Forgetting of Self-Relevant Emotional Information

in Major Depression

by

Hyang Sook Kim

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Psychology)
in The University of Michigan
2011

Doctoral Committee:

Professor Patricia J. Deldin, Chair
Professor John Jonides
Assistant Professor Ethan F. Kross
Assistant Professor Scott A. Langenecker

ACKNOWLEDGEMENTS

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ABSTRACT

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Chair: Patricia J. Deldin

Dysfunctional cognitive control plays a central role in the occurrence and maintenance of rumination and depressed mood. For a better understanding of the cognitive, psychophysiological, and emotional characteristics involved in cognitive control in depression, this dissertation consists of three studies that investigate the forgetting of self-generated, emotional material in individuals diagnosed with major depressive disorder (MDD) as compared with healthy controls (HCs). In the first study, the relationship between self-complexity and retrieval induced forgetting (RIF) was assessed in order to examine the underlying mechanisms and individual differences in forgetting unwanted thoughts. As a result, individuals with MDD demonstrated reduced recall of unpracticed but competing negative words (e.g. RIF effect), especially as they came up with more categories relevant to aspects of themselves or their life with less overlap among them. In the second study, event-

related potentials (ERPs) in response to valenced self-relevant information in a directed forgetting (DF) task were obtained to examine if either attentional inhibition or lack of elaborative processing or both were related to intentional forgetting, and if those cognitive processes underlying DF varied by valence. The results suggested that HC individuals initiated effortful allocation of attentional resource to remember non-mood congruent (negative) material in early stage of information processing (indexed by the P300 ERP component). HC individuals also demonstrated preferential elaboration and rehearsal of positive self-relevant information in remembering compared to negative one (e.g. positive bias; indexed by the slow wave component). In contrast, individuals with MDD showed even-handed processing of positive and negative stimuli, and also passive and less effortful processing for both remembering and forgetting. In the third study, Joormann et al.'s (2009) forgetting training was revised to better model naturalistic cognitive behavioral therapy process. Therefore, unlike in previous studies, a Think/No-Think (TNT) task with self-referent material and a pre- and post- task mood measurement was administered. As a result, individuals with MDD showed below-baseline forgetting of negative self-relevant information when provided positive substitutes. However the expected mood change was not observed in the MDD group. Implications and limitations of the studies are discussed and future directions are suggested.

CHAPTER I

INTRODUCTION

Major depressive disorder (MDD) is one of the most widespread mental disorders with 16.2% of lifetime prevalence in the United States of America (Kessler et al., 2003). It is also the third leading cause of disease burden with a high morbidity (World Health Organization, 2008). MDD encompasses a large number of psychobiological symptoms with the core features of depressed mood and/or loss of interest and pleasure associated with cognitive and somatic disturbances. According to previous studies, one of the most debilitating cognitive symptoms of MDD is ruminative thinking (Joormann & Tran, 2009).

Rumination is persistent and recurring negative thinking that is difficult to control and terminate (Joormann & Tran, 2009). It is differentiated from negative automatic thoughts by its process rather than content of negative thoughts (Nolen-Hoeksema et al., 2008). Therefore, cognitive processes have been investigated to enhance our understanding of the mechanisms of rumination and as a result, our understanding of MDD.

Dysfunctional cognitive control is a psychological process which plays a central role in the occurrence of rumination (Joormann, 2005; Linville, 1996). Given that rumination is characterized by repetitive thinking, ruminative response style might be related to deficits in inhibiting the processing of irrelevant material. Specifically,

Joormann (2004) found that dysphoric participants and participants with a history of depressive episodes demonstrated reduced inhibition of negative materials they were instructed to ignore. Joormann (2006) also reported that participants who scored high on rumination measurement showed a reduced ability to inhibit the processing of emotional distracters.

The purpose of present series of three studies is to investigate the cognitive control of self-generated, emotional information in individuals diagnosed with MDD in order to better understand rumination and major depression. The dissertation consists of three studies of individuals with MDD and healthy controls (HCs): (1) self-complexity and retrieval induced forgetting (RIF) of self-relevant information, (2) event-related potential (ERP) investigation of directed forgetting, and (3) suppression training of self-relevant information.

Study 1. Previous research has noted that there is a decreased recall of unpracticed, but competing items followed by retrieval practice of other items (Anderson, Bjork, & Bjork, 1994). This phenomenon is known as RIF in which the attempt to retrieve a target item also activates other related items, and to resolve the interference, the item causing the competition is inhibited (Storm & White, 2010). Given that persistent rumination may be a failure in inhibiting unwanted thoughts, the RIF paradigm is ideal to examine underlying mechanisms of dysfunctional inhibition in depression. In the present study, individuals diagnosed with MDD were compared with HCs in RIF. In addition, self-complexity was investigated in relation to RIF to examine how the organization of self-representation affects the ability to inhibit unwanted thoughts. The goal of the study was to better understand cognitive mechanisms of RIF in major depression and also

individual differences involved in forgetting negative information.

Study 2. Directed forgetting (DF) is a paradigm which has been commonly utilized to examine people's ability to inhibit or forget items (see MacLeod, 1998, for a review). In DF studies, participants are presented with lists of words and are instructed to either remember or forget the words. The DF effect is characterized by a decreased recall of the to-be-forgotten (TBF) words and an increased recall of the to-be-remembered (TBR) words (Bjork, Bjork, & Anderson, 1998). Because rumination is associated with deficits in cognitive control and specifically with problems inhibiting emotional material, individuals with MDD were expected to experience difficulties when trying to intentionally forget negative information. This study was designed to investigate differential information processing involved in DF of positive and negative self-relevant stimuli between HCs and individuals with MDD while collecting ERPs. Given that ERPs have high temporal resolution, the present study was expected to address the question as to whether attentional inhibition or lack of elaborative processing or both was involved in valence specific biases of DF in MDD (e.g. preferential processing of negative information or even-handed processing).

Study 3. The Think/No-Think (TNT) paradigm is another procedure developed to examine the mechanisms of intentional inhibition (Anderson & Green, 2001). The TNT task includes explicit instructions and a training process to suppress certain specific target words and respond to other cue words (Salamé & Danion, 2007). The reduced accuracy of recall followed by suppression instruction is interpreted as reflecting a controlled inhibitory mechanism that prevents unwanted memories from accessing consciousness. Using the TNT task, Joormann and her colleagues (2009) trained participants and found

that both individuals diagnosed with MDD and HCs were aided in forgetting negative material when utilizing positive substitutes. The present study aimed to extend its application to more naturalistically valid, self-relevant stimuli. Therefore, participants generated stimuli which were relevant to their self-concept and life experience. Findings from this study has significant clinical implication for cognitive behavioral therapy (CBT) in which patients are helped to decrease negative thinking by increasing accessibility to positive self representation and memories (Brewin, 2006). Like the CBT process in clinical settings, it was expected that individuals with MDD would forget negative self-relevant material by learning to substitute negative self-concepts or memories with positive ones.

In all three studies, self-relevant stimuli were utilized not only to elicit deeper level of information processing, but also to reflect goal-directed and selective nature of forgetting. These self-relevant stimuli are different from normed or other-relevant stimuli because they are emotional, inter-related, often meaningful, and associated with the self-identity (Harris, Sutton, & Barnier, 2010). According to the level of processing model (Cermak & Craik, 1978; Craik & Lockhart, 1972; Craik & Tulving, 1975), personal relevance increases the depth of processing which strengthens memory trace. Furthermore, previous studies suggest that people are motivated to recall memories relevant to their sense of self, and to forget memories that are discrepant with or threatening to their sense of self (Conway, 2005). Therefore, the use of self-relevant emotional words were expected to provide a better way to investigate the precise nature of forgetting, particularly effortful and intentional cognitive control over unwanted thoughts in MDD.

In summary, various aspects of forgetting were investigated through a series of three studies including a retrieval-induced forgetting experiment, ERP investigation, and suppression training. Through these studies, it is hoped that a better understanding of the underlying mechanisms of dysfunctional cognitive control in depressed individuals will be gained and a clinical approach to help them control a seemingly endless loop of rumination will be found.

CHAPTER II

SELF-COMPLEXITY AND RIF

OF SELF-RELEVANT INFORMATION IN DEPRESSION[1]

Persistent rumination is not only a critical symptom of depression, but also a tendency which increases and predicts the likelihood of major depression (e.g. Nolen-Hoeksema et al., 2008). Therefore, research that examines the underlying mechanisms and individual differences in rumination has significant clinical implication.

Rumination is commonly conceptualized as a failure in inhibiting unwanted thoughts, and has been studied using retrieval-induced forgetting (RIF) paradigms. According to Anderson, Bjork, and Bjork (1994), RIF is a phenomenon in which the retrieval of a memory trace causes a decrease in the retrieval of competing memory traces. In RIF experiments, participants initially study a series of category cue-exemplar word pairs (e.g. fruit-orange, fruit-apple). During the practice phase, participants perform repeated directed retrieval in which half of the exemplars from half of the categories are practiced by category-stem cued recall (e.g. fruit-or_____). Finally, participants are presented with the entire list of category cue words and asked to recall all of the

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[1] This study was done in collaboration with Emre Demiralp in cognitive psychology of the University of Michigan.

exemplars associated with each category cue. Previous studies have shown that retrieval practice not only facilitates the recall of practiced items but also suppresses the recall of unpracticed but competing items (e.g., Anderson, Bjork, & Bjork, 2000; Barnier, Hung, & Conway, 2004; Bäuml & Hartinger, 2002; Groome & Grant, 2005; MacLeod, 2002; Perfect et al., 2002).

Although RIF appears to be a general phenomenon observed in many contexts including during episodic memory (e.g., Anderson, Bjork, & Bjork, 1994; Ciranni & Shimamura, 1999) and semantic memory (e.g., Johnson & Anderson, 2004), there are boundary conditions under which it does not occur (Anderson, 2003). In particular, when the associates of a cue are connected to one another, retrieving some of them does not interfere with the recall of their competitors, which is called an integration effect (Anderson & McCulloch, 1999). Integration as a boundary condition on RIF has been evidenced from previous studies showing that RIF depends on whether participants inter-relate the associates of a retrieval cue. For example, Anderson and McCulloch (1999) asked participants to study six exemplars from each of eight categories, under either standard or integrative rehearsal instructions. In the standard encoding condition, participants were instructed to study the relation between the category and each exemplar, while in the integrative encoding condition, participants were further asked to inter-relate the exemplars of each category. As a result, integrative encoding instructions reduced RIF relative to standard encoding.

Thus far, these integration effects have been demonstrated only in studies which asked participants to explicitly encode relationships between the associates of a cue. The present study aimed to extend the application of the integration effects and explore if it

can be observed when associates have preexisting semantic relationships. For this reason, Linville's (1985, 1987) self-complexity model was incorporated into this RIF study.

According to Linville (1985, 1987), self-concept is a multi-faceted cognitive construct composed of self-aspects. These self-aspects can refer to important and meaningful roles (e.g., student), relationships (e.g., mother), behaviors (e.g., writing a paper), or situations (e.g., separation). As a person identifies more self-aspects (e.g., dimensionality) and perceives that relatively unique qualities characterize each of those self-aspects (e.g., distinctiveness), he or she can be regarded as having greater self-complexity. Linville demonstrated that individuals with low self-complexity had more extreme affective reactions following a failure experience and displayed greater emotional variability, while individuals with high self-complexity were less likely to respond to stressful events in a dysfunctional way. Other studies have also shown that that complexity of negatively valenced self-knowledge, but not of positively valenced self-knowledge, is associated with negative outcomes (Brown et al., 1995; Morgan & Janoff-Bulman, 1994; Woolfolk et al., 1995).

