance when the rule unexpectedly changes. Cognitively flexible individuals easily alter their response pattern according to feedback, generating and testing new rules. Cognitively inflexible individuals persist in performing the task according to the old rule, despite receiving feedback that their response is no longer correct (Channon, 1996; Damasio & Anderson, 2003). For example, during the WCST individuals are asked to match a "target" card with various shapes to one of several "category" cards according to 3 rules: color, number, and type of shape on the cards. These rules switch without warning after a certain number of correct matches have been completed.

Dysphoric undergraduates (Channon, 1996) and individuals with MDD have exhibited impairments on the WCST, suggesting decreased cognitive flexibility (Austin, Ross, O'Carrol, Ebmeier, & Goodwin, 1992; Grant, Thase & Sweeney, 2001; Kindermann, Kalayam, Brown, Burdick, & Alexopoulos, 2000; Merriam, Thase, Haas, Keshavan, & Sweeney, 1999). However, impairments on this task are not universally found (Fossati, Amar, Raouz, Ergis, & Allilaire, 1999; Martin, Oren, & Boone, 1991). In addition, undergraduates who ruminate demonstrated decreased WCST performance as compared to those who do not ruminate (Davis & Nolen-Hoeksema, 2000).

Taken together, these literatures suggest that individuals with depression are characterized by constricted styles of thinking. Because ruminative, rigid, and automatic negative thoughts within a negative schema have been tied with the etiology, maintenance, and exacerbation of depressed mood states, a better understanding of cognitive flexibility and what subcomponent processes may be particularly aberrant may be important for improving the treatment and prevention of MDD (Nolen-Hoeksema, 1991, 2000; Young, Weinberger, & Beck, 2001).

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Emotional Nature of Stimuli Affects Performance on Cognitive Tasks

One area of interest is how cognitive flexibility processes affect some of the maladaptive cognitions and emotional processing that are theorized to characterize depression (Beck, 1967). Does an inability to think flexibly play a role in how individuals with MDD process emotional information? Might decreased flexibility in the presence of negative stimuli play a role in the negative ruminative thoughts observed in clinical and experimental studies of MDD? A robust empirical literature indicates that the emotional nature of stimuli can influence task performance. Research on numerous cognitive tasks has highlighted the existence of preferential processing of positive information by non-psychiatric controls as compared to negative information (e.g. Matt, Vasquez, & Campbell, 1992; Taylor & Brown, 1988, 1994). Dysphoric individuals exhibit a similar mood congruency effect, exhibiting preferential recall, identification, and delayed color naming of negative stimuli (for a review see Williams, Watts, MacLeod, & Matthews, 1997). Indeed, this unique processing of negative information is a core component of many information-processing models of depression (Bower, 1981; Ingram, 1984), perhaps involving an enhanced processing of negative information (Williams et al., 1997).

Theoretically, it is likely that cognitive flexibility would be another cognitive process that is influenced by the emotional nature of the stimuli. If individuals are likely to preferentially process or elaborate on mood congruent information as is suggested by the clinical and research literatures (Beck, 1967; Williams et al., 1997), this may result in a decrease in resources available in the dorsolateral prefrontal cortex, given its importance in cognitive flexibility tasks (Channon, 1996; Damasio & Anderson, 2003). Similarly, some research suggests that the processing of negative stimuli by dysphoric individuals results in decreased processing of and attending to the non-emotional aspects of these stimuli (Siegle, Ingram, & Matt, 2002), consequently poor performance on cognitive flexibility tasks relates to a failure to attend to aspects of the stimuli that are essential to good task performance. Alternatively, mood congruent information may be processed more quickly and efficiently due to congruency with an activated cognitive schema (Bower, 1981), and the resulting decrease in task load may lead to increased flexibility for mood congruent information.

To date, research on cognitive flexibility has only examined the impact of induced positive mood upon flexibility for non-emotional stimuli in a healthy population and has not used standard neuropsychological tests of cognitive flexibility (Ashby, Isen, & Turken, 1999). This line of research suggests that the induction of a positive mood state can increase creative problem solving skills and spontaneous cognitive flexibility among non-psychiatric controls (Ashby et al., 1999; Isen, Daubman, & Nowicki, 1987; Isen, Johnson, Mertz, & Robinson, 1985; for alternate findings see Phillips, Bull, Adams, & Fraser, 2002).

Research using neuropsychological tests of cognitive flexibility in individuals with depression have used non-emotional stimuli and consequently cannot inform us about whether cognitive flexibility is influenced by the emotional stimuli used in the task. A first step towards understanding the influence of emotion on cognitive flexibility processes is to investigate whether performance on cognitive flexibility processes, measured by standard neuropsychological tests, differs depending on the emotional valence of the stimuli employed and the clinical status of the study participants.

