

Neurocognitive Effects of Resolving Interference for
People Suffering from Bipolar Disorder
by
Maria E. Tecos

A Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of Bachelor of Sciences
With Honors in Neuroscience from the
University of Michigan
2011

Advisors: Dr. Marc Berman & Dr. John Jonides

Abstract

This study examines the ability to overcome interference from negatively and positively valenced words in short-term memory (STM) and how these abilities relate to self-distancing for people suffering from bipolar depression (BPD). People with BPD who also had a current psychosis (BPP) were compared to those without psychoses (BPN), and both groups were compared to age-matched control participants (HC). Theoretically, individuals who are better at distancing should exhibit less rumination, and have less difficulty overcoming interference from negatively information (Berman, Nee, Casement, Kim, Deldin, Kross, Gonzalez, Demiralp, Gotlib, Hamilton, Joorman, Waugh, & Jonides, 2010; Joormann, Nee, Berman, Jonides, & Gotlib, 2010). These results hold true for patients with Major Depressive Disorder (Berman et al., 2010). However, BPD is a polarized depressive disorder during which patients also experience periods of mania. Because of this, we hypothesized that similar, but oppositely valenced effects (to MDDs) would be found for the analysis of BPP subjects: BPP subjects would have greater suppression of positively valenced stimuli in their short-term memory.

Neurocognitive Effects of Resolving Interference for
People Suffering from Bipolar Disorder

Self-distancing refers to adaptive self-reflection where one looks at the past from a self-distanced third party perspective rather than an immersed first person perspective. Such self-distancing has been found to reduce adverse symptoms related to thinking about a negative event (Kross, Adyuk, & Mischel, 2005). Paired with the ideas presented for self-distancing in MDDs, we expected to find BPPs self-distancing less when presented with positive stimuli. Through the analysis of the EEG neural signals of said distancing, and suppression values gleaned from behavioral tasks, we have begun to uncover the neural mechanisms that underlie overcoming positively valenced interference in the STM of BPP subjects.

BPD, as defined by the Diagnostic and Statistical Manual-v-4, is a depressive mood disorder, marked by quickly interchanging episodes of mania and depression. Major Depressive Disorder (MDD) is another depressive disorder that is shown to have high levels of rumination. Rumination is defined as the inability to control negative thoughts about one's depressive symptoms. Rumination can interfere with concentration and the completion of daily activities (Nolen-Hoeksema, 2000). However, it is more than a symptom of depression: it acts to uphold and aggravate depressive symptoms. Additionally, it predicts the probability of recurrence of depressive episodes (Nolen-Hoeksema, 2000; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Individuals who are better at distancing should exhibit less rumination, and have less difficulty overcoming interference from negatively valenced information (Berman et al., 2010; Joormann, Nee, Berman, Jonides, & Gotlib, 2010).

While these findings are at the oppositely valenced ends of the emotional spectrum, they still hold relevance. In essence, the effect we expected was analogous to a positive counterpart of

rumination, which is sometimes referred to as “savoring” (Bryant, 1989). Savoring is considered a cognitive mechanism of emotional regulation through which a person may extend and maintain their positive emotional experiences (Bryant, 1989; Tugade & Fredrickson, 2007). Thus, we were interested in the effects of our hypothesized inability of BPPs to remove positive information from their STM. According to the findings of Stein, Roizen, and Leventhal (1999), BPD and attention deficit hyperactivity disorder have historically been misdiagnosed, and share many similar symptoms, including lack of attention and acting out. Theoretically then, individuals who are better at distancing should exhibit less STM interference from positively valenced information. Further research could then be completed to assess if this diminished interference correlates with greater attention. By further uncovering the neural bases of rumination and savoring, its positive counterpart, a better understanding of the etiology and maintenance of depressive disorders can be obtained.