Despite the paradigms value, the psychometrics of Linville's (1987) self-complexity index has been criticized because the two mechanisms underlying the buffering effects of self-complexity - dimensionality and distinctiveness - probably do not reflect a single construct. The first index, dimensionality, reflects the number of self-aspects generated by the participant. According to Linville (1987), dimensionality serves as a buffer against depression by providing alternative foci of attention following a stressful event. Since the affect generated by an activated self-aspect puts an influence on our overall emotional experience in proportion to how much that self-aspect is prominent

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(Brown & Rafaeli, 2007), for an individual with few self-aspects, any activated aspect takes up a large proportion of the self-schema which leads to negatives outcomes. A second index reflects the degree of distinctiveness or overlap among self-aspects (Rafaeli-Mor et al., 1999). Greater distinctiveness prevents spillover effect in which the spread of activation from one aspect of the self to other aspects (Brown & Rafaeli, 2007). Consequently, for an individual with low distinctiveness, any activated aspect will lead to activation in overlapping aspects and as a result to a greater impact on the total self-concept.

In the present study, it was hypothesized that individuals diagnosed with major depression would show lower dimensionality and distinctiveness in their self-concept, especially for negative self-knowledge compared with positive self-knowledge. Second, due to difficulties in inhibition, it was expected that individuals diagnosed with MDD would demonstrate weaker RIF effect especially for negative self-aspects. Third, given integration as a boundary condition on RIF (Anderson & McCulloch, 1999), a positive linear correlation between the self-complexity and the RIF effect was expected.

<center>Method</center>

Participants

Participants were recruited through posters and newspaper advertisements in Ann Arbor and nearby areas. All participants were given the consent form to read and sign prior to their research participation, which was approved by the University of Michigan Institutional Review Board. The Structured Clinical Interview for the DSM-IV, Patient Edition (SCID-I/P; First et al,. 1994) was then administered by trained graduate students.

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Participants who have current and/or past alcohol abuse, alcohol dependence, anorexia nervosa, schizophrenia, schizophreniform, schizoaffective disorder, and bipolar disorder were excluded. Twenty-six participants were included in the HC group who have no current or past Axis I pathology (6 males, 20 females, mean age=21 years, SD=4.4) and 24 participants who met criteria for a current episode of MDD (6 males 18 females; mean age=24 years, SD=6.6). Data from 2 HCs and 3 individuals with MDD were excluded from analysis because the task was interrupted by an unexpected fire alarm. Participants were compensated $20/hour for their time.

Questionnaires

To obtain dimensionality and distinctiveness indices, a self-complexity questionnaire was administered. On the next day, a second self-complexity questionnaire, which limits the number of self-categories and traits, was administered in order to generate a large enough sample of stimuli needed for the RIF study. Details of the questionnaires are as follows.

Self-Complexity Questionnaire 1. The questionnaire was administered on the first day of study participation. The participants were asked to generate a list of categories that might be relevant to aspects of themselves and/or their life, and to find traits (i.e., adjectives) that fit into each of the categories that they described (see Appendix 1).

Self-Complexity Questionnaire 2. To generate enough number of category cues and exemplars for the RIF study, on their second visit, the participants were asked to generate at least 10 categories that might be relevant to aspects of them and/or their life. Additionally, they were asked to generate at least 15 traits that fit into each of the

categories. To examine if the RIF effect in this study is valence specific, two positive, two neutral, and two negative exemplars from each of eight self-categories were chosen. Each category has unique exemplars of which the stems (the first two letters) are different (see Appendix 2).

Procedures

Two weeks after participants completed the second self-complexity questionnaire, they came back to the lab to be administered the RIF test. The memory items for the RIF study consisted of 48 category-exemplar word pairs made up of six exemplars from each of eight categories. For each participant, the practiced 12 items (Rp+) and unpracticed 12 items (Rp-) from the practiced category each comprised 24 word pairs, and the control condition (Nrp) comprised the remaining 24.

The RIF test involved four separate phases: learning, retrieval practice, distraction, and cued recall. First, in the learning phase, participants were shown all 48 category-exemplar pairs (e.g., student-paper) one at a time in random order. Each pair was presented for five seconds, and participants were asked to remember as many words as possible. Then, in the retrieval practice phase, participants were asked to retrieve 12 exemplar words in response to a cue and the first two letters of the exemplar (e.g., student-pa___). These practiced items consisted of a one positive, one neutral, and one negative exemplars for each of four categories. Each pair appeared three times and participants were given 10 seconds to complete each exemplar. Next, a gender naming stroop task, which is not relevant to the RIF test, was administered for ten minutes as a distractor task. Finally, in the recall phase, participants were shown each of the category

names one at a time, and were allowed one minute to list as many exemplars of each as possible.

Analysis

Two separate indices for dimensionality and distinctiveness were used in analysis of the self-complexity data. The first index, dimensionality, was calculated based on the number of self-categories and compared between groups. The second index, distinctiveness, was calculated from the formula proposed by Rafaeli-Mor et al. (1999):

$OL = (\sum_i (\sum_j C_{ij})/T_i)/n*(n-1)$, where C is the number of common features in two aspects; T is the total number of features in the referent aspect; n is the total number of aspects in the person's sort and i and j vary from 0 to n (i and j are unequal). The positive and negative overlap indices were also obtained based on valence ratings from the participants and compared by groups. To examine RIF effect, the accuracy of recall (%) was submitted to a Group (MDD, HC) x Valence (positive, negative) x Practice (RP+, RP-, NRP) ANOVA. Finally, the self-complexity indices were correlated to the RIF score to examine relationship between the self-complexity and the RIF effect.

Results

The distribution of ratings presented in Figure 1 demonstrates that HCs have a tendency to generate words rated positively. Ratings from individuals with MDD were evenly distributed resulting in a significant group difference in negative ratings from one to three ($t(43) = -2.544$, $p < .05$).
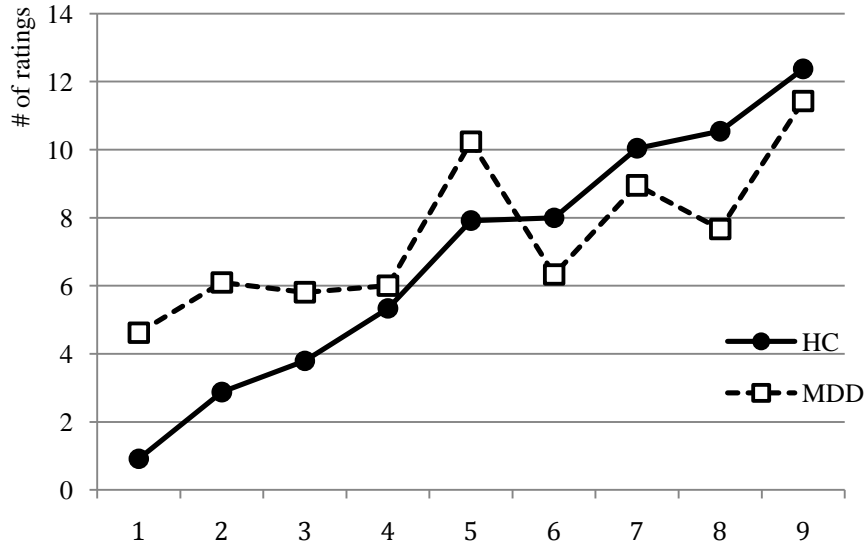
[Figure 1] Distribution of ratings

The number of self-categories and the overlap among traits were compared between individuals diagnosed with MDD and HCs. As a result, no significant difference in dimensionality (e.g. number of categories) between HCs and depressed participants was observed, $F(1, 43) = .512$, $p=n.s.$ For distinctiveness measured by overlap (OL) index, however, the results demonstrated significant difference in negative overlap between HC and MDD groups, $F(1, 42) = 4.407$, $p< .05$ (Figure 2).
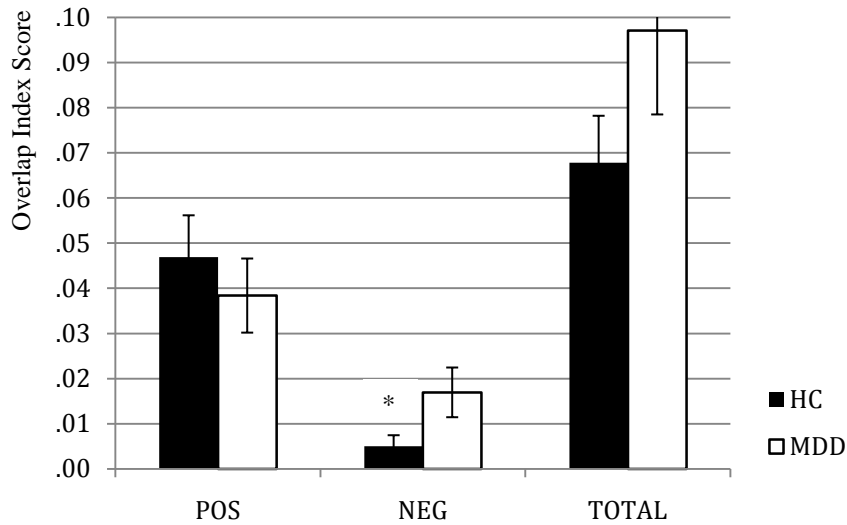
[Figure 2] Mean overlap (OL) index score

An ANOVA analysis to examine the RIF effect revealed a main effect of Practice, $F(2, 76) = 55.288$, $p< .01$. When parsed, RP+ words were recalled more than NRP words, $t(39)=8.277$, $p< .01$ (e.g. practice effect) and NRP words were recalled more than RP- words, $t(39)=3.022$, $p< .01$ (e.g. RIF effect; Figure 3). In addition, the RIF effect differed by group such that the MDD group demonstrated significant RIF effect ($t(16) = 3.594$, $p< .01$), while the HC group did not. Within the MDD group, this RIF effect was observed only for negative words ($t(16) = 2.870$, $p< .05$), not for positive words (Figure 4).
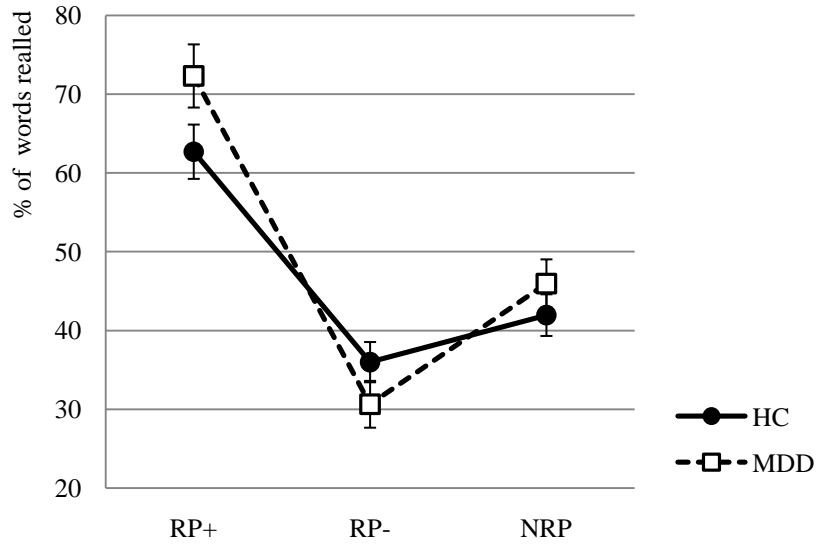
[Figure 3] Accuracy (%) of recall
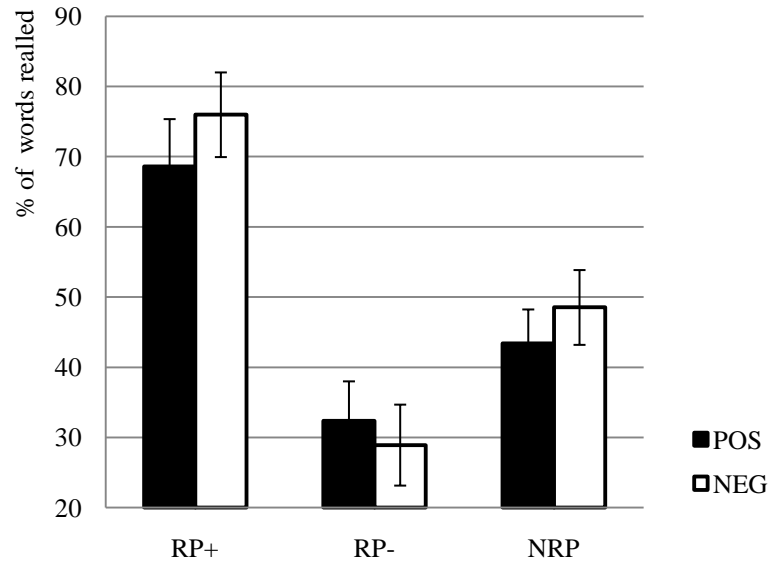
[Figure 4] Accuracy (%) of recall in the MDD group