Current Study

Taken together, the previous literature suggests that the emotional nature of many cognitive tasks affects the performance of individuals with MDD and non-psychiatric controls (for a review see Williams et al., 1997). It remains unclear whether emotional stimuli will influence performance on cognitive flexibility tasks in non-depressed and MDD populations and, to the best of our knowledge, no versions of the WCST have evaluated whether the emotional nature of stimuli affects the ability of individuals to shift between perceptual properties of the stimuli.

In the current study, the impact that emotional stimuli have on cognitive flexibility in individuals with MDD and non-psychiatric controls was assessed. Specifically, this preliminary study addressed whether individuals with MDD exhibit poorer performance on a cognitive flexibility task when stimuli are negatively valenced. In addition, it addressed whether varying the emotional nature of the stimuli would impact the performance of controls on the task. To this end, participants completed a computerized WCST as well as a modification of this task to include emotional stimuli (ECST). The following hypotheses were made: (1) individuals with MDD will exhibit decreased flexibility for the negatively valenced words in the ECST compared to the positively valenced words; (2) the controls will exhibit no decrease in flexibility on any valenced block of the ECST. No explicit hypotheses were made regarding the WCST because of the inconsistent results in the literature.

Method

Participants

Newspaper advertisements and flyers posted in the Boston area were used to recruit participants for a series of studies investigating “depression” or “thoughts and emotions.” Individuals were screened using the Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders (4th edition) (*DSM-IV*), Patient Edition (SCID-I/P), administered by a doctoral level clinician (PJD) or graduate students in clinical psychology trained in SCID administration (First, Spitzer, Gibbon, & Williams, 1995). Individuals were excluded from the study if they reported or were diagnosed during the SCID interview with cognitive impairments (i.e., learning disabilities), head injuries resulting in loss of consciousness for more than ten minutes, bipolar disorder, psychosis, current substance abuse, current or past substance dependence, or seizure disorders.

Eighteen individuals (11 women), ages 21 to 63 ($M = 33.8$, $SD = 12.6$) with a mean education level of 16.3 years ($SD = 1.1$) and with no current or past Axis I psychiatric diagnosis, comprised the control group. Nineteen individuals (14 women), ages 21 to 58 years ($M = 32.2$, $SD = 10.2$) with a mean education level of 15.7 years ($SD = 1.4$) who met *DSM-IV* criteria for a current major depressive episode (MDE), comprised the MDD group. Two individuals were experiencing a current MDE superimposed on dysthymic disorder at the time of testing and 12 met criteria for at least one current anxiety disorder (8 social phobia, 4 generalized anxiety disorder, 1 specific phobia, 1 post traumatic stress disorder, 1 panic disorder, 1 agoraphobia without panic disorder, and 1 anxiety disorder not otherwise specified). Other comorbidities included body dysmorphic disorder (1) and somatoform disorder (1). Eleven individuals had experienced at least one additional MDE in the past. Seventeen individuals had received treatment for depression in the past and 10 were currently in treatment and taking antidepressant medications. Groups did not differ significantly for age, education level, or number of men and women as determined by univariate analyses of variance (ANOVA) and chi square analyses. See Table 1.

Exploratory analyses confirmed that there were no behavioral performance differences on the WCST and ECST between those individuals diagnosed with MDD who were taking medications and those who were not, between those currently receiving treatment and those who were not, and between those with recurrent MDD and those experiencing their first MDE. Consequently, the MDD group was not separated into separate subgroups based on medication, treatment, or first episode status.

Participants were also administered the vocabulary subtest of the Wechsler Adult Intelligence Scale (3rd edition) as a proxy for general intellectual ability. There were no group differences on this measure, suggesting that performance on the card sorting tasks is not likely to be attributable to intellectual differences between the groups, $F(1, 35) = 0.31$, $p = .58$.

Materials

Participants completed the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), Beck Hopelessness Scale (Beck & Weissman, 1974), and Spielberger Anxiety Inventory–State and Trait Scales (STAIS/T; Spielberger, Gorsuch, & Lushene, 1970) as indices of current depression severity, hopelessness, and present or trait anxiety levels, respectively. Participants also completed the Ruminative Responses Scale (RRS), Short Form, which assesses the degree to which individuals engage in ruminative behavior in response to depressed mood (Nolen-Hoeksema & Morrow, 1991; Treynor, Gonzalez, & Nolen-Hoeksema, 2003). Groups differed predictably on self-report scales of depression, anxiety, and rumination as tested by separate univariate ANOVAs.

Stimuli

All stimuli were created using Microsoft Paint. Each WCST trial consisted of the presentation of one "trial card" at the bottom of the screen and four "key cards" at the top of the screen (see Figure 1). The four key cards consisted of one red triangle, two green circles, three blue stars, and four yellow crosses, respectively. The 128 trial cards consisted of all 64 combinations of color (red, green, yellow, or blue); shape (triangle, circle, star, or cross), and number (1, 2, 3, or 4 shapes) presented twice. The order of the trial cards was randomized and then presented in a fixed sequence so that all individuals saw the same order of stimuli.