Cognitive Processes of Rumination

While rumination was not assessed for the participants of this study, it is important to have a well-rounded understanding of the factors influencing depressive disorders. It is especially important to have a good understanding of the cognitive processes of rumination, since our findings give evidence of the need for investigation related to a positive counterpart of rumination, savoring. Joormann and Gotlib (2008) and Joormann, Nee, Berman, Jonides, and Gotlib (2010) posited a mechanism for the process of rumination that involves a deficit in the ability to control the contents of one’s short-term memory. Rumination is also posited to mediate the relationship between anxiety and suicidal ideation in BPDs (Simon, Pollack, Ostacher, Zalta, Chow, Fischmann, Demopolous, Nierenberg, & Otto 2007). The results of Berman et al. (2010) showed that an inability to remove negative information from short-term memory was related to

rumination. We suspect that BPP (but not BPN) subjects will have a similar effect, for oppositely valenced (positive) stimuli.

Much past research has considered the cognitive and neural mechanisms at work in STM when resolving interference (Berman et al., 2010; Berman, Jonides, & Lewis, 2009; D'Esposito, Postle, Jonides, & Smith, 1999; Jonides, Smith, Marshuetz, Koeppel, & Reuter-Lorenz, 1998; Nee, Jonides, & Berman, 2007; Nelson, Reuter-Lorenz, Sylvester, Jonides, & Smith, 2003; Oztzekin & McElree, 2007; Thompson-Schill, D'Esposito, Aguirre, & Farah, 1997). While it was found that an impaired ability to remove negative information from STM (after it enters) is associated with depression (Joormann & Gotlib, 2008; Joormann, Nee, Berman, Jonides, & Gotlib, 2010; Whitmer & Banich, 2007), Berman (2010) delved into the neural basis of the relationship between the two. They found that "MDD participants had more difficulty than did HCs expelling negative, but not positive, words from STM. Overall, the neural networks involved in directed forgetting were similar for both groups, but the MDDs exhibited more spatial variability in activation in the left inferior frontal gyrus (a region critical for inhibiting irrelevant information), which may mediate their relative inability to inhibit negative information" (Berman et al. 2010). This study aims to explore whether or not the same types of relations (but instead for positively valenced stimuli) found between MDD and STM hold true for BPD and STM.

Overview of Present Research

This study is an extension of a previous study, Berman et al. (2010), in order to assess if the findings for MDDs translate to BPDs. In order to accomplish this, a directed-forgetting task was used. This task functions as an assessment of interference resolution of affectively valenced stimuli in STM (Nee, Jonides & Berman, 2007; Zhang, Leung, & Johnson, 2003). During the

task, participants are instructed to forget specific STM-encoded stimuli; positively and negatively valenced words (Joormann & Gotlib, 2008; Joormann, Nee, Berman, Jonides, & Gotlib, 2010). We hypothesize that the suppression of positively valenced stimuli will be greater for BPP subjects than for both BPN and HC subjects. We do not believe that BPN and HC participants will exhibit differing results for the suppression of positively and negatively valenced information.

Currently, the Kross Laboratory at the University of Michigan is also doing research in the area of BPD. This laboratory investigated the regulation of emotions that were overwhelmingly positive in bipolar patients. Experimenters accomplished this by assessing the relationship between self-distancing and relative left frontal cortical activity. We hypothesized that our suppression results would relate to the neurological activity measured via EEG while participants were asked to complete a distancing task. The effects of self-distancing, as reported by Adyuk and Kross (2010) and Kross (2009) are illustrated in Table 1. Past studies have shown a smaller number of physiological and psychological symptoms associated with manic states (Gruber, Culver, Johnson, Nam, Keller, & Ketter, 2009). Based on this information, the investigators hypothesized that bipolar patients would spontaneously immerse more (thereby distancing less) into experiences involving positive emotions.

Their second hypothesis was centered around the neural signature of self-distancing, investigated by assessing frontal EEG asymmetry in the left and right hemispheres. This asymmetry is reflective of a person's tendency to engage or approach a stimulus (Coan & Allen, 2004). According to the investigators, bipolar patients should show greater left frontal cortical activity, relative to right frontal cortical activity. The researchers concluded that bipolar patients exhibiting psychosis self-distance less, and show greater neurophysiological activity. Our goal

was to explore whether BPP subjects had more difficulty in removing positive information from their STM compared to BPN and HC participants. Furthermore, we attempted to relate interference resolution abilities to self-distancing, both neurologically and behaviorally.