Finally, the correlation between two indices – dimensionality and distinctiveness – and the RIF score was investigated. Given integration as a boundary condition on RIF (Anderson & McCulloch, 1999), distinctiveness (or low overlap among self-aspects) was expected to have a positive correlation with the RIF score. A positive correlation between the RIF score for negative words and dimensionality index (e.g. number of categories) was observed in the MDD group, $r= .499$, $p< .05$, while the HC group did not show any significant correlation. In the MDD group, furthermore, the RIF score for negative words was marginally correlated with overall overlap index and negative overlap index, while the total RIF score was positively correlated to positive overlap index (Table 1; Figure 5).

	r	$p <$
RIF_Neg × N. of Categories	.499	.05
RIF_Neg × OL_Overall	-.431	.10
RIF_Neg × OL_Negative	-.419	.10
RIF_Total × OL_Positive	.570	.05

[Table 1] Significant correlation in the MDD group

$R^2 = 0.3247$

RIF_Overall (y-axis)
OL-Positive (x-axis)
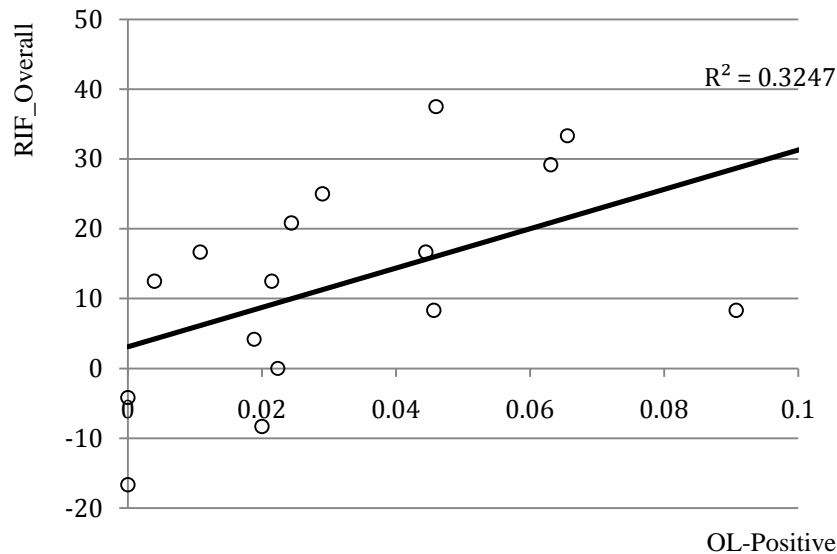
[Figure 5] Scatter plot between RIF_Total and OL_Positive in the MDD group

Discussion

In the present study, the RIF effect in MDD was examined in relation to self-complexity utilizing self-relevant material. The results suggest that individuals with MDD have increased overlap among negative self categories. This lack of distinctiveness observed in the MDD group might result in a spillover effect in which any self-aspect affected by a stressor activates another overlapped self-aspect easily and therefore increase a possibility for the MDD group to respond with depression, perceived stress, psychosomatic symptom, and illness (Brown & Rafaeli, 2007). However, the hypothesized group difference in dimensionality was not found. Since, for the person who has fewer self-aspects, a relatively larger portion of the self would be activated by a stressor, a lower dimensionality was expected in the MDD group. In contrast, Ross, Mueller, and Torre (1986) suggested that the maintenance of more self-aspects can be related to increased responsibility, greater subjective and mundane stress and elevated depressive symptoms. This complicated nature of the relationship between

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dimensionality and depression may explain no simple group difference on dimensionality in the present study.

Contrary to the hypothesis, individuals with MDD also demonstrated increased RIF effect. Consequently, the MDD group showed impairment in recall of self-relevant material that was not practiced, but competing with the practiced words. This RIF effect was especially significant for negative words such that the MDD group less remembered unpracticed negative self-related information compared to HCs. This finding contrasts with previous RIF studies demonstrating that negative material has been less likely to be forgotten (e.g. Moulds and Kandris, 2006). One of possible explanations is that when participants with MDD repeatedly practice negative memories, they may forget related negative memories due to interference (e.g. associative blocking). This interference account assumes that RIF arises as a result of increased interference from the (stronger) practiced items, blocking access to the (relatively weaker) unpracticed items (e.g., Camp, Pecher, & Schmidt, 2007; Jakab & Raaijmakers, 2009). Therefore, due to competition between negative information, recall of unpracticed items was decreased in the present study. This result is consistent with findings from Joormann et al.'s (2009) study in which participants with MDD showed successful forgetting of negative material when being provided with negative substitute words. Harris and her colleagues (2010) also demonstrated that participants with dysphoria only showed RIF for negative memories but not for positive memories. This finding may explain mechanisms of expressive writing that written self-disclosure of negative experiences can reduce related negative thoughts as a result (Pennebaker, 1997).

The relationship between self-complexity and RIF effect in the present study

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suggested that individuals with MDD were more successful in forgetting negative information as they have more self categories or roles with less overlapping among them. This result supports Anderson and McCulloch (1999)'s integration as a boundary condition hypothesis that interference with recall of competitors reduces due to preexisting association among self-aspects. Therefore, as a depressed person defines him- or herself with more self categories or roles with less overlapping among negative self-aspects, he or she would be better at forgetting negative self-related information.

Another finding from the present study was that there was a significant relationship between overlaps among positive self-aspects and RIF in general. Although people lower in distinctiveness find it more difficult to get self-relevant events out of mind since their highly interconnected self-concept structures make mental regulation more difficult (McConnell, Rydell, & Brown, 2009), the present study suggested that higher overlap among positive self-aspects may play a different role. As the spillover effect of positive experience was increased followed by the low distinctiveness in positive self-aspects, ability to inhibit relevant self-aspect was also increased. Considering RIF effect is positively related to working memory capacity (WMC) such that high-WMC individuals demonstrated more RIF than low-WMC individuals (Aslan & Bäuml, 2010), this result raises a possibility that higher overlap among positive self-aspects may reflect high WMC in MDD.

The present study is important in that (1) RIF effect was examined in clinically diagnosed individuals, (2) the integration as a boundary condition of RIF effect was demonstrated in material with preexisting semantic relationships, (3) Non-inhibitory explanation on forgetting in major depression (e.g. associative blocking) was supported

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by increased RIF effect observed in individuals with MDD, and (4) self-complexity of individuals with MDD was investigated as an individual difference in forgetting valenced self-relevant information. In particular, the finding on relationship between organization of self-representation and RIF effect was expected to shed light on development of therapy which helps individuals with MDD to reduce extreme emotional reactivity to stressor and to forget unwanted negative thoughts. The CBT techniques which address cognitive distortions such as overgeneralization and/or all-or-nothing can be an effective way for individuals with MDD to increase dimensionality and distinctiveness of the self. Since the present study had the limitation that only a correlational relationship between self-complexity and RIF effect was examined, however, future research on whether changes in the individual's self-complexity predicts actual recovery from stressful negative life events is needed.

Another limitation can be found in the use of self-relevant word stimuli. In the present study, self-generated emotional words were utilized to elicit the deeper and more personally meaningful information processing. However, they also caused difficulties in differentiation of the episodic memory on the moment the participants generated the words from the semantic memory on the word list they learned. Although the RIF task was administered two weeks after participants came up with the self-relevant word list, there was still a possibility that the episodic memory affected the participants' performance during the task. Therefore, future research which addresses how the influence of episodic memory on semantic memory can be measured and furthermore, controlled, is required for a better understanding and proper application of the findings of the present study.

Appendix 1. Self-Complexity Questionnaire 1

Hello and thank you for your interest in the Self and Cognition study. In this study, we are interested in how you describe yourself. There are probably many traits and/or characteristics that you could use to describe yourself. Your tasks are;

(a) to come up with a list of categories that might be relevant to aspects of you or your life, and

(b) to find trait adjectives that fit into each of the categories that you have created. Please make sure that you use adjectives to describe yourself (i.e., words that modify nouns, in the phrase "beautiful girl" beautiful is the adjective and girl is the noun).

You may create categories on any meaningful basis—but remember to think about yourself while doing this. Each category of trait adjectives might represent a different aspect of yourself. For example, if you made a category called "social life" as a description of yourself, you might fit into it adjectives such as 'outgoing' or 'competitive.' As another example, you may make a category called, "friend" under which you may list adjectives such as 'trustworthy' or 'flaky.'

Form as many or as few groups as you desire. Continue forming groups until you feel that you have formed the important ones. Also, each group may contain as few or as many trait adjectives as you wish. Each trait adjective may be used in more than one group; so you may keep reusing traits as many times as you like. For example, you may

find that you want to use the trait 'competitive' to describe your social life and also to describe your school life. The order in which you record the categories is not important, nor is the order of the traits within a category. We are only interested in which traits you put together.

Let me remind you of a few things you need to keep in mind. Remember that you are describing yourself in this task, not people in general. You may reuse a trait in several categories, and take as much time as you like on the task. The traits must be adjectives. Don't forget to label all the categories you generate. When you are finished, please return your answer sheet by your next visit to the lab.

Appendix 2. Self-Complexity Questionnaire 2

Thank you for submitting the first answer sheet. For this time, you are going to do the same task with following exceptions.

(a) Come up with **at least 10 categories** that might be relevant to aspects of you or your life.

(b) Find **at least 15 trait adjectives** that fit into each of the categories that you have created.

(c) Refer to **the word list** and **the answer sheet** you submitted for the first task

Again, remember that you are describing *yourself* in this task, not people in general. Each category of traits might represent a different aspect of yourself. You may reuse a trait adjective in several categories, and take as much time as you like on the task. The order in which you record the categories is not important, nor is the order of the trait adjectives within a category. The traits must be adjectives (words that modify nouns, i.e., in the phrase "beautiful girl" beautiful is the adjective and girl is the noun). Don't forget to label all the categories you generate.

After listing up categories and traits, please rate all the traits for 'representativeness,' 'valence,' and 'arousal' using a scale ranging from 1 to 9. For **representativeness**, please rate how much representative/ typical / relevant each word to each category. The lower extreme of the scale indicates low representativeness, and the upper extreme of the scale indicates high representativeness.

For **<u>valence</u>**, please rate how unhappy or happy each word seems to you. The lower extreme of the scale indicates feelings of unhappiness, annoyance, dissatisfaction, melancholy, despair, and boredom. The upper extreme of the scale indicates feelings of happiness, pleasure, satisfaction, contentment, and hope.

For **<u>arousal</u>**, please rate how excited or calm each word seems to you. The lower extreme of the scale indicates feelings of feeling relaxed, calm, sluggish, dull, sleepy, or unaroused. The upper extreme of the scale indicates feelings of feeling excited, frenzied, jittery, wide-awake, or aroused.

When you are finished, please return your answer sheet by your next visit to the lab.

CHAPTER III

ERP INVESTIGATION

OF DIRECTED FORGETTING IN DEPRESSION

Mood-congruent memory (MCM) refers to the tendency for individuals to recall information that is congruent with their mood. According to MCM theory, individuals with major depressive disorder (MDD) tend to remember negatively valenced stimuli better than positively valenced ones, whereas the opposite is true for healthy controls (HCs) (Blaney, 1986). This memory bias is consistent with Beck's (1967) theory suggesting that individuals with MDD will show preferential processing of negative stimuli. Despite substantial evidence of depression-congruent bias (e.g. Bradley & Mathews, 1983; Mathews & Bradley, 1983), there also have been studies contradicting such findings (e.g., Banos, Medina, & Pascual, 2001; Deldin et al., 2001; Denny & Hunt, 1992; Ilsley, Moffoot, & O'Carroll, 1995; Rottenberg, Gross, & Gotlib, 2005; Sloan et al., 1997; Watkins et al., 1992). Importantly, research comparing individuals with MDD and HCs reveals that depression can be characterized as even-handed processing or lack of positive biases or illusion (e.g., Taylor & Brown, 1988) which is robustly found in HCs.