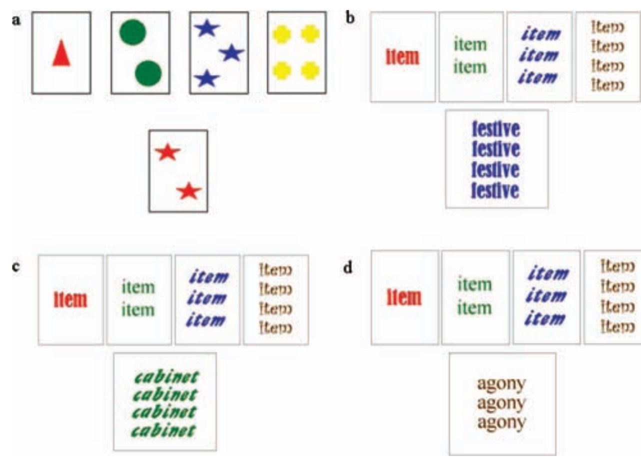

Figure 1. Stimuli examples: a) Wisconsin Card Sorting Task, b) Emotional Card Sorting Task (ECST)-positive, c) ECST-neutral, d) ECST-negative

We designed the ECST to be as similar as possible to the WCST and, therefore, although stimuli were emotional in nature, emotional valence was irrelevant to successful performance on the task (see Figure 1). The key cards in the ECST consisted of the word "item" appearing in the following formats: printed once in red ink and Bauhaus 93 font, twice in green ink and Curlz MT font, three times in blue ink and italicized Mercurius Script MT Bold font, and four times in brown ink and Times New Roman font. The color brown was chosen for the fourth color category (rather than yellow as in the WCST) to make it easier to read the words in the various fonts.

The words that appeared on the ECST trial cards were drawn from the Affective Norms of English Words (ANEW; Bradley & Lang, 1999) set, which includes separate ratings on a 9-point Likert scale for valence and arousal (low scores indicate low arousal or negative valence; see Appendix). Two hundred and sixty-four words were classified into three categories:

Table 1
Demographic Characteristics of the Sample

Characteristic	Mean: Controls	Mean: MDD[a]	Standard deviation: Controls	Standard deviation: MDD	*F*	*p*
N	18	19				
Age (years)	33.83	32.18	12.6	10.18	0.19	0.66
Sex (F)	7 (11)	5 (14)			0.67[b]	0.41
Education (years)	16.25	15.74	1.1	1.4	1.49	0.23
BDI	2.67	26.63	2.5	6.7	201.86	<0.001
BHS	3.00	13.31	2.6	4.0	82.74	<0.001
STAI-S	32.33	57.68	9.6	11.9	49.50	<0.001
STAI-T	31.47	64.89	8.8	6.6	168.21	<0.001
RRS	41.00	62.84	10.1	8.9	47.68	<0.001
Reflect	11.53	11.89	3.4	2.5	0.14	.72
Brood	7.41	11.10	2.4	1.6	30.62	<0.001
Depression	20.59	35.47	5.8	11.1	24.99	<0.001

Note. BDI = Beck Depression Inventory; BHS = Beck Hopelessness Scale; STAI-S/STAI-T = Speilberger Anxiety Inventory-State/Trait; RRS = Ruminative Response Scale and subscales measuring reflection, brooding, and depression.
[a] MDD = participants with major depressive disorder. [b] Chi square analysis.

positive valence ($M_{valence}$= 7.65; $M_{arousal}$ = 5.68), neutral ($M_{valence}$ = 5.08; $M_{arousal}$ = 4.32), and negative valence ($M_{valence}$ = 2.28; $M_{arousal}$ = 5.80). Univariate ANOVAs and subsequent pairwise comparisons using Bonferroni corrections were conducted to evaluate valence and arousal differences between the three categories of valenced stimuli. Mean valence ratings differed significantly between each of the three valence categories, *Valence, F*(2, 261) = 2829.504, $p < .001$, $\eta^2 = 0.97$. Arousal ratings also differed between the categories, *Arousal, F*(2, 261) = 100.246, $p < .001$, $\eta^2 = 0.43$. Positive and negative stimuli were both significantly more arousing than neutral; however, positive and negative stimuli had equal arousal ratings. Participants were asked to rate the emotional stimuli according to the self-assessment manikin ratings scale used in the initial ANEW ratings (Bradley & Lang, 1999) at the end of the testing session. Participants in both groups rated the stimuli similarly to each other and the initial ANEW index group.