Method

Participants and Measures

Forty-seven adults (seventeen males and thirty females) were the subjects of this study. The mean age of the males was 37.18 years. The mean age of the females was 38.33 years. Forty-three total participants met the criteria for bipolar disorder. Sixteen of these were bipolar with no psychosis; twenty-seven exhibited psychosis. BPD was assessed via the Structured Clinical Interview (SCID, which was further confirmed by a second independent interviewer), and had no history of Axis I disorders. Twenty total healthy control Thirty-six participants met the criteria for bipolar disorder. Slightly different numbers of subjects were used in each analysis, based on the information of task order recorded for each subject. Two types of task order were assessed: whether behavioral tasks were first and ERP tasks second, and the specific order of the four behavioral tasks the subjects underwent. Table 2 displays the specific information regarding the number of subjects included in analyses of general task order (behavioral, then distancing or distancing, then behavioral). Table 3 displays the specific information regarding the number of subjects and other descriptive information included in the accuracy analyses of suppression and subject group.

Materials and Procedures

Jonides laboratory task. For this experiment, the subjects focused on a computer screen. The screen displayed four words, three in blue and three in red. The subjects were told to remember all six of the words displayed to them, thereby encoding them in their short-term

memory. Next, a colored square patch was shown to the participants, after a four-second delay. The patch was either red or blue. The participants were instructed to forget the words that were the same color as the patch that was displayed, and to remember the words that were in the other color. Thus, they were only to remember three of the six words that were displayed. Then, the participants experienced a predetermined cue-to-stimulus (CSI) interval that lasted for four seconds. After the CSI, a probe word was shown to the subjects. If the probe word was one of the words that the subjects were supposed to remember, they were to press a key indicating “yes.” If the probe word was one of the words that the subjects were supposed to forget, they were to press a key indicating “no.” The time between trials was deemed the inter-trial-interval (ITI), and was also fixed, at two seconds. Figure 1 shows a schematic of the task.

Subjects encountered two different types of “no” trials while they were completing the task. The first type of “no” trial was a “control” probe; these probes were comprised of words not seen for an average of over 100 trials. The second type of “no” trial was called a “lure” probe. “Lure” probes drew from a pool of words that included only items that the participants had been instructed to forget in their current trial. Nee, Jonides, and Berman (2007) and Zhang, Leung, and Johnson (2003) both found that lure trials throw off subjects, making them slower to respond, and more apt to respond erroneously. The difference between the “control” probes and the “lure” probes gives a measure of “suppression.” The “suppression” refers to the ability of the subjects to manage the information in their short-term memory, thereby providing information of how well each participant is able to resolve interference. Because this task is centered on positively and negatively valenced items, measured of both positive and negative suppression were generated. Our hypothesis was that BPP subjects (not HC, nor BPN), would be the only

participants to find saying “no” to a positive lure significantly more difficult than saying “no” to a negatively valenced lure. This can be assessed either via reaction time or task accuracy.

Before the actual task began, had the opportunity to undergo a practice session. During the session, they completed thirty-two trials of the task. However, these trials did not use the same words that appeared in the legitimate task. All of the words in this experiment were chosen from the Affective Norms of English Words (ANEW; Bradley & Lang, 1999). The words were chosen specifically for their apparent positivity and negativity. This was to ensure that the subject would view each word as having either a positive or negative valence. Negative words were assessed to have an average ANEW valence of 3.15; positive words had an average ANEW valence of 7.21. The words of both valences were balanced for arousal and frequency. After the participants completed the task, they were instructed to rate the positivity and negativity (the valence) of each of the words used in the study. This information will be used in both future behavioral and neural analyses, in order to more accurately determine the effect of affective valence.

The entire task was composed of the following, totaling 192 trials: forty-eight lure trials (half positive, half negative), forty-eight control trials (half positive, half negative), ninety-six yes trials (half positive, half negative). The experiment was run twelve times for each subject, in two sessions of six trials per session. Figure 1 shows a schematic of the task. Each session took about 1.25 hours. Then, the second session of the task was administered. The purpose of separating the experiment into two sessions was to avoid any possible fatigue that might be encountered during 2.5 total hours of testing. Following the completion of the second session, the participants were given three minutes during which they were instructed to reproduce as many words as possible that they encountered during the experiment. Then, they rated these

words on a scale from one to seven on their apparent positivity or negativity; “one” indicated a word that the subjects thought was very negative, and “seven” indicated a word that the subjects thought was very positive.