To address the controversy between preferential processing of negative material and even-handed processing in depression, and furthermore, to examine underlying

mechanisms of those processing, directed forgetting (DF) paradigm has been studied. DF is a paradigm to investigate intentional forgetting by presenting cued to remember and cued to forget items. The directed forgetting effect can be characterized by decreased performance for the to-be-forgotten (TBF) items and increased performance for the to-be-remembered (TBR) items in memory task (Bjork, Bjork, & Anderson, 1998). Several hypotheses have been proposed to explain directed forgetting effects, including differences in attentional inhibition and rehearsal processing between TBR and TBF items (MacLeod, 1998; Woodward et al., 1973).

According to the attentional inhibition hypothesis, the DF effect can be found when the TBF items are actively inhibited and prevented from entering into working memory (Hasher & Zacks, 1988; Zacks et al., 1996). This view is supported by the study showing that older adults, who find it difficult to ignore TBF items, exhibited a weaker directed forgetting effect than young adults (Zacks et al., 1996). However, there is also evidence suggesting that TBF items may not be actively inhibited, as TBR and TBF items elicited similar semantic priming effects (Marks & Dulaney, 2001). Another explanation on the DF effect is differential rehearsal between TBR and TBF items (Gardiner et al., 1994). According to this hypothesis, unlike to the TBF items, elaborative rehearsal processes are allocated to the TBR items in response to a cue. This view is supported by the finding that increasing the processing time of the remember/forget cues enhances performance for the recognition of TBR items but not TBF items (Gardiner et al., 1994).

To explore the precise nature of directed forgetting in MDD, event-related potentials (ERPs) were utilized for this study. ERPs are electroencephalographic measurements that are time-locked to a stimulus and allow one to parse the specific

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aspects of cognitive processing. ERPs are also beneficial because they distinguish between certain memory processes and confounding factors including psychomotor retardation and demand characteristics of participants. In the present study, the P300 and slow-wave (SW) were expected to reveal differences in attentional inhibition and elaboration/rehearsal between TBF and TBR conditions of directed forgetting.

The P300 component is a positive wave with centro-parietal scalp distribution at approximately 300 and 600 ms post-stimulus (see Polich, 2007 for review). Previous studies have provided converging evidence that the amplitude of the P300 component can serve as an index of the attentional resource allocation. By utilizing dual-tasks, for example, researchers found that higher priorities are associated with larger P300 amplitudes (Hoffman et al., 1985; Strayer & Kramer, 1990). Other studies have demonstrated that as the difficulty of primary task increases, the amplitudes of the P300 elicited by primary-task events increase while the amplitudes of the P300 elicited by secondary-task events decrease (Isreal et al., 1980; Kramer, Sirevaag, & Braune, 1987; Kramer, Wickens, & Donchin, 1985; Sirevaag et al., 1989; Strayer & Kramer, 1990; Wickens et al., 1983). Furthermore, in clinical samples with schizophrenia or depression, reduced P300 amplitudes have been observed, which may reflect a depleted supply of processing resources (e.g., Mirsky & Duncan, 1986; Nuechterlein, 1990; Yee & Miller, 1994).

Another ERP component investigated was slow wave, which is a negative shift beginning around 800 ms post-stimulus (Ruchkin et al., 1992). By using the paradigm in which participants are instructed to maintain S1 information while making a decision on S2, previous studies found the slow wave component during the inter-stimuli interval,

especially in left parietal regions for verbal tasks (Barrett & Rugg, 1989; Barrett, Rugg, & Perett, 1988). Ruchkin and colleagues have also identified later SWs that are closely related to conceptual difficulty in working memory tasks. They found that the amplitudes of the slow wave increase as the loading of information increases, which suggests that the slow wave component may reflect elaboration, maintenance, and rehearsal in working memory (Ruchkin et al., 1988; Ruchkin et al., 1992). Furthermore, Deldin and her colleagues (2001) found that SW amplitudes are enhanced to negative words in individuals with MDD and positive words in HCs, which suggests that depressive memory biases might be related to later elaboration and rehearsal processes indexed by the slow wave component.

In summary, the present study examined the behavioral and electrophysiological correlates of the processing of the TBR and TBF items in a directed forgetting task. In particular, ERPs time-locked to study items were compared between individuals diagnosed with MDD and HCs in order to examine different attentional resource allocation (e.g. P300) and elaborative and rehearsal (e.g. slow wave) processing. Furthermore, valenced stimuli were used to examine mood-congruent information processing (Bower, 1981). By utilizing positive and negative self-relevant word stimuli, valence specific bias not only in remembering but also in forgetting was compared between individuals with MDD and HCs. Specifically, it was hypothesized that (1a) individuals diagnosed with MDD would show negative bias which was operationally defined as increased recall of negative items, decreased P300 and/or SW for negative TBF items, and/or increased P300 and/or SW for negative TBR items, and also alternatively hypothesized that (1b) individuals diagnosed with MDD would show

even-handed processing which was operationally defined as no valence specific difference in recall, P300, and/or SW. For HCs, it was hypothesized that (2) they would show positive bias which were operationally defined as increased recall of positive items, decreased P300 and/or SW for positive TBF items, and/or increased P300 and/or SW for positive TBR items.

Method

Participants

Twenty-seven participants were recruited through posters and advertisements in local news papers from the Boston and Cambridge areas. All participants were screened with a phone interview and those that met the exclusion criteria were excluded from further participation. The exclusion criteria included symptoms of psychosis, current of past engagement of substance abuse, eating disorders with the exception of pure binging, and loss of consciousness for longer than ten minutes. All participants who passed the phone interview were given the consent form to read and sign before the study began. The consent form was approved by the Harvard Institutional Review Board. The second part of the screening process was a diagnostic interview using the Structural Clinical Interview for the DSM-IV, Patient Edition (SCID-I/P; First et al., 1997). All SCIDs were administered by a doctoral level clinical psychologist or a graduate student trained in SCID administration.

There were a total of 14 participants in the control group with no current or past history of Axis I disorders. The depressive group consisted of 13 individuals who met criteria for a current episode of MDD. Participants were matched for age, gender, and

level of education (Table 2). All participants were treated in accordance with the policies

of the Harvard Institutional Review Board. Informed consent was obtained and

participants were compensated $10/hour for their time.

	HC	MDD	Statistics	*p.*
Age	41.86 (16.05)	30.54 (12.63)	$F(1,25)=4.102$	n.s.
Education	16.08 (1.85)	15.62 (2.66)	$F(1,24)=.264$	n.s.
Gender	9F, 5M	10F, 3M	$X^2(1)=.516$	n.s.

[Table 2] Demographic information
Note. Mean is listed with standard deviation values in parentheses

Materials

A questionnaire was administered approximately one week before the

physiological recordings in order to obtain self-relevant stimuli that consisted of words

that were positively and negatively valenced. The questionnaire requested information

regarding important people, places, and events in the participants' lives (e.g. "The person

who loves me the most is _____."). For each answer given in response to the items in

the questionnaire, the participants were asked to rate the valence (happy versus sad) and

arousal (excited versus calm) on a nine point scale.

Stimuli

Stimuli for each participant were obtained from the responses in the self-relevant

questionnaire. Ninety words (30 positive, 30 neutral, and 30 negative) were extracted

from the questionnaire according to the valence ratings. Words rated between one and

four were considered positive, and words rated between six and nine were considered

negative. All neutral stimuli had ratings of five.

Stimuli were created using Adobe Photoshop 5.0 and consisted of red or blue letters 1.0 inches in height presented on a white background using a 17 inch ViewSonic color monitor. Stimuli were presented for 500 ms each with an interstimulus interval of 4500ms. Words were presented in random order in three blocks of thirty words each. The James Long Company stimulus presentation program was used for presentation.

Procedure

Participants who responded to the advertisements and posters complete the phone screening. Qualified participants completed a diagnostic interview. Those who met criteria for HC or MDD were scheduled to complete the self-relevant questionnaire.

On the day of the physiological recordings, participants were first given an explanation of the general procedures. Electroencephalographic signals were recorded using a conductive electrogel and Ag/AgCl electrodes, located in a 32-site electrode cap (Electro-Cap International, Inc., Eaton, OH) with placement according to the International 10-20 System. Bipolar electroculography (EOG) was recorded using electrodes placed on the outer canthi, and right supraorbital and suborbital positions. Data were referenced to the left mastoid (M1) and analog filtered using high and low pass filters of .01 and 100 Hz. Impedances for all electrodes were kept below 5 kohms and data were digitally sampled at 3 kHz.

In the directed forgetting task, participants were instructed that they would see a series of red or blue words. Participants were told to try and remember the red, but not the blue ones. Instructions were given to concentrate on the current word on the screen

until the next one appears. Participants were also told that their memory was to be tested at the end of the session. Words were presented in three blocks of 30 words in random order. At the end of the task, participants were given unlimited amount of time to write down all the words they could recall from the previous portion regardless of color.

Data Reduction

All data reduction was completed using Brain Vision Analyzer software. First, data were re-sampled offline at 256 Hz. Channels that had been collected but were not to be included in further analyses were then removed from the data. All channels were digitally re-referenced to the average of the two mastoids (M1 and M2) and data above 80μV was automatically removed. A semi-automatic eye movement correction program utilizing a three-point algorithm, regression, and linear transformation of each of the channels was applied to residualize eye blink artifact as well as horizontal eye movement artifact. Data were digitally filtered using a low pass setting of 7 Hz. A semi-automatic artifact rejection program was used and then data were visually inspected to ensure that all artifacts such as muscle movement or residual eye movement had been removed. Any trials with residual eye blink or other artifact were not included in further analyses. Finally, ERPs were averaged separately for each participant, site, stimulus valence, and TBR/TBF condition relative to a 200 ms baseline.

Analysis

Behavioral recall data and physiological ERP data were analyzed to compare TBR with TBF conditions. To ascertain whether there were valence or diagnostic

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differences in the free recall for either TBR or TBF conditions, the number of words recalled was submitted to a Group (MDD, HC) x Valence (positive, negative) x Instruction (TBR, TBF) repeated-measures ANOVA.

To test the psychophysiological hypotheses, a principal components analysis (PCA) was performed to help identify time windows for the ERP components. Accordingly, ERP analyses were conducted separately for each of the components: P300a and P300b (300-500 and 500-700ms, respectively) and slow wave (early: 800-1900; middle: 1900-2500; late: 2500-4800). Mean amplitude scores for each component were submitted to a Group (MDD, HC) x Valence (positive, negative) x Instruction (TBR, TBF) x Caudality (frontal, central, parietal) x Laterality (left, middle, right) repeated-measures ANOVA. In addition, mean SW amplitudes at the left parietal region (P3), the site where differential activation for mood-congruent information between individuals with MDD and HCs was evidenced by Deldin et al.'s (2001), were submitted to Group (MDD, HC) x Valence (positive, negative) x Instruction (TBR, TBF) repeated-measures ANOVA. The Huynh and Feldt correction (1976) was used when the homogeneity of covariance assumptions of the repeated-measures ANOVA were not met.