Words were matched for length and frequency of use (Kŭcera & Francis, 1967). Words were presented in three blocks of 88 words: positive, neutral, and negative. Each word was presented once as a trial card. Trial cards consisted of words printed in a combination of the following three factors: colors (red, green, blue, and brown), fonts (Bauhaus 93, Curlz MT, italicized Mercurius Script MT Bold, and Times New Roman) and number of words on the card (1, 2, 3, and 4). Each word was randomly assigned to a font, color, and number of words. Word order was randomized and then presented to participants in a fixed order.

Procedure

Consistent with Harvard Institutional Review Board approval, the details of the study were explained to all participants and written consent was obtained. Study participation lasted between three and four hours over the course of two days. After completing the SCID in the first session, participants returned to the lab to complete the WCST, ECST, vocabulary test, and questionnaires. Participants were compensated $10 for each hour of their time.

Card Sorting Tasks

All tasks were performed on a Mac computer using the Psyscope program (Cohen, MacWhinney, Flatt, & Provost, 1993). In both the WCST and ECST, participants were instructed to match each trial card to one of the four key cards as best as they could. They were told that they would receive feedback as to whether they were correct or incorrect after each match and should use that information to decide how to correctly match subsequent cards. Consistent with standard WCST administration, participants were not told what the rules might be, nor that the rules would change in either task. The rules that governed task feedback were color, shape, and number of shapes in the WCST, and color, font, and number of words in the ECST. In both the WCST and ECST, once a participant made 10 consecutive correct matches according to the operating rule, the computer changed the rule. At that point, the participant heard a beep signifying that an error had been made and the word "incorrect" appeared at the bottom of the screen when s/he attempted to continue matching under the old rule. The participant needed to discover the new rule and match cards correctly according to the new rule to hear a beep signifying that a correct response had been given and to see the word "correct" printed at the bottom of the screen. The task was terminated when individuals correctly sorted to six different rules (each of the three rules repeated) or until all of the cards in the set were used. Rule order was counterbalanced in the WCST and ECST. Each rule occurred in each position (1st, 2nd, or 3rd) an equal number of times. In the ECST, each rule occurred an equal number of times in each valence block and an equal number of times in each position (1st, 2nd, or 3rd). The ECST was structured so that, for each participant, a different rule was in operation at the beginning of each block. In order to be consistent with the standard administration of the WCST and to provide an accurate test of standard cognitive flexibility ability, all participants completed the WCST task first to ensure that individuals did not know about rule changes before completing this task. Participants then completed the three blocks of the ECST: one positive, one neutral, and one negative block. Block order was counterbalanced across participants with each valence block occurring 1st, 2nd, or 3rd an equal number of times.

Data Reduction and Analysis

Univariate analyses of variance (ANOVA) were used to assess group differences for five variables commonly assessed in the WCST: (1) number of perseverative errors (the number of times the subject continues to sort according to an old rule after the rule has changed; higher numbers indicate decreased cognitive flexibility); (2) number of categories correctly sorted (maximum of six before the task terminated; higher numbers indicate increased task performance); (3) number of cards used in the test (the number of cards to complete six categories and successful rule changes, or the number of total cards viewed prior to test termination; higher numbers indicate decreased task performance); (4) number of non-perseverative errors (the number of times a subject sorted according to a new rule or when a sort occurred for a trial card that matched more than one category; higher numbers indicate decreased task performance, but not necessarily perseveration or decreased cognitive flexibility); and (5) the total number of errors (sum of perseverative and non-perseverative errors; higher numbers indicate decreased task performance, including measures of decreased cognitive flexibility as well as poor performance more generally). We were particularly interested in group differences for perseverative errors, the purest index of cognitive inflexibility; and we analyzed non-perseverative errors as well to evaluate whether our findings were specific to inflexibility, rather than to overall poorer task performance reflecting general cognitive deficits, including decreased task engagement that are not relevant to the hypotheses in this project. If participants made more non-perseverative errors during mood congruent blocks, then we would have strong support that participants were less engaged with the task during the mood congruent blocks, potentially reflecting distraction or rumination on the emotional content of the words. This, in turn, would suggest that any relative inflexibility during mood congruent blocks for the two participant groups was due to decreased task engagement rather than decreased cognitive flexibility.

ECST data were analyzed using 3×2 repeated measures ANOVAs with stimulus *Valence* (positive, neutral, negative) as the within-subjects factor and *Group* (control, MDD) as the between-subjects factor. Because our hypotheses were specific for cognitive flexibility, which is best tapped by the number of perseverative errors made during the task, analyses were computed for the number of perseverative errors committed during each ECST block. Higher numbers of perseverative errors in the negative ECST block among individuals with MDD would indicate decreased cognitive flexibility in the presence of negative stimuli. In order to test the specificity of these findings to perseverative errors and rule out the possibility that distraction or level of task engagement accounted for our findings, we conducted the same analysis for non-perseverative errors. The Huyndt-Feldt correction was employed to correct for sphericity violations (Huyndt & Feldt, 1976) and η^2 values were calculated as an estimate of effect size. Simple univariate ANOVAs and pairwise comparisons were performed in order to interpret the hypothesized significant *Group* $\times$ *Valence* interaction for the ECST data. Finally, in order to ascertain whether age influenced task performance, WCST and ECST analyses were repeated with participant age entered as a covariate.