Kross laboratory task. Our associates’ study included a positive memory reflection task. A schematic of that task is shown in Figure 1. A baseline value was collected with a resting EEG, for a total of six minutes. For three of those six minutes, the participants had their eyes open. For the other three of those six minutes, the participants had their eyes closed. Following this measure, the participants were asked to recall and visualize and experience from their past that they considered to be a time of great happiness. This visualization lasted for an average of forty seconds. After this stage was completed, the participants were asked to reflect on their chosen experiences. They were asked to think on why they had those specific feelings, as well as the underlying reasons for and causation of those feelings. This reflective portion of the task spanned three minutes.

A person with bipolar disorder including psychosis was defined as someone having severe symptoms like hallucinations, motor abnormalities (Winokur, 1984), and a greater number of mood episodes (Miklowitz, 1992; Tohen, Strakowski, Zarate, Hennen, Stoll, Suppes, Faedda, Cohen, Gebre &, Baldessarini, 2000). The participants were also asked how they perceived themselves in relation to their positive memories. They rated the experience on a scale of one to seven. A score of one was given by patients who were immersed participants in their memories, and a score of seven was given by participants who were distanced observers of their positive experiences. We then correlated our findings with the experiment of Kross Laboratory .

Analysis

Behavioral analysis. We have considered several factors that could potentially alter or confound the results garnered from our experiment. The investigation of these factors should be the subject of future research. Firstly, the degree to which each patient was manic or depressive might have some effect on his or her task performance. This could be resolved as the analysis of this study progresses, by examining how each participant rated the valenced words.

Another factor that we thought might have an impact on the validity of our results was the task order. Not all of the possible combinations of task orders were used when subjects were participating in the study. While we found the relationship between suppression and task order to have a trend, it was statistically insignificant. The p of this relationship was .061.

Distancing analysis. In order to further investigate the relevance and applicability of our results, we paired them with the results of a study on bipolar people in the Kross laboratory. This study found that bipolar patients exhibiting psychosis self-distanced less, and showed greater neurophysiological activity. One of our main findings was a high level of suppression of positive information in BPP subjects. That is, BPP subjects had a harder time removing positive information from their short-term memories than the other subjects did. This agrees with the findings of the Kross laboratory, since BPPs were found to immerse in positive memories, and have greater EEG response showing activity in the left frontal cortex.

In the analysis of this study, baseline values were controlled for as a possible confounding variable, since the values of baseline activity differed so greatly with each subject. The final conclusions of the study centered around the idea the BPN and BPP patients cannot be considered, and more importantly, treated as if they are equals. Prior research has focused on the severity of clinical syndromes, and genetic evidence for BPP and BPN patients. The current

study measured brain activity and self-reported self-distancing. A connection between our study and the study underway in the Kross laboratory could prove to be revolutionary in the assessment of people with BPD, in particular, those who classify as BPPs. We hypothesized that our findings (greater positive suppression for psychotic bipolar subjects) would correlate with the findings of the Kross laboratory (greater positive reflection in psychotic bipolar subjects).

Thus far, we have not been able to determine an overall correlation between positive suppression and reflection on positive memories, nor have we been able to obtain data suggesting a specific correlation between positive suppression and BPP subjects. We have also been unable to secure an overall correlation between positive suppression and self-distancing, and a specific BPP correlation for positive suppression and self-distancing.

Results

Behavioral Results

The tests of within-subjects effects table summarizes several of the key findings of this study. Firstly, when positive and negative suppression were compared, a trend was found ($p = .088$), supporting our hypothesis that positive suppression created more interference in STM. This is shown in Figure 3.

A significant difference was found when the relationship between suppression and subject group was evaluated. The p for this relationship was .047. This is shown in Figure 4. The words after the hyphen in the legend describe when the participants experienced their psychoses. As it is displayed, one can see that HC, BPN, and BPP-depression subjects all had higher values of negative suppression than positive suppression. One can also see that BPP-mania, depression and mania, and uncertain, all had higher suppression for positively valenced items. The subject who claimed he or she was “uncertain” of the timing of his or her psychoses likely experienced

them during both depression and mania. BPP subjects whose psychoses were during depression having greater negative suppression is in accordance with Berman et al. (2010).