Behavioral results

Participants recalled a greater number of TBR words relative to TBF words, Instruction, F (1, 24) = 6.706, MSE= 64.654, $p < .05$, η^2_P= .218. In addition, positive stimuli were recalled more than negative stimuli, Valence, F (1, 24) = 7.164, MSE= 49.846, $p < .05$, η^2_P= .230. This main effect of valence was modified by the instruction effect, Valence × Instruction, F (1, 24) = 5.640, MSE= 28.038, $p< .05$, η^2_P= .190, suggesting that for TBR words, participants recalled more positive than negative stimuli, while they did not show any difference in recall of emotional information for TBF words. Furthermore, HC and MDD participants demonstrated differential recall for positive and negative stimuli, Valence × Group, F (1, 24) = 4.333, MSE= 30.154, $p< .05$, η^2_P= .153. Control participants recalled more positive words than negative words (e.g. positive memory bias), while depressive participants did not show valence differences (Figure 6).
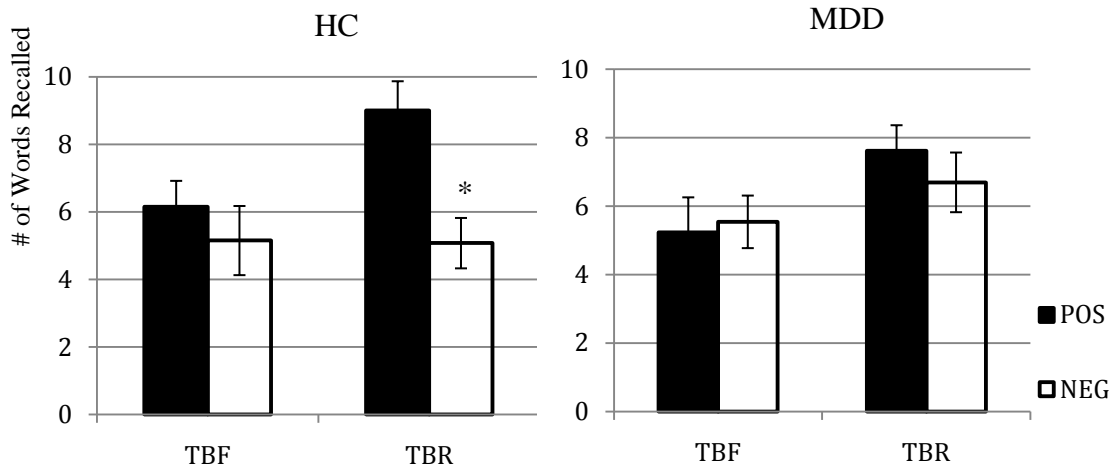
[Figure 6] Free Recall

Psychophysiological Results

Participants with MDD and HCs demonstrated marginally differential mean amplitudes in the P300b (500-700ms) for TBR and TBF stimuli depending on valence, Instruction × Valence × Group, $F(1, 24) = 2.947$, $MSE= 128.948$. $p= .09$, $\eta_P^2= .109$. Simple effect ANOVAs revealed that HCs demonstrated enhanced amplitudes for negative TBR words compared to negative TBF words, while participants with MDD did not show any significant difference between negative TBF words and negative TBR words ($F (1, 12) = 6.997$, $MSE= 304.177$, $p< .05$, $\eta_P^2= .368$). Average P300 waveforms for negative stimuli at Pz, the site where the amplitude of P300 is largest, are presented in Figure7.
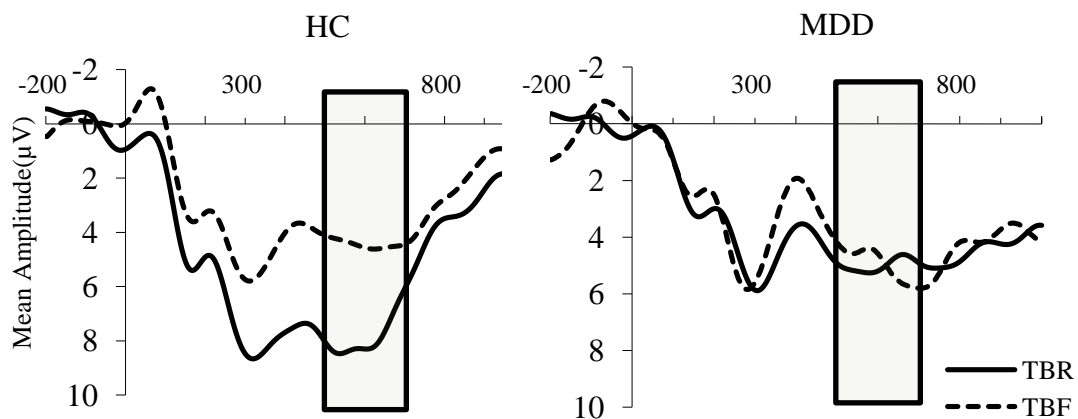
[Figure 7] ERP waveform for negative words at Pz

Since SW component group differences have typically been found in the left parietal region, in addition, a priori analysis for mean amplitudes between 2500ms and 4800 ms at P3 site was conducted. As a result, the HC group demonstrated enhanced late SW for positive TBR words, Valence, $F (1, 9) =5.748$, $MSE= 20.368$, $p<.05$, $\eta_P^2= .390$,

while the MDD group did not show significant differences (Figure 8).
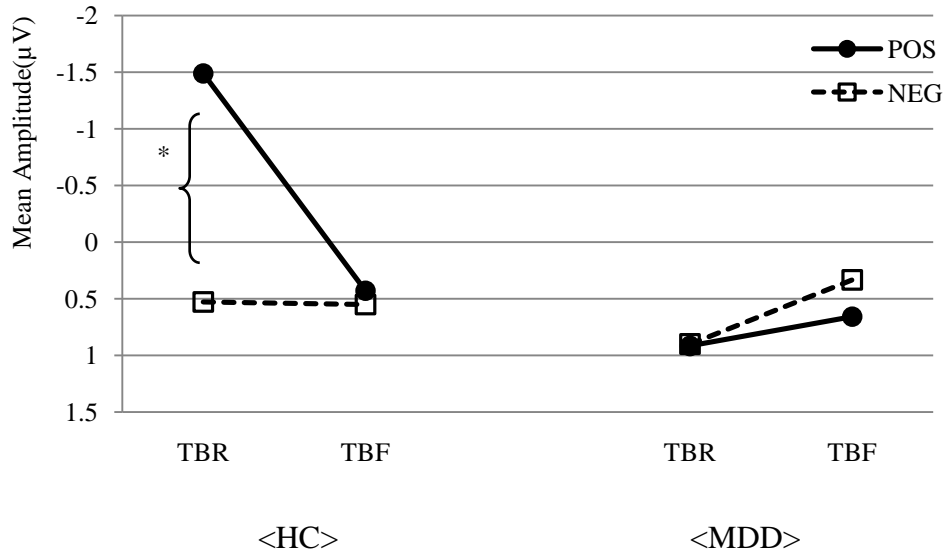
[Figure 8] Mean amplitudes between 2500ms and 4800ms at P3

Discussion

The present study compared free recall, and the P300 and the SW components of ERPs between individuals with MDD and HCs during a directed forgetting task in order to examine different attentional and elaborative/rehearsal processing of self-relevant emotional word stimuli. Behavioral results and a part of ERP results evidenced preferential processing of positive stimuli in memory in HCs. For individuals with MDD, even-handed processing or decreased processing of positive relative to negative information was supported (Deldin et al., 2001; Shestyuk et al., 2005).

Specifically, enhanced mean amplitude of P300 for negative TBR items compared to negative TBF items in the HC group suggested differential attentional processing between remembering and forgetting negative information in HCs. Considering the P300 is related to resource allocation (Donchin & Coles, 1988), the enhanced amplitude for

TBR words seemed to reflect a larger amount of attentional resources engaged in remembering than forgetting negative stimuli in the HC group, and that this process occurred during a relatively early stage of information processing. This finding suggests that HCs actively and effortfully allocate attentional resources to resolve the difficulty in remembering negative items which are not consistent with their self-concept and life experience. Despite this effort to remember negative items, however, there was no significant difference in the number of negative words actually recalled between TBR and TBF conditions. Therefore, although HCs put special efforts to remember negative material, this enhanced processing does not seem to result in successful memory of negative self-relevant information.

The HC group demonstrated increased SW amplitudes for positive TBR words at left parietal region (P3) suggesting enhanced elaboration/rehearsal processing of positive information. This result supported Deldin and her colleagues (2001) finding that enhanced SW amplitude was observed when maintaining mood-congruent valenced words in working memory as compared with non mood-congruent ones. By elaborating and rehearsing positive information compared to negative information, HCs seem to maintain their positive bias (e.g., see Taylor & Brown, 1988) which was also evidenced from enhanced recall of positive items in the present study.

Findings from the present study in which individuals with MDD demonstrated passive and less effortful processing for both remembering and forgetting raised the necessity of treatment which addresses lack of valence specific attentional allocation and/or lack of elaboration/rehearsal issues. For example, helping individuals with MDD to generate and use attentional strategy (e.g. distraction for TBF items, elaboration for

TBR items) would be beneficial for them to remember positive and to forget negative self-relevant information. Future research on whether the use of these strategies predicts enhanced memory and/or preferential processing of positive material seems to be needed.

Considering the purpose of the present studies was to investigate forgetting of negative self-relevant information to better understand rumination, furthermore, future research is required to directly relate findings from the present studies to rumination. For example, ERPs during directed forgetting task can be compared pre- and post-rumination induction (Nolen-Hoeksema & Morrow, 1993) in which participants are instructed to spend 8 min focusing on and thinking about self- and symptom-focused statements.

Although underlying cognitive processes were revealed through EPRs, there was a limitation that only encoding process was focused in the present study. ERP investigation during recognition task, instead of recall task, can be another way to investigate processes involved in retrieval difficulties found in individuals with MDD. The present study has another limitation in which due to lack of trials for ERP analysis, there was no differentiation between items successfully recalled and failed. Therefore, future research which includes enough number of trials and compares learning phase ERPs for items that are remembered in a subsequent memory test with those that are not would be required. For example, differences between ERPs for items that are correctly remembered and those for items that are incorrectly forgotten are known as Dm (difference in subsequent memory) or subsequent memory effects. This ERP difference is expected to reflect the more effective cognitive processes and as a result, to address more precise nature of underlying mechanisms of directed forgetting (Otten & Rugg, 2001).

In conclusion, the present study is important in that it provided behavioral and

psychophysiological evidence for differential information processing in individuals with MDD in comparison with HCs. The findings suggest that individuals with MDD are characterized by even-handed processing (e.g. deficit in the processing of positive self-relevant information) relative to HCs who showed positive memory bias during the working memory task. In addition, HCs were characterized by effortful, active, and valence-specific cognitive processing in both early attentional allocation stage and in late elaboration/rehearsal stage.

CHAPTER IV

SUPRESSION TRAINING OF

SELF-RELEVANT INFORMATION IN DEPRESSION

Forgetting plays an important role in emotion regulation. According to Lyubomirsky and Nolen-Hoeksema (1993), individuals with major depressive disorder (MDD) have a difficulty suppressing negative thoughts, which results in increased rumination. Therefore, training individuals with MDD to intentionally forget may be an effective strategy to counteract ruminative tendencies and promote emotion regulation.

Anderson and Green (2001) demonstrated that people are able to forget unwanted thoughts if they actively prevent retrieval of the material. Using the Think/No-Think (TNT) procedure, they found that the level of recall of to-be-forgotten (TBF) items dropped below baseline recall. Joormann et al. (2005) also employed the TNT paradigm with clinically depressed participants who successfully forgot negative targets when given instruction to suppress them.

The typical suppression training during the TNT phase, however, has a limitation in that it does not provide participants with any specific guidance of how to keep unwanted material from coming to mind. Hertel and Calcaterra (2005) demonstrated that intentional forgetting can be strengthened when substitutes are provided. In their study,

participants who were provided with substitute words (aided condition) demonstrated increased forgetting compared to participants in the unaided condition. Considering individuals with depression have deficits in cognitive control (Hertel, 2000), providing such strategies may be particularly important when training intentional forgetting. Joormann and her colleagues (2009) extended the discussion to a clinical population, and investigated whether training to use cognitive strategies can aid forgetting in depression. Participants with MDD and healthy controls (HCs) learned a list of word pairs each of which consisted of a neutral cue and either positive or negative target and were then administered TNT task. Some participants were assigned to the substitute conditions, in which they were instructed to use new targets to keep from thinking about the original targets. Three different conditions - an unaided condition, a positive substitute condition, and a negative substitute condition- were compared and as a result, participants with MDD showed successful forgetting of negative material in both positive and negative substitute conditions. However, only positive substitutes helped HCs to forget negative material.