Results

WCST

Groups did not demonstrate any statistically reliable differences on any of the five WCST measures: number of categories, *F*(1,

35) = 0.11, p = .74, η^2 = .003; number of cards, $F(1, 35) = 0.16$, p = .69, η^2 = .005; number of perseverative errors, $F(1, 35)$ = 0.22, p = .64, η^2 = .006; number of non-perseverative errors, F(1, 35) = 0.46, p = .51, η^2 = .013; number of total errors, $F(1, 35)$ = 0.08, p = .79, η^2 = .002. See Table 2.

Groups did not differ significantly on any of the five WCST measures after participant age was entered as a covariate: number of categories, $F(1, 34) = 0.07$, $p = .79$, $\eta^2 = .002$; number of cards, $F(1, 34) = 0.13$, $p = .72$, $\eta^2 = .004$; number of perseverative errors, $F(1, 34) = 0.25$, $p = .62$, $\eta^2 = .007$; number of non-perseverative errors, $F(1, 34) = 0.39$, $p = .54$, $\eta^2 = .011$; number of total errors, $F(1, 34) = 0.051$, $p = .88$, $\eta^2 = .002$.

ECST

There was no main effect of *Group* or *Valence* in the ECST; however, as hypothesized, there was a significant interaction of stimulus valence and group for the number of perseverative errors, *Valence* × *Group*, $F(2, 66) = 5.00$, $p < .02$, $\eta^2 = 0.13$ (See Figure 2). Subsequent simple effects ANOVAs indicated that individuals with MDD made more perseverative errors than the controls during the negative ECST block, $F(1, 34) = 4.60$, $p < .04$, η^2 = 0.12. There was also a trend for controls to make more perseverative errors in the positive ECST block as compared to the individuals with MDD, $F(1, 34) = 3.55$, $p < .07$, $\eta^2 = .094$. Perseverative error scores did not differ between groups for the neutral ECST condition, $F(1, 35) = 2.49$, $p = .12$, $\eta^2 = .066$.

Within-group pairwise comparisons indicate that the controls made more perseverative errors during the positive ECST block than during the negative and neutral blocks, *Valence*, $F(2, 32)$ = 5.61, $p < .03$, $\eta^2 = 0.26$. Individuals with MDD did not show any differences in the number of perseverative errors across ECST blocks, *Valence*, $F(2, 34) = 1.59$, $p = .22$, $\eta^2 = 0.09$.

There was no significant *Group* × *Valence* interaction for non-perseverative errors $F(2, 70) = 0.49$, $p = .58$, $\eta^2 = 0.01$.

ECST data were reanalyzed with participant age entered as a covariate. As before, there was a significant interaction of stimulus valence and participant group for the number of perseverative errors, *Valence* × *Group*, $F(2, 64) = 4.63$, $p < .02$, $\eta^2 = 0.13$. Subsequent simple effects ANOVAs covarying age indicated that individuals with MDD made more perseverative errors than the controls during the negative ECST block, $F(1, 33) = 4.49$, $p <$ .05, $\eta^2 = .013$. Controls exhibited a trend towards making more perseverative errors in the positive ECST block relative to the individuals with MDD, $F(1, 33) = 3.28$, $p < .08$, $\eta^2 = .09$. Perseverative error scores did not differ between groups for the neutral ECST condition, $F(1, 34) = 2.69$, $p = .11$, $\eta^2 = .07$.

Within-group comparison with age covaried indicated no effect of valence for healthy controls or individuals with MDD, *Valence*, $F(2, 30) = .20$, $p > .7$, $\eta^2 = .013$ and *Valence*, $F(2, 32) = 1.36$, $p > .2$, $\eta^2 = .08$, respectively. However, a post-hoc Neuman-Keuls analysis confirmed that the number of perseverative errors made by healthy control participants during the positive block remained significantly greater than those in the neutral and negative blocks ($p < .03$ and $p < .04$, respectively).