A third comparison was made between suppression and task order. The p for this relationship indicated a trend, at .061. As previously explained, suppression of positive stimuli was greater than suppression of negative stimuli. This is shown in Figure 5. A trend ($p = .12$) was found between HC and BPP subjects (task accuracy > 50%) in the portion of the task assessing suppression of positive items. No other trend or significant differences were found. If more strict accuracy parameters were employed, it is likely that a significant relationship may have been found. It is also possible that with more subjects, a truly significant relationship would have been found.

When all of the above mentioned variables were compared together with suppression, no trend or significance was found ($p = .427$). Figures 3-5 shows graphical representations of these relationships and findings. All of the above statistics (save those related to Figure 6) can be found in Table 4. The R^2 value for this study was .375. That is to say, 37.5% of the variance in this study was accounted for by our findings.

Distancing Results

HC participants had the highest values of baseline activity, followed by BPNs, and finally BPPs. A significant difference ($p < .05$) was found between BPPs and BPNs for reflection values. That is, BPP subjects had significantly more left frontal cortical activity while reflecting on their positive memories. This is illustrated in Figure 7, a graph of frontal EEG asymmetry. Psychotic bipolar subjects were also the only participants with a significant distancing effect (see Figure 8). That is to say, BPPs self-distanced significantly less than HCs and BPNs; thus, they immersed themselves more in their recollections of their positive memories. When a regression analysis

was run between self-distancing and relative left-frontal cortical activity, a significant ($p < .05$) r value was found, equal to .306 (see Figure 9). This regression analysis measures the strength of the relationship between self-distancing and left frontal cortical activity, relative to right frontal cortical activity. The correlative effects of positive suppression and positive memory reflection are displayed in Table 5.

Discussion

Our main finding was that bipolar patients who exhibit episodes of psychosis—except when those episodes of psychosis only coincide with times of depression—have difficulty that is significantly different in removing positively valenced stimuli from their short-term memories, as compared to bipolar patients who do not exhibit psychosis, and healthy control subjects. This agrees with past research identifying savoring (a person's mental fixation on positive stimuli) as a cognitive mechanism by which positive experiences are maintained and extended; a mechanism that can further be used to regulate emotions (Bryant, 1989).

The Kross and Jonides Laboratories have individually produced experimental evidence that supports the notion of savoring as a significant neural mechanism directing the cognitive processes of BPP subjects. Although the data of the two laboratories did not correlate in this study, there is still much possibility that positive suppression and self-distancing are intimately related. One reason why the two sets of data did not correlate could be the simple fact that the subjects were not performing the same tasks, or even the same types of tasks in each study. During the behavioral task, the subjects were asked to perform a new activity; however, during the distancing task, the subjects were asked to recall a positive experience that had already happened to them. While both tasks assessed positively valenced stimuli, their respective active and passive natures may employ completely different cognitive processes. An additional study

gathering EEG data while performing the behavioral task would be most beneficial in resolving this discrepancy. Another source of error could have originated in the exclusion of a subset of subjects for which both laboratories had unusable data.

Now that these relationships (and potential relationships) have been identified, important questions can be investigated more efficiently. Several areas of future research may include the further identification of the neural processes underlying rumination and savoring (and the differences between them), assessing a correlation between savoring in BPD and ADHD, and extending this study further, to other depressive mental illnesses, such as dysthymia or seasonal affective disorder.

In conclusion, the diminished ability of BPP subjects to resolve positive interference in the STM is likely related to their tendency to immerse themselves in the savoring of positive stimuli. At this point, it is unclear if the inability to remove this positively valenced information from the STM is the cause of the savoring, or if the savoring is the cause of the inhibition of positively valenced stimuli removal in the STM. Furthermore, the significantly decreased relative activation of the left frontal cortex provides evidence for the hypothesis that BPP subjects have difficulty in self-distancing from positively valenced materials, which could itself feed the cycle of continued savoring and increased inability to suppress of positively valenced stimuli.