The present study aimed to address three issues raised in Joormann et al.'s (2009) study using a similar experiment procedure. First, the current study extended the application of suppression training to self-relevant material making it more similar to what actually occurs during some forms of psychotherapy. According to Brewin (2006), cognitive behavioral therapy (CBT) may not work by directly modifying negative information but, instead, may work by producing changes in the relative accessibility of positive self-representation. For example, the individuals with MDD may decrease their negative memories by increasing accessibility to positive memories and making them win

the retrieval competition. In order to simulate CBT approach, therefore, participants were asked to generate their own stimuli which represent their self-concept and individual life experience. Considering that positive self-relevant material has high accessibility in HCs, it was expected that they would show enhanced training effect in forgetting relative to the MDD group. Second, the findings from Joormann et al.'s (2009) study raises a question as to whether substitution is an effective strategy for individuals with MDD to help emotion regulation, not just forgetting originally learned words. A principle of CBT is that as cognition become more adaptive, depressed mood is alleviated (Hollon et al. 1996). To examine the influence of positive substitutes on mood, therefore, pre- and post-task mood ratings were administered in this study. Third, individual differences in influence of substitution on memory and mood were explored. Previous research on CBT demonstrated that depressed individuals are characterized by extreme rigidity in their cognition including dichotomous thinking styles. It has also been suggested that such rigidity causes maladaptive beliefs to become more automatic, thus maintaining the depressed state (Moore, 1996; Teasdale et al., 1995). Therefore, cognitive flexibility was measured as a potential factor which affects differential benefits from substitution.

In summary, the present study aimed to extend the application of suppression training to CBT by utilizing self-relevant material to investigate influence of positive substitution on mood, and to examine individual differences in cognitive and emotional change followed by substitution. It was hypothesized that (1) positive substitutes would increase forgetting of negative material, (2) HCs would get more benefit from positive substitution (e.g. decreased recall of negative material) compared to individuals with MDD, (3) individuals receiving positive substitutes would have a more positive post-task

mood relative to pre-task mood, and (4) individuals with higher cognitive flexibility would demonstrate more decreased recall and enhanced mood as a result of positive substitution.

Method

Participants

Participants were recruited from flyers and newspaper advertisements near the Ann Arbor area. Respondents took part in a phone screening and then the Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders (4th ed.; SCID; First et al., 1997) administered by a trained interviewer to assess diagnosis. Participants have normal or corrected-to-normal vision, no color blindness, no reported history of neurological disorder, no reported history of head injury resulting in loss of consciousness greater than two minutes, and no reported alcohol or drug dependence history for the last six months. Additionally participants who have current and/or past anorexia nervosa, schozophorenia, schizophreniform, schizoaffective disorder, and bipolar disorder were excluded. The MDD group consisted of individuals who, at the time of testing, met criteria for MDD, and the HC group consisted of individuals with no current diagnosis and no history of any Axis I disorder.

Participants who qualified during SCID completed an online questionnaire which asked them to describe three positive and three negative self-descriptions and/or life experiences for each self-category and rate them in terms of valence, representativeness, and arousal (see Appendix 3). After two weeks, the participants visited the lab and were administered the computerized TNT task. Only the participants who passed the 50% of

cutoff in learning phase comprised the final sample of 24 HCs (13 females, 11 males; mean age=22 years, SD=6.9; 12 participants for each condition) and 22 individuals diagnosed with MDD (19 females, 3 males; mean age=28 years, SD=10.6; 11 participants for each condition). Participants received $20 per hour of research participation.

Questionnaires

In the present study, BDI-II and RRS were administered to examine difference in depression symptoms and level of rumination between individuals with MDD and HCs. In addition, VAS was administered to compare mood in pre- and post-test conditions. Finally, the participant's level of cognitive flexibility was measured through the Cognitive Flexibility Inventory (CFI) to examine how cognitive flexibility mediates influence of substitutes on forgetting. Details of the questionnaires are as follows.

Visual Analogue Scale (VAS). The visual method of assessment widely used in clinical and psychological research to assess subjective states. Participants are presented with a 10 cm line, with its boundaries clearly defined as the extremes of the mood (e.g., low extreme for feeling negative, high extreme for feeling positive) and asked to indicate their response by marking a position on the line between the two extremes.

Beck Depression Inventory-Second Edition (BDI-II; Beck et al. 1996). The BDI-II is a 21-item self-report questionnaire designed to measure cognitive, somatic, and behavioral aspects of depression. Evidence of excellent internal consistency ($\alpha = .92$) as well as high 1-week test–retest reliability ($r = .93$) when used with a sample of college students were reported.

The Ruminative Response Scale (RRS) of the Response Style Questionnaire

(Nolen-Hoeksema & Morrow, 1991). The RRS is a 22-item scale that assesses

individuals' tendency to ruminate in response to depressed mood (e.g., "I repeatedly

analyze and keep thinking about reasons for my sadness"). Respondents are required to

indicate how often they engage in each of the items using a 4-point rating scale ranging

from 1 (almost never) to 4 (almost always).

Cognitive Flexibility Inventory (CFI; Dennis & Vander Wal, 2010). A brief

self-report which consists of 20 items to measure cognitive flexibility necessary for

individuals to successfully challenge and replace maladaptive thoughts with more

balanced and adaptive thinking. There are two subscales: control subscale which

measures the tendency to perceive difficult situations as controllable and alternative

subscale which measures the ability to perceive multiple alternative explanations and to

generate multiple alternative solutions to difficult situations. Excellent internal

consistency (α = .90) and high 7-week test–retest reliability (r = .81) were reported.

Stimuli

Cues and targets were selected from the participant's response on online

questionnaire administered two weeks +/-1day before. Out of 41 self-relevant categories,

36 categories which are rated as relevant to the participant were used as cues being paired

with 18 negative and 18 positive targets. Five remaining categories were used as filler

cues with two additional fillers. For each cue presentation condition (0, 2, or 10),

therefore, six category cues paired with negative targets and six category cues paired with

positive targets were included. Twelve substitute words were also selected from the

participant's online questionnaire response. As a substitute, the positive word which has

relatively higher relatedness to the cue (or representativeness) was chosen to establish

stronger association with a cue. Participants' ratings on valence, relatedness, arousal of

the word stimuli under each condition is presented in Table 3.

	HC			MDD		
	Valence	Relatedness	Arousal	Valence	Relatedness	Arousal
Unaided						
Think items	7.81(0.60)	7.41(0.88)	6.18(0.87)	7.70(0.66)	7.22(0.90)	5.65(1.55)
No-Think items	2.60(0.64)	6.11(1.04)	4.21(1.00)	2.16(0.44)	6.73(0.73)	5.06(1.71)
Aided						
Think items	7.72(0.49)	7.09(1.00)	5.92(1.39)	7.76(0.56)	7.23(0.74)	5.79(0.86)
No-Think items	2.37(0.71)	5.43(1.89)	4.29(1.47)	2.23(0.49)	6.41(1.11)	4.78(1.78)
Substitutes	8.02(0.55)	7.57(0.83)	6.28(1.51)	8.32(0.36)	7.93(0.74)	6.03(0.96)

[Table 3] Mean (and standard deviations) of ratings

Procedure

Before the task began, the VAS was given to measure the participant's mood

status. The task was then administered following four different phases: learning,

feedback, TNT, and recall. For the participants who were in the substitution condition,

substitute words were presented before TNT task. First, during the learning phase,

participants were asked to remember 43 word pairs, each of which consisted of a

self-related category (cue) and a negative or positive self description (target). The word

pairs appeared randomly for 5s each. Seven of the 43 pairs were fillers, three of which

were presented at the beginning of the list, one in the middle, and three at the end. Participants were instructed to say the word pairs aloud and try to remember them for a later test of attention.

After the participants were presented the complete list of word pairs once, a feedback test was administered. When presented with each cue word, participants were asked to type in the target as quickly and accurately as they could. After each trial, the target appeared for 2s regardless if the participant answered correctly in order to strengthen the cue-target association. The feedback test was run up to four times until the participant reached 50 % of accuracy.

Next, for the participants who were in substitution condition, a list of 12 pairs of words was presented for their learning. The participants were instructed to study and say the new word pairs aloud so that they could use the substitutes to help them suppress targets in the following TNT task.

The TNT task was started with a short practice task to familiarize participants with the procedure. In the main TNT phase, cues were presented either two or 10 times and participants responded with positive targets to the cues in green and suppressed negative targets to the cues in red. Each trial was started with a cross for 200ms. Next, a cue appeared in either a green or a red font for 3s (or less if the participant responded sooner) which was followed by 7s of response time (except for No-Think trials in the unaided condition). When the cue was green, participants were instructed to respond with the target. The blue feedback target was displayed for 500 ms only when participants responded incorrectly. When the cue was red, participants were instructed to focus on and comprehend the cue word but to avoid responding or thinking about the associated target.

Those who had learned a substitute were asked to think about and respond with the substitute word instead. If participants mistakenly responded with the original target, a series of very large red Xs were displayed for 500ms. For participants who had learned substitutes, the same series of red Xs were displayed if they respond with an incorrect substitute word or not at all. Regardless of participants' accuracy in recalling the substitute, the feedback appeared in blue font for 500 ms at the end of every suppression trial. Right after the TNT task, VAS was administered again to measure the participant's post-task mood status at the moment.

Finally, in the recall phase, participants were asked to recall all original targets associated with the cues, regardless of whether they have practiced recalling or suppressing them during training. After the cued recall task, the same test was administered with cues that were followed by the first letter of the original target. Participants were told to use the letter to help them recall the target. Finally, participants were given all cue words that had been paired with substitutes and were asked to type in the substitute word.

After the participants finished the task, they completed questionnaires including BDI, RRS, and CFI, and rated all the cues and targets used in the experiment in terms of valence, representativeness, and arousal.

<center>Analysis</center>

The accuracy of free recall was submitted to a repeated-measures of ANOVA with the between-subject factors as group (MDD, HC) and substitution condition (unaided, aided) and within-subject factors as instruction (think, no think) and the number

<center>48</center>

of cue presentations (0, 2, 10) during the TNT phase. The recall of targets for the cues

which are never presented in the TNT phase (in the 0 cue presentation condition) served

as a baseline. To investigate mood change influenced by positive substitution,

furthermore, post-VAS minus pre-VAS score was submitted to independent t-tests

between the MDD and HC groups, and between unaided and aided conditions. Finally,

the CFI score, a measurement of participants' level of cognitive flexibility, and its two

sub-scale scores were submitted to a zero order correlation to examine the relationship

between cognitive flexibility and influence of substitution on memory and mood.

Results

Recall

The ANOVA analysis revealed that there was significant interaction of instruction

(think, no think) with the number of cue presentations (0, 2, 10), Instruction × Repeat, F

$(2, 84) = 21.533$, $MSE= 2983.488$, $p< .001$, $\eta_P^2= .339$, such that the accuracy of words

recalled in the think and no think conditions depended on the number of cue presentations

in the TNT task. This interaction effect was modified by the substitution condition

(unaided, aided), Instruction × Repeat × Substitution, $F (2, 84) = 3.571$, $MSE= 494.712$,

$p< .05$, $\eta_P^2= .078$, and group (MDD, HC), Instruction × Repeat × Substitution × Group, F

$(2, 84) = 2.960$, $MSE= 410.171$, $p= .05$, $\eta_P^2= .066$. To understand these interactions,

further analyses were separately conducted based on the instruction given to participants

(think, no- think). First, in think condition, there was no group difference observed

(Figure 9).