Discussion

The present preliminary investigation aimed to expand the understanding of cognitive flexibility processes among individuals with MDD and non-psychiatric controls using a standard neuropsychological paradigm, the WCST, in conjunction with a novel emotional modification of the paradigm. In the present sample of moderately depressed participants drawn from the community, results argue against an overall cognitive flexibility deficit in individuals with MDD and suggest that task performance reflects an interaction between diagnostic group and the emotional valence of the stimuli. Results indicate that individuals with MDD perform more poorly on a cognitive flexibility task when the stimuli are negative relative to controls. Controls also performed more poorly on the task when the stimuli were positive as compared to neutral and negative. Further analyses suggested these findings were unlikely the result of decreased task engagement, because the same *Group* × *Valence* interaction was not observed for non-perseverative errors, a measure sensitive to overall task engagement and accuracy. Results were also unrelated to participant age.

Mood Congruent Inflexibility

As a group, participants with MDD perseverated when stimuli were negatively valenced relative to healthy controls. This is consistent with the clinical and rumination literatures suggesting decreased flexibility in the presence of negative information and suggests that cognitive flexibility is another process influenced by the emotional valence of the stimuli employed. Further research is necessary to clarify how negative stimuli impact cognitive flexibility, although many possibilities exist. First, the processing of negative information by dysphoric individuals has been shown to

Table 2
WCST Performance Means

Characteristic	Mean: Controls	Mean: MDD	Standard deviation: Controls	Standard deviation: MDD	F	p
Cards	107.28	110.05	22.6	19.6	0.16	0.69
Categories completed	5.17	5.00	1.3	1.7	0.11	0.74
Perseverative errors	9.83	8.42	10.3	7.8	0.22	0.64
Non-perseverative errors	17.56	20.89	11.5	17.8	0.46	0.51
Total errors	27.39	29.32	20.9	21.6	0.08	0.79

Note. WCST = Wisconsin Card Sorting Task; MDD = participants with major depressive disorder.

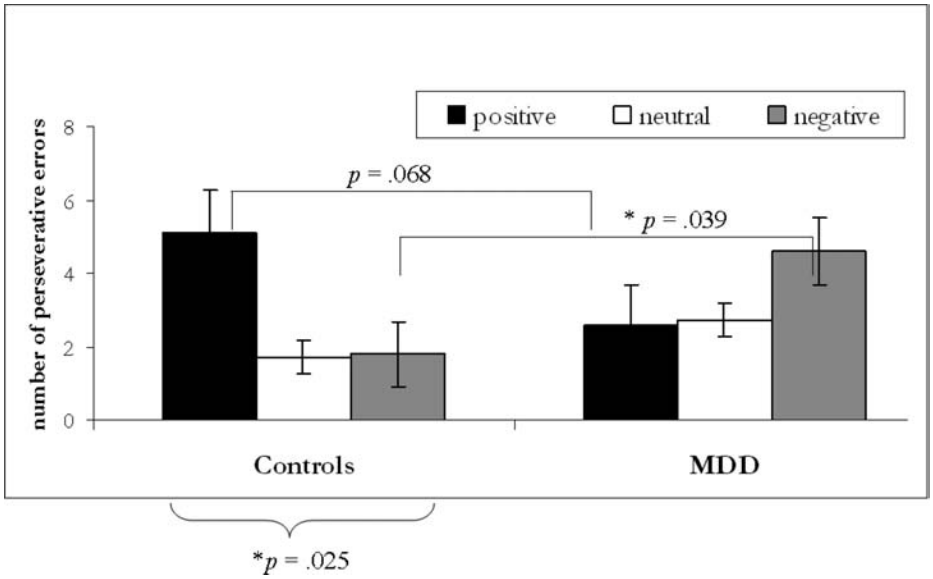

Figure 2. Number of perseverative errors on the Emotional Card Sorting Task in each diagnostic group for each stimulus valence (bars represent standard errors). * $p < .05$.

result in decreased processing of or attending to non-emotional aspects of these stimuli (Siegle et al., 2002), making it more difficult for individuals with MDD to attend to the non-emotional features of the task that were essential to sorting the cards correctly. Second, if the processing of negative stimuli recruited brain regions essential to performing the tasks to a greater degree in the individuals with MDD, decreased resources in these regions may have reduced executive functioning ability. Third, decreased cognitive flexibility may reflect an inability to adjust performance in response to feedback. Individuals with MDD often fail to show an increase in accuracy following feedback that they have made an error, suggesting aberrant responses to task feedback (Elliott et al., 1996). However, these studies have not employed emotional stimuli and it is unknown whether the emotional nature of the stimulus can affect responses to feedback.