References

- Adyuk, O., Kross, E. (2010). From a distance: implications of spontaneous self-distancing for adaptive self-reflection. *Journal of Personality and Social Psychology*. 98(5), 809-29.
- American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (Revised 4th ed.). Washington, DC: American Psychiatric Association.
- Berman, M. G., Jonides, J., & Lewis, R. L. (2009). In search of decay in verbal STM. *Journal of Experimental Psychology-Learning Memory and Cognition*, 35(2), 317-333.
- Berman, M. G., Nee, D. E., Casement, M., Kim, H. S., Deldin, P., Kross, P., Gonzalez, R., Demiralp, E., Gotlib, I. H., Hamilton, P., Joorman, J., Waugh, C., & Jonides, J. (2010). Neural and Behavioral Effects of Interference Resolution in Depression and Rumination. *Cognitive, Affective and Behavioral Neuroscience*. DOI: 10.3758/s13415-010-0014-x.
- Bradley, M. M., & Lang, P. J. (1999). *Affective Norms for English Words(ANEW): Technical manual and affective ratings*. Gainesville, FL: The Center for Research in Psychophysiology.
- Bryant, F. B. (1989). A four-factor model of perceived control: Avoiding, coping, obtaining, and savoring, *Journal of Personality* 57, 773-797.
- Coan, J. A., Allen, J. J. (2004). Frontal EEG asymmetry as a moderator and mediator of emotion. *Biological Psychology*. 67(1-2), 7-49.
- D'Esposito, M., Postle, B. R., Jonides, J., & Smith, E. E. (1999). The neural substrate and temporal dynamics of interference effects in working memory as revealed by event-related functional MRI. *Proceedings of the National Academy of Sciences of the United States of America*, 96(13), 7514-7519.

- Gruber, J., Culver, J. L., Johnson, S. L., Nam, J. Y., Keller, K. L., & Ketter, T. A. (2009). Do positive emotions predict symptomatic change in bipolar disorder? *Bipolar Disorders*, 11(3), 330-6.
- Jonides, J., Smith, E. E., Marshuetz, C., Koeppel, R. A., & Reuter-Lorenz, P. A. (1998). Inhibiting in verbal working memory revealed by brain activation. *Proceedings of the National Academy of Sciences in the United States of America*, 95(14), 8410-3.
- Joormann, J., & Gotlib, I. H. (2008). Updating the contents of working memory in depression: Interference from irrelevant negative material. *Journal of Abnormal Psychology*, 117(1), 182-192.
- Joormann, J., Nee, D. E., Berman, M. G., Jonides, J. and Gotlib, I. (2010). Interference Resolution in Major Depression. *Cognitive, Affective and Behavioral Neuroscience* 10(1): 21-33.
- Kross, E. (2009). When the self becomes other: toward an integrative understanding of the processes distinguishing adaptive self-reflection from rumination. *Annals of the New York Academy of Sciences*, 1167, 35-40.
- Kross, E., Ayduk, O., Mischel, W. (2005). When asking “why“ does not hurt. Distinguishing reflective processing of negative emotions. *Psychological Science*, 16(9), 709-15.
- Miklowitz, D. J. (1992). Longitudinal outcome and medication noncompliance among manic patients with and without mood-incongruent psychotic features. *The journal of nervous and mental disease*, 180(11), 703-11.
- Nee, D. E., Jonides, J., & Berman, M. G. (2007). Neural mechanisms of proactive interference-resolution. *NeuroImage*, 38, 740-751.

Nelson, J. K., Reuter-Lorenz, P. A., Sylvester, C. Y. C., Jonides, J., & Smith, E. E. (2003).

Dissociable neural mechanisms underlying response-based and familiarity-based conflict in working memory. *Proceedings of the National Academy of Sciences of the United States of America*. 100(19), 11171-11175.

Nolen-Hoeksema, S. (2000). The role of rumination in depressive disorders and mixed anxiety/depressive symptoms. *Journal of Abnormal Psychology*. 109(3), 504-511.

Nolen-Hoeksema, S., Wisco, B. E., & Lyubomirsky, S. (2008). Rethinking rumination. *Perspectives on Psychological Science*. 3(5), 400-424.