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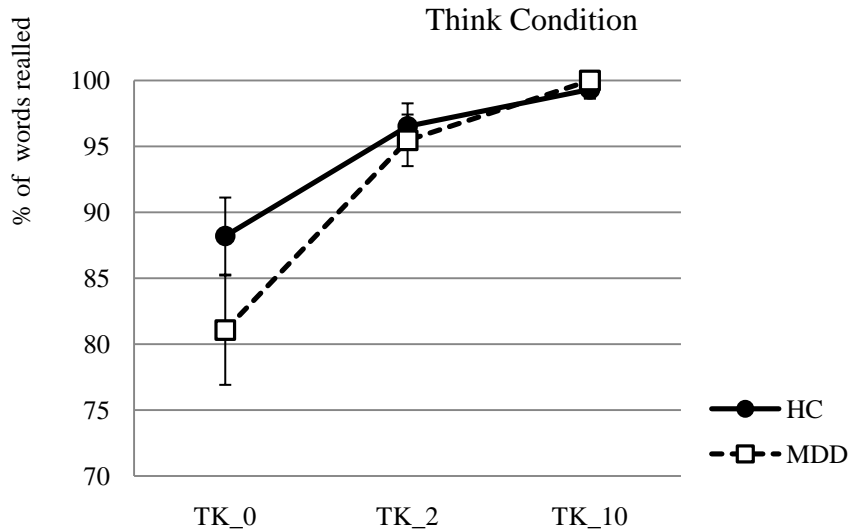
[Figure 9] Accuracy (%) of recall in Think condition

In no-think condition, however, a significant group difference was found when the accuracy of free recall was compared between unaided and aided conditions as a function of the number of cued presentations (0, 2, 10), Repeat × Substitution × Group, F (2, 84) = 4.539, MSE= 1043.100, p< .05, η_P^2= .098. When parsed, the HC group showed an interaction between substitution condition and number of presentations, Repeat × Substitution, F (2, 44) = 8.018, MSE= 1867.284, p< .01, η_P^2= .267. In the substitution condition, the HC group demonstrated significant quadratic trend, Repeat, F (1, 22) = 6.187, MSE= 92.593, p< .05, η_P^2= .220. As seen Figure 10, the HC group demonstrated training effects in the forgetting of negative targets in the aided conditions only when the positive substitutes were provided twice.
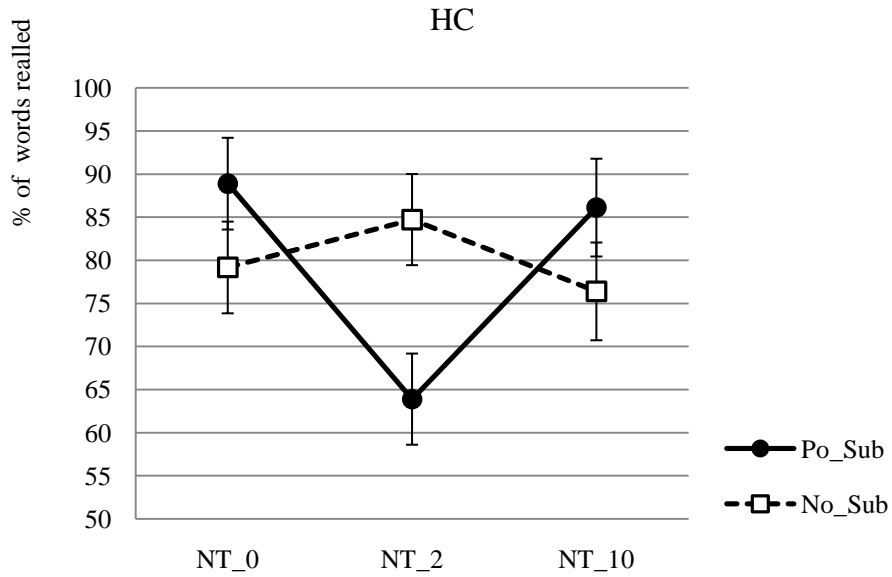
[Figure 10] Accuracy (%) of recall in No-Think condition in the HC group

In the MDD group, the linear trend across the number of cue presentations was significant in the positive substitution condition, $F (1, 20) = 4.587$, $MSE= 631.313$, $p > .05$, $\eta_P^2 = .187$. As seen in Figure 11, in particular, below-baseline forgetting was significant when positive substitutes were presented up to 10 times.
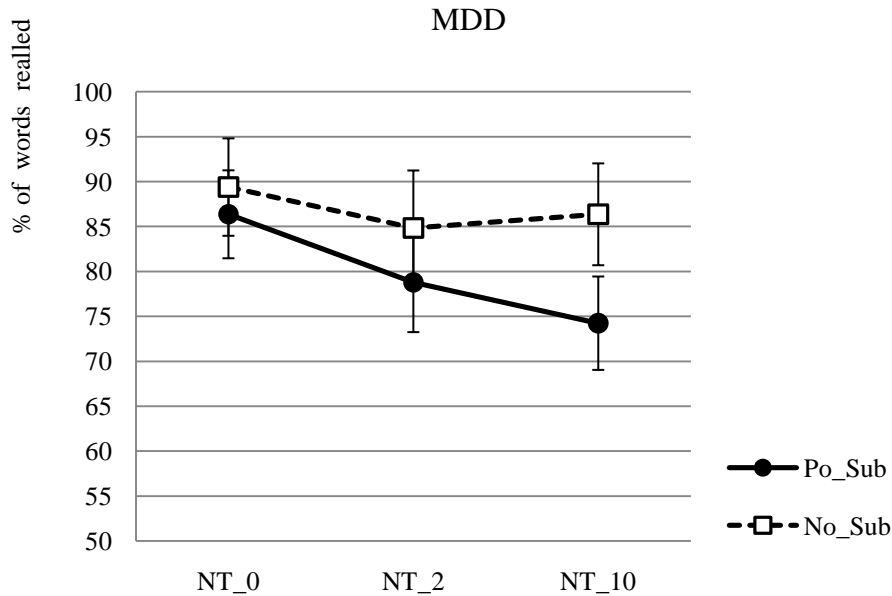
[Figure 11] Accuracy (%) of recall in No-Think condition in the MDD group

In both unaided and aided conditions, participants were asked to recall substitute word they used in TNT task (Table 4). There was no group differences found in the number of substitute words for both unaided (t (21) = -.256, p = n.s.) and aided conditions (t (21) = -.449, p = n.s).

	HC		MDD	
Condition	Unaided	Aided	Unaided	Aided
2	36.11(44.28)	88.89(19.24)	39.39(41.00)	90.91(17.26)
10	44.44(45.68)	98.61(4.81)	50.00(40.13)	100.00(0.00)
Total	40.28(44.07)	93.75(9.48)	44.69(44.69)	95.45(8.63)

[Table 4] Mean percentage (and standard deviations) of substitute words recalled

Mood Change

The pre- and post-task VAS scores are presented in Table 5. A zero order correlation revealed that the pre-task VAS score was significantly related to the total number of substitutes remembered in aided condition (r (23) = .554, $p < .01$). The below-baseline forgetting in aided condition (difference between baseline and twice cue presentations) was marginally correlated with the pre- and the post-VAS score for HCs (r (12) = .552, $p = .06$ for pre-VAS; r (12) = .546, $p = .06$ for post-VAS), but not for individuals with MDD. Consequently, the better HCs felt, the more they got benefit from positive substitutes to forget negative self-relevant information.

	HC		MDD	
	Unaided	Aided	Unaided	Aided
Pre_VAS	7.51(1.17)	7.47(1.78)	5.15(2.00)	5.46(1.81)
Post_VAS	7.25(1.20)	7.70(1.50)	5.40(1.52)	5.93(1.45)

[Table 5] Mean (and standard deviations) of VAS scores

Regarding the difference between unaided and aided conditions in the mean difference VAS scores (e.g. mood change; post-VAS minus pre-VAS), the HC group demonstrated marginally significant mood change followed by positive substitution (t (22) = -1.827, $p = .08$) compared to unaided condition. However, the MDD group showed no significant difference (Figure 12).
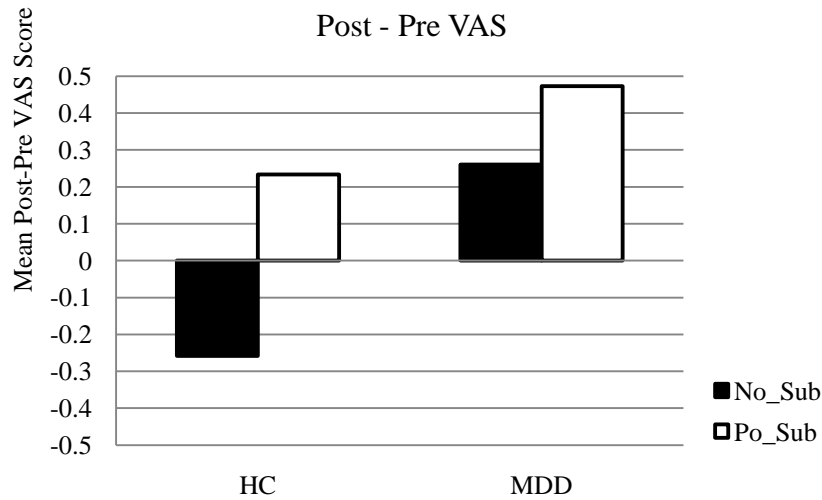
[Figure 12] Mean of difference scores (Post-VAS minus Pre-VAS)

Cognitive Flexibility

The HC and the MDD groups demonstrated significant differences in questionnaire scores including the CFI (Table 6). The first order correlation revealed that the CFI score was negatively correlated with the RRS score(r (45) = -.658, p < .001) and the BDI score (r (45) = -.492, p < .01). Within the MDD group, in particular, the correlation with alternative subscale of the CFI differed depending on types of rumination: reflection and brooding. The alternative subscale was positively related to reflection (r (21) = .470, p < .05), but was negatively related to brooding (r (21) = -.662, p < .01). In addition, the CFI score, especially the alternative subscale, was positively correlated with the number of substitutes participants recalled (r (45) = .345, p < .05 for the CFI total; r (45) = .414, p < .01 for alternative subscale).

	HC	MDD	Statistics	p
BDI	2.38(2.88)	26.55(8.67)	$F(1,44)= 166.594$	$< .001$
RRS	30.28(9.14)	56.09(10.36)	$F(1,44)= 43.328$	$< .001$
Reflection	7.29(2.34)	11.91(4.09)	$F(1,44)= 16.433$	$< .001$
Brooding	6.83(2.01)	11.23(6.58)	$F(1,44)= 23.431$	$< .001$
Depressive Symptoms	16.58(5.19)	35.41(12.56)	$F(1,44)= 45.741$	$< .001$
CFI	113.08(12.42)	92.90(17.97)	$F(1,43)= 19.591$	$< .001$
Alternative	72.83(9.73)	66.81(12.86)	$F(1,43)= 3.183$	$= .08$
Control	40.25(5.15)	26.10(8.80)	$F(1,43)= 44.625$	$< .001$

[Table 6] Mean (and standard deviations) of questionnaire scores

Discussion

In the present study, directed forgetting was compared between unaided and aided conditions for individuals with MDD and HCs. It may be the first exploration of the influence of positive substitution on forgetting utilizing self-related information generated by the participants. By simulating a standard CBT procedure, it was expected to extend Joormann and her colleague's (2009) findings to clinical applications. The results demonstrated that forgetting in the MDD group depended upon whether they are given substitutes. When individuals with MDD were provided positive substitutes, which replace the negative self-relevant information originally learned, they showed below-baseline forgetting. This result is consistent with the rationale of the CBT in which individuals with MDD are helped by being provided alternative perspectives. In particular, the linear trend of forgetting in function of number of cue presentations

suggested how important repeated exposure to substitution practice is. Therefore, offering MDD substitution in therapy should be help them reduce depressive memories but they need to be warned that they need to do this a repeated number of times to be successful.

For HCs, benefits of positive substitutes for forgetting negative self-relevant information was also observed, but only when the cue were provided twice in the TNT task. The negative correlation with VAS scores suggested that the better HCs felt, the less they remembered negative items. In addition, the positive correlation between mood states and the number of substitutes recalled was observed such that the better HCs felt, the more they remembered positive substitutes. These findings generally supported the controversial concept of mood-congruent memory (Bower, 1981) suggesting that individuals have enhanced memory for information that is concordant with their present mood state. In the present study, as a person was currently experiencing positive mood, the positive conceptual nodes seemed to be more readily accessed which resulted in enhanced memory of positive substitutes and increased baseline forgetting of negative self-relevant information.