Although the current study does not allow us to distinguish between these alternative explanations, results suggest that individuals with MDD experience decreased cognitive flexibility in the presence of negative stimuli relative to healthy controls. However, our original hypothesis that individuals with MDD would be less cognitively flexible when the stimuli were negative as compared to positive or neutral was not confirmed. While this is somewhat surprising given the robust literature on negatively biased cognitive processes in MDD (see Williams et al., 1997 for review), it is consistent with depressive realism theory, indicating that a defining feature of depression is the failure to exhibit the positive biases and illusions exhibited by non-depressed controls (Alloy & Abramson, 1979, 1988). An extensive cognitive literature fails to find preferential attention, recall, recognition, and reaction to positively valenced information among individuals with depression (Deldin, Deveney, Kim, Casas, & Best, 2001; Matt et al., 1992; Sloan, Strauss, & Wisner, 2001). Intact ability to inhibit responses in the presence of positive stimuli may lead to an override of more immediate adaptive responses with later and potentially more negative responses. Similarly, the ability to view and respond to positive information more flexibly may allow for alternate and less positive interpretations of that information. It is therefore possible that a relative decrease in flexibility when stimuli are negative as compared to controls coupled with a lack of enhanced perseveration when stimuli are positively valenced, as was exhibited by the controls, may be detrimental to individuals with MDD and may contribute to some of the ruminative and rigid styles of thinking noted in MDD populations (Beck, 1967; Nolen-Hoeksema, 1991).

Control participants were less flexible when the stimuli were positively valenced, making more perseverative errors during the positive ECST block as compared to the neutral and negatively valenced blocks. This indicated a return to the previous matching rule or a difficulty overriding a previous response pattern despite receiving feedback that responses consistent with the old rule were incorrect. Healthy controls often demonstrate performance differences for positive information, including enhanced memory for positive words (Matt et al., 1992), enhanced attribution of positive characteristics to oneself (Brown, 1986), and more positively biased views of the self and the world (Taylor & Brown, 1988, 1994). Consequently, measurements of cognitive flexibility may represent another cognitive realm in which positively valenced information is processed preferentially. Indeed, this preferential processing may have impaired the control participants' ability to flexibly shift between different perceptual features of the stimuli.

In contrast to the current findings, prior work by Isen and colleagues suggests that induced positive moods in a control population increase performance on cognitive flexibility tasks involving non-emotional stimuli (for review see Ashby et al., 1999). However, recent work by Phillips and colleagues (2002) demonstrated that induced positive mood impaired performance on executive functioning tasks involving forced switching between response patterns as compared to an induced neutral mood. Despite the fact that our healthy controls were presumably experiencing more positive affect than the individuals in the MDD group, they did not exhibit greater cognitive flexibility during the neutral ECST block or the WCST, a finding somewhat inconsistent with that of Isen and colleagues. However, the focus of our study was on investigating the impact of the emotional content of the stimuli on task performance, and we did not induce mood states in our participants. Investigations of the impact of emotional state on specific cognitive processes may be different than those that evaluate the impact of the emotional content of stimuli on those same cognitive processes (Kensinger & Corkin, 2003). Consequently, the ability to process information flexibly may be dependent not only on an individual's mood, but also on the emotional valence of the stimuli. As this is the first study to investigate cognitive flexibility while varying the emotional content of the stimuli, further research is necessary to clarify the exact nature of the impact of emotional stimuli on cognitive flexibility.

The differential cognitive flexibility performance as a result of stimuli valence by the participant groups is striking given the fact individuals were never directed to, nor needed to pay attention to the meanings of the words in the ECST. Anecdotal reports suggest that many individuals did not actively pay attention to the words during the task, although some participants ($n = 5$) spontaneously classified the ECST blocks by valence during the study debriefing.

WCST

Finally, our WCST findings are inconsistent with much of the research noting impairments in depressed populations on the same measures. One possible explanation for this is that impaired cognitive functioning is most consistently observed in populations who are older and who have more severe depressions (see Grant et al., 2001; Ottowitz, Dougherty, & Savage, 2002 for reviews). Although the age range in our study was broad (21–63), only three participants were older than 50 and the mean age was 32. In addition, although all participants were currently experiencing a major depressive episode according to *DSM-IV* criteria and many were undergoing treatment for depression at the time of testing, they were not recruited from an inpatient setting and may therefore reflect a less severely ill population than those used in other neuropsychological studies. Several researchers have noted that neuropsychological study findings in MDD are less consistent when younger samples (<40) are employed (Purcell, Maruff, Kyrior, & Pantelis, 1997), however, it is important to note that other studies have noted WCST deficits in younger and dysphoric populations (e.g. Channon, 1996). It is unlikely that our failure to detect significant differences in the WCST resulted from a small sample size and insufficient power given that the effect size in our study ($d = .21$) was smaller than those in other studies ($d = .60$).

Limitations

Certain methodological limitations should be considered when interpreting the study results. First, the ECST blocks were limited to 88 words per block. Researchers have noted that modified versions of the WCST that utilize fewer than the standard 128 cards may lack the sensitivity necessary to detect performance differences between depressed and non-depressed individuals (Fossati, Ergis, & Allilaire, 2001). Consequently, replication of this study using a more comparable number of trials in the ECST as in the WCST may better clarify cognitive flexibility for emotional information in this population.