Öztekın, I., & McElree, B. (2010). Relationship between working memory capacity measures and the timecourse of short-term memory retrieval and interference resolution. *Journal of Experimental Psychology: 2 Learning, Memory, and Cognition*. 36, 383-397.

Simon, N. M., Pollack, M. H., Ostacher, M. J., Zalta, A. K., Chow, C. W., Fischmann, D., Demopulous, C. M., Nierenberg, A. A., & Otto, M. W. (2007). Understanding the link between anxiety symptoms and suicidal ideation and behaviors in outpatients with bipolar disorder. *Journal of Affective Disorders*. 97(1-3): 91-99.

Stein, M. A., Roizen, N. M., & Leventhal, B. L. (1999). Bipolar disorder and ADHD. *Journal of the American Academy of Child and Adolescent Psychiatry*. 38, 1208–1209.

Thompson-Schill, S. L., D'Esposito, M., Aguirre, G. K., & Farah, M. J. (1997). Role of left inferior prefrontal cortex in retrieval of semantic knowledge: A reevaluation. *Proceedings of the National Academy of Sciences of the United States of America*. 94(26), 14792-14797.

Tohen, M., Strakowski, S. M., Zarate, C., Hennen, J., Stoll, A. L., Suppes, T., Faedda, G. L., Cohen, B. M., Gebre-Medhin, P., Baldessarini, R. J. (2000). The McLean-Harvard first-

episode project: 6-month symptomatic and functional outcome in affective and nonaffective psychosis. *Biological Psychiatry*. 15,48(6), 467-76.

Tugade, M. M., & Fredrickson, B. L. (2007). Regulation of positive emotions: Emotion regulation strategies that promote resilience. *Journal of Happiness Studies*. 8(3), 311–333.

Whitmer, A. J., & Banich, M. T. (2007). Inhibition versus switching deficits in different forms of rumination. *Psychological Science*. 18(6), 546-553.

Winokur, G. (1984). Psychosis in bipolar and unipolar affective illness with special reference to schizo-affective disorder. *The British Journal of Psychiatry*. 13(1), 13-8.

Zhang, J. X., Leung, H. C., & Johnson, M. K. (2003). Frontal activations associated with accessing and evaluating information in working memory: An fMRI study. *NeuroImage*, 20(3), 1531-1539.

Author Note

Maria E. Tecos, Department of Psychology, University of Michigan, Ann Arbor.

I would like to thank the following individuals for their continued assistance on this project: Lisa O'Donnell, Jiyoun Park, Dr. Patricia Deldin, and Dr. Ethan Kross. I would also like to express my appreciation to Dr. John Jonides for the opportunity to do research in his laboratory. To Dr. Marc Berman, my mentor, I am so grateful for the continual support and guidance. Working with him has truly been a pleasure.

Table 1

Effects of self-distanced and self-immersed reflection in the short and long-term

| | Short-Term | Long-Term |
|---------------------------|---|------------|
| Self-Immersed Reflection | Greatly increased emotional and physiological reactivity | Vulnerable |
| Self-Distanced Reflection | Slightly increased emotional and physiological reactivity | Buffered |

Note. The effects of self-distancing, according to the research of Adyuk and Kross (2010), and Kross (2009). During short-term self-immersed reflection, subjects' emotional and physiological reactivity is greatly increased. During long-term self-immersed reflection, subjects are more emotionally vulnerable. During short-term self-distanced reflection, subjects' emotional and physiological reactivity is slightly increased. During long-term self-distanced reflection, subjects are more emotionally buffered.

Table 2

Number of subjects included in analysis of general task order

| | Behavioral First | Distancing First |
|-----|------------------|------------------|
| HC | 6 | 5 |
| BPP | 11 | 12 |
| BPN | 12 | 1* |

Note. For the analysis of suppression and general task order, 6 HC, 11 BPP, and 12 BPN subjects had the behavioral tasks first, and distancing task second; 5 HC, 12 BPP, and 1 BPN subjects had the distancing task first, and the behavioral tasks second. *Only one participant was run in this order, and as a result, statistical analysis was limited.