When the substitute presentation increased up to 10 times, however, HCs recalled originally learned negative items as a baseline level. This result is different from Joormann et al.'s (2009) finding in which benefits from being provided with a strategy to forget negative material was increased in proportion to the number of substitute presentation. One possible explanation could be found in the characteristics of self-relevant information. Unlike materials used in Joorman's study, the stimuli in the present study were generated by participants themselves, which are closely inter-related. As a cue was repeatedly presented, not only the association between the cue and a

substitute was strengthened, but also an original target in relation to the cue seemed to be automatically activated due to their strong pre-existing association. For example, when a participant was instructed to inhibit 'cold' and instead to think about 'responsible' for the cue word 'mother,' the repetition of 'mother' may lead to not only an activation of 'responsible' but also an activation of 'cold' due a close relationship between 'mother' and 'cold.' This bounce effect of memory was observed only in the HC group because relatively high working memory capacity and positive memory bias of HCs allowed them to have enough cognitive resource to remember a positive substitute and a target at the same time for the cue presented.

The HC group demonstrated significant mood changes between the unaided and aided conditions. For the HCs, a positive mood induced by positive substitution seemed to buffer against negative mood (e.g. fatigue) induced by the task. However, enhanced forgetting of negative information did not lead to expected mood change in positive direction in individuals with MDD. Therefore, future study examining mediating factor which links decreased negative memory to adaptive mood change would be beneficial to development of treatment for MDD.

In addition, investigation on influence of cognitive flexibility on forgetting and mood change suggested that individuals with MDD with high alternative score show increased intentional pondering of one's mood with a focus on problem solving (e.g. reflection) and decreased passive and judgmental pondering of one's mood (e.g. brooding; Treynor et al., 2003). In addition, higher alternative scores seemed to be related to better processing of positive substitutes provided. This result suggested that among individuals with MDD, those who are less rigid and more flexible in shifting a course of

thought or action according to the changing demands of the situation (Lezak, 1995) are better at remembering positive substitutes which may result in enhanced suppression of negative self-relevant information.

The findings from the present study have clinical implications in light that they were designed to utilize self-relevant information, to explore individual differences in relation to intentional forgetting, and to simulate the CBT procedure. First of all, by presenting self-referent information, it was expected to access the deeper self-concept structure and as a result, to obtain personally meaningful findings with increased applicability to real-life settings. One concern about utilizing self-relevant stimuli though, was that it was hard to match all characteristics of word stimuli across the experiment conditions. Future study will get benefit from examining influences of other word characteristics than valence, such as frequency, arousal, and association to the cue. Another limitation raised in the use of self-relevant word stimuli was difficulty in control influence of episodic memory on the moment the participants generated the words on the semantic memory on the word list they studied. Although the TNT task was administered two weeks after word list generation, there was still a remaining question if TNT performance was affected from the episodic memory, and if so, how. Future study addressing this issue to differentiate semantic memory from episodic memory would be required to understand and apply findings from the present study properly.

As discussed above, furthermore, the present study examined cognitive flexibility as individual difference which influences intentional forgetting of negative self-relevant information. The finding would be important in that it may shed light on development of therapy which helps individuals with MDD to forget unwanted negative thoughts. The

CBT techniques which address cognitive distortions such as overgeneralization and/or all-or-nothing can be an effective way for individuals with MDD to enhance cognitive flexibility. Future research should investigate whether the treatment focuses on the individual's cognitive flexibility predicts actual recovery from stressful negative life events.

Finally, the present study has important clinical implications in that it extended application to naturalistically more valid settings by simulating CBT procedure in which individuals with MDD were provided positive self-generated substitutes to suppress negative self-relevant thoughts. However, there is still a remaining question on the underlying mechanisms of substitution. Therefore, further investigation would be required to clarify whether inhibitory (e.g. suppression of no-think item) or non-inhibitory (e.g. interference caused by substitution) forgetting is associated with thought substitution. ERP measurement during the TNT phase can be a way to examine those two different strategies in forgetting.

In conclusion, the present study examined the role of positive substitution in forgetting and mood change and related individual differences in individuals with MDD compared with HCs. The results showed that benefit of substitution in forgetting negative self-relevant thoughts. The importance of cognitive flexibility was emphasized as a mediating factor which may link stressful event and ruminative response style. The findings of the present study suggest a clinical approach which may help individuals with MDD to suppress unwanted thoughts.

Appendix 3: Life Categories

- Ethnicity
- Gender
- Grandparents
- Mother
- Father
- Sibling
- Son
- Daughter
- Friend
- Roommate
- Pet
- Dating
- Marriage
- Parenting
- Personality

- Religion
- Politics
- Sports
- Entertainment
- Hobby
- Party
- Study
- Work
- Community
- Home
- Childhood
- Future
- Creativity
- Spirituality
- Intelligence

- Mood
- Motivation
- Finance
- Health
- Appearance
- Exercise
- Travel
- Housekeeping
- Eating
- Sleeping
- Socializing

CHAPTER V

GENERAL DISCUSSION

The present studies aimed to investigate underlying mechanisms of forgetting in major depression utilizing the retrieval induced forgetting (RIF) task, event-related potential (ERP) investigation during directed forgetting (DF) task, and suppression training with Think/No-Think (TNT) task. Self-generated emotional words were used to elicit the deeper and more personally meaningful information processing. Through the studies, cognitive, psychophysiological, and emotional characteristics and individual differences (e.g. self-complexity, cognitive flexibility) involved in forgetting in major depression were examined in comparison with healthy control (HC). Importantly, the present studies were expected to shed light on the mechanisms underlying forgetting of self-relevant emotional information, mainly focused on (1) inhibitory vs. non-inhibitory processing and (2) negatively biased vs. even-handed processing.

Inhibitory vs. Non-inhibitory Processing. Inhibition can be described as a process in which to-be-forgotten (TBF) items are actively suppressed and consequently, are expunged from working memory (Hasher & Zacks, 1988; Zacks, Radvansky, & Hasher, 1996). Previous studies have demonstrated that deficient inhibition would fail to suppress unwanted thoughts and therefore lead to increased negative thoughts in depression. Another explanation on forgetting is non-inhibitory hypothesis including passive decay in encoding and associative blocking in retrieval. According to the passive decay

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interpretation, TBF items are forgotten since they are dropped from working memory processes and not elaborated or rehearsed (Lau et al., 2007). Associated blocking account suggests that a strengthened item has a retrieval advantage that leads to competition with and blocking of the recall of related traces (Raaijmakers & Shiffrin, 1981; Román et al., 2009).

Based on RIF and DF paradigms, the present studies provided supporting evidence of non-inhibitory processing, compared to inhibitory processing, as an explanation of forgetting in MDD. During the RIF task of Study 1, the MDD group demonstrated impairment in recall of self-relevant negative material that was not practiced, but competing with the practiced words. The finding that individuals with MDD, who have limited working memory capacity and dysfunctional cognitive control, showed more forgetting than HCs, suggest that the forgetting process was a result of passive non-inhibitory processing and not active inhibition. The positive relationship between distinctiveness of negative self-aspects and the number of negative words forgotten in Study 1 also supports non-inhibitory information processing, especially associative blocking. Therefore, because individuals with MDD have more overlap among self-concepts, this strong association seemed to increase competition between practiced and unpracticed, but related items and consequently blocked retrieval of unpracticed one. In Study 2, this non-inhibitory hypothesis was supported by the ERP findings during DF task. Specifically, lack of attentional allocation indexed by P300 and lack of elaborative/rehearsal processing indexed by slow wave in individuals with MDD, compared to HCs, may provide evidence of passive nature of forgetting (e.g. passive decay) in depression.

Biased vs. Even-handed Processing. Another question addressed through the present studies was whether dysfunctional forgetting in major depression is valence-specific. By utilizing positive and negative word stimuli, the present studies examined biases in self-evaluation, encoding and retrieval in individuals with MDD compared with HCs. First of all, previous studies suggest that HCs are characterized by positive biases (Taylor & Brown, 1988). For example, healthy controls recall more positive than negative stimuli, and make more positive than negative self-evaluation (Baumeister, Tice, & Hutton, 1989; Matt, Vazquez, & Campbell, 1991). The results of present studies also evidenced positive bias in HCs in that they rated self-descriptions positively (Study 1); elaborated and rehearsed positive words in encoding (Study 2); and recalled more positive words compared to negative words in retrieval (Study 2).

Contrary to the HCs, there has been controversy between preferential processing of negative material and even-handed processing in MDD. Consistent with Beck's cognitive model (Beck, 1967) which emphasizes negative cognition and biased information processing in the development, maintenance, and recurrence of MDD, there has been substantial evidence suggesting that individuals with MDD tend to engage in depressogenic thinking including negative biases in memory and self-evaluation (Bradley & Mathews, 1983; Mathews & Bradley, 1983; Matt, Vazquez, & Campbell, 1991). However, there also have been studies contradicting such findings, especially suggesting that depression can be characterized as even-handed processing or lack of positive biases or illusion (Deldin et al., 2001; Rottenberg, Gross, & Gotlib, 2005; Sloan et al., 1997).

Through behavioral and ERP investigation, the present studies supported even-handed processing rather than negative biases in MDD. In Study 2, individuals with

MDD did not show any difference in recall for negative and positive items. EPR results also showed that individuals with MDD did not differentiate remembering and forgetting processes valence-specifically in early stage of information processing. There was no differentiation observed in elaborative/rehearsal processing of positive and negative self-relevant to-be-remembered and to-be-forgotten items.

In summary, the present studies supported non-inhibitory and even-handed information processing in forgetting of self-relevant information in MDD. This result leads to a further question on the distinction between inhibitory and non-inhibitory processing, and the distinction between negative bias and even-handed (or attenuated positive bias): which mediating factor is involved in those differential processing? As a possible explanation, the common characteristics of the present three studies - the use of self-relevant material – can be considered. According to the dual-process model, there are two components of information processing: associative processing (e.g. automatic, implicit) and reflective processing (e.g. controlled, explicit, motivated; see Beevers, 2005 for review). Given that associative processing is based on associations in memory that have been formed with repeated experience (Smith & DeCoster, 2000), the self-relevant words participants themselves generated based on their life experience also seemed to elicit this associative processing. Therefore, the observed non-inhibitory processing in forgetting in MDD can be understood in the context of the associative processing embedded in the nature of self-relevant stimuli. Furthermore, attenuated positive bias also can be explained by this lack of controlled and intentional processing motivated to enhance positive mood. In contrast, HCs who have relatively enough cognitive capacity would employ the associative process and reflective processing simultaneously, and this

dual processing seemed result in positive memory bias (motivated to maintain positive mood), enhanced attentional resource allocation, and increased elaboration and rehearsal. Therefore, future investigation which clarifies the role of self-relevance in cognitive control and biases by directly comparing with normed or other-relevant stimuli would be required.

The present studies have clinical implication since they were designed to explore individual differences in relation to intentional forgetting, and to simulate the CBT procedure. Investigation of self-complexity (Study 1) and cognitive flexibility (Study 3) as individual differences suggested that organization of self-representation plays a critical role in forgetting of unwanted thoughts. Therefore, the development of treatment techniques which help individuals with MDD to think about various aspects of the self and life experience, to differentiate their generalized and broad negative self-descriptions, and to generate alternate perspectives in problem solving will be effective to forget unwanted negative thoughts. Future research should investigate whether the treatment focuses on the individual's self-complexity and cognitive flexibility predicts recovery from depression.

Through simulation of CBT procedure in Study 3, the importance of constant and repeated practice of substitution to forget unwanted thoughts was emphasized. Considering decreased memory of negative information by substitution was not followed by mood change in positive direction in the present study, future research examining mediating factor which links decreased negative memory to adaptive mood change would be beneficial to development of treatment for major depression.

In conclusion, present studies examined various cognitive, psychophysiological,

and emotional characteristics involved in forgetting of self-relevant valenced material. As underlying mechanisms of forgetting in major depression, non-inhibitory and even-handed processing was suggested. Through a better understanding of the information processing and individual differences in forgetting, it is hoped to develop clinical approach which addresses difficulties in suppressing unwanted negative thoughts in major depression.

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