Secondly, this test was designed to adhere as closely as possible to the standard WCST, one of the most commonly used cognitive flexibility tasks (Damasio & Anderson, 2003), and therefore the emotional content of the words was irrelevant to actual task demands. Further evidence of differential cognitive flexibility for emotional information may be detected if valence is a condition on which to sort or if the task involved individuals needing to switch between positive, neutral, and negative interpretations of ambiguous stimuli. Based on the rumination literature (Nolen-Hoeksema, 1991) and findings from the present study, individuals with MDD may find it more difficult to shift from negative interpretations of stimuli to positive or neutral interpretations of stimuli, while controls may show difficulty switching from positive interpretations.

Third, because the WCST was always administered first in order to maintain the integrity of the task, this study cannot control for order effects. However, valence block order was counterbalanced across participants and the specificity of the ECST findings to the positive block for controls and the negative block for between group differences argues against nonspecific or habituation effects. In addition, because all participants completed the WCST prior to completing the ECST, they were likely more aware of rule changes during all the ECST blocks. Consequently, despite ample "warning" that rules would change during the blocks of the ECST, the two groups still exhibited a relative lack of flexibility for mood congruent stimuli.

Fourth, we failed to find the expected correlation between participant age and neuropsychological task performance (see Grant et al., 2001; Ottowitz et al., 2002 for reviews) and analysis of WCST and ECST performance were similar regardless of whether participant age was included as a covariate. This may be due in part to a restricted range of participant age. Only three participants were older than age 50 ($M = 32$) and therefore would not qualify as "older" for many neuropsychological studies.

Finally, this is a preliminary study with a small sample size. Further research is necessary to replicate these findings and to correct some of the methodological limitations we experienced with the current sample.

Conclusion

The current preliminary research study suggests that individuals with MDD and those with no history of psychiatric problems demonstrate differential performance on a set-shifting task depending on the emotional nature of the stimuli. These divergent styles of responding to emotionally valenced information may contribute to the relative risk or protection from depressed mood.

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Appendix

ANEW[A1] Words Used in the ECST

Positive Words

admired, adorable, alive, ambition, angel, applause, beautiful, birthday, bold, brave, bride, bright, capable, carefree, caress, champion, circus, confident, cute, dancer, devoted, dignified, dollar, ecstasy, elated, elegant, engaged, fame, famous, fantasy, festive, fireworks, flirt, friendly, gentle, glory, graduate, grateful, grin, happy, heaven, holiday, honest, hopeful, infant, inspired, jolly, joyful, laughter, liberty, lively, loyal, lucky, masterful, melody, memories, ocean, outdoors, outstanding, palace, passion, profit, proud, puppy, respectful, reward, riches, satisfied, savior, scholar, sexy, silly, spouse, sunrise, sunset, surprised, talent, terrific, thoughtful, thrill, treasure, treat, trophy, twilight, untroubled, useful, vigorous, wise

Neutral Words

alert, aloof, appliance, barrel, bench, bland, blond, cabinet, chair, clock, coarse, column, contents, context, cord, cork, corridor, curious, curtains, detached, doctor, elbow, elevator, engine, hairpin, hammer, haphazard, hard, humble, icebox, indifferent, journal, kerchief, lavish, limber, locker, machine, mantel, meek, modest, month, moral, muddy, mystic, naked, noisy, nonchalant, pamphlet, passage, patient, phase, plain, pungent, quality, quiet, radiator, rain, repentant, reserved, reverent, rough, rusty, scissors, serious, sheltered, shy, skeptical, slow, solemn, sour, statue, stiff, stomach, storm, stove, street, subdued, swamp, swift, taxi, tidy, timid, tool, trunk, umbrella, volcano, windmill, yellow

Negative Words

accident, ache, afraid, agony, alcoholic, alone, angry, anguished, assassin, bored, brutal, bullet, burdened, burial, carcass, cemetery, coffin, corpse, crash, criminal, cruel, crushed, defeated, depressed, devil, disgusted, disloyal, displeased, distressed, divorce, dreadful, evil, fearful, fever, frustrated, garbage, grief, guilty, hardship, hatred, headache, helpless, hostile, hurt, illness, insane, insecure, jealousy, lonely, lost, malice, misery, mistake, morbid, neglect, obnoxious, panic, penalty, pistol, poison, prison, quarrel, rejected, rifle, roach, rude, sad, scared, selfish, shamed, sickness, sinful, slum, snake, stupid, surgery, terrible, terrified, traitor, troubled, tumor, ugly, unhappy, upset, useless, venom, victim, violent

[A1] Affective Norms for English Words (ANEW): Bradley, M. M., & Lang, P. J. (1999). *Affective norms for English words (ANEW): Instruction manual and affective ratings*. (Tech. Rep. C-1). The Center for Research in Psychophysiology, University of Florida.

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