Table 3

Descriptive information of subjects included in analysis of suppression and subject group

| | # Subjects | # Males | # Females | Average Age | Parental Education | Onset Age | Suicidal History |
|-----|------------|---------|-----------|-------------|--------------------|-----------|------------------|
| HC | 12 | 6 | 6 | 36.58 | 16.08 | | |
| BPP | 12 | 4 | 8 | 40.33 | 15.91 | 17.17 | 2.58 |
| BPN | 10 | 3 | 7 | 41.1 | 15.4 | 14.4 | 2.7 |

Note. This table reports descriptive information the subjects included in the analysis of suppression and subject group. 12 HC (6 male, 6 female), 12 BPP (4 male, 8 female), and 10 BPN (3 male, 7 female) subjects were included in this analysis. The average age for each subject group was 36.58, 40.33, and 41.1 years of age for HC, BPP, and BPN, respectively. Parental education was measured in years, as was the age of bipolar disorder onset for BPD subjects. The numerical suicidal history values for both BPP and BPN subjects represented an average of between “thought but never acted” (2) and “acted with ambivalence, minimal consequences” (3).

Table 4

Tests of Within-Subjects Effects

| Measure:ReactionTime | | Type III Sum | df | Mean Square | F | Sig. |
|--|--------------------|--------------|--------|-------------|-------|------|
| Source | | of Squares | | | | |
| Suppression | Sphericity Assumed | 49028.797 | 1 | 49028.797 | 3.062 | .088 |
| | Greenhouse-Geisser | 49028.797 | 1.000 | 49028.797 | 3.062 | .088 |
| | Huynh-Feldt | 49028.797 | 1.000 | 49028.797 | 3.062 | .088 |
| | Lower-bound | 49028.797 | 1.000 | 49028.797 | 3.062 | .088 |
| Suppression * GeneralOrdCode | Sphericity Assumed | 59577.594 | 1 | 59577.594 | 3.720 | .061 |
| | Greenhouse-Geisser | 59577.594 | 1.000 | 59577.594 | 3.720 | .061 |
| | Huynh-Feldt | 59577.594 | 1.000 | 59577.594 | 3.720 | .061 |
| | Lower-bound | 59577.594 | 1.000 | 59577.594 | 3.720 | .061 |
| Suppression * BPHCplusPsychosis | Sphericity Assumed | 201439.839 | 5 | 40287.968 | 2.516 | .047 |
| | Greenhouse-Geisser | 201439.839 | 5.000 | 40287.968 | 2.516 | .047 |
| | Huynh-Feldt | 201439.839 | 5.000 | 40287.968 | 2.516 | .047 |
| | Lower-bound | 201439.839 | 5.000 | 40287.968 | 2.516 | .047 |
| Suppression * GeneralOrdCode * BPHCplusPsychosis | Sphericity Assumed | 45611.496 | 3 | 15203.832 | .949 | .427 |
| | Greenhouse-Geisser | 45611.496 | 3.000 | 15203.832 | .949 | .427 |
| | Huynh-Feldt | 45611.496 | 3.000 | 15203.832 | .949 | .427 |
| | Lower-bound | 45611.496 | 3.000 | 15203.832 | .949 | .427 |
| Error(Suppression) | Sphericity Assumed | 592511.499 | 37 | 16013.824 | | |
| | Greenhouse-Geisser | 592511.499 | 37.000 | 16013.824 | | |
| | Huynh-Feldt | 592511.499 | 37.000 | 16013.824 | | |
| | Lower-bound | 592511.499 | 37.000 | 16013.824 | | |

Note. This table displays the tests of within-subject effects, as measured by reaction time, from which Figures 3-5 were constructed.

Table 5

Correlation of distancing and behavioral data

| Control Variables | | Correlations | | |
|-------------------|---------|-------------------------|------------|-------|
| | | SuppPos | reflection | |
| baseline | SuppPos | Correlation | 1.000 | .205 |
| | | Significance (2-tailed) | . | .224 |
| | | Df | 0 | 35 |
| reflection | | Correlation | .205 | 1.000 |
| | | Significance (2-tailed) | .224 | . |
| | | Df | 35 | 0 |

Note. This table displays the correlative data produced by the correlation of positive suppression (behavioral task data) and reflection (distancing task data). The relationship was not significant ($p=.224$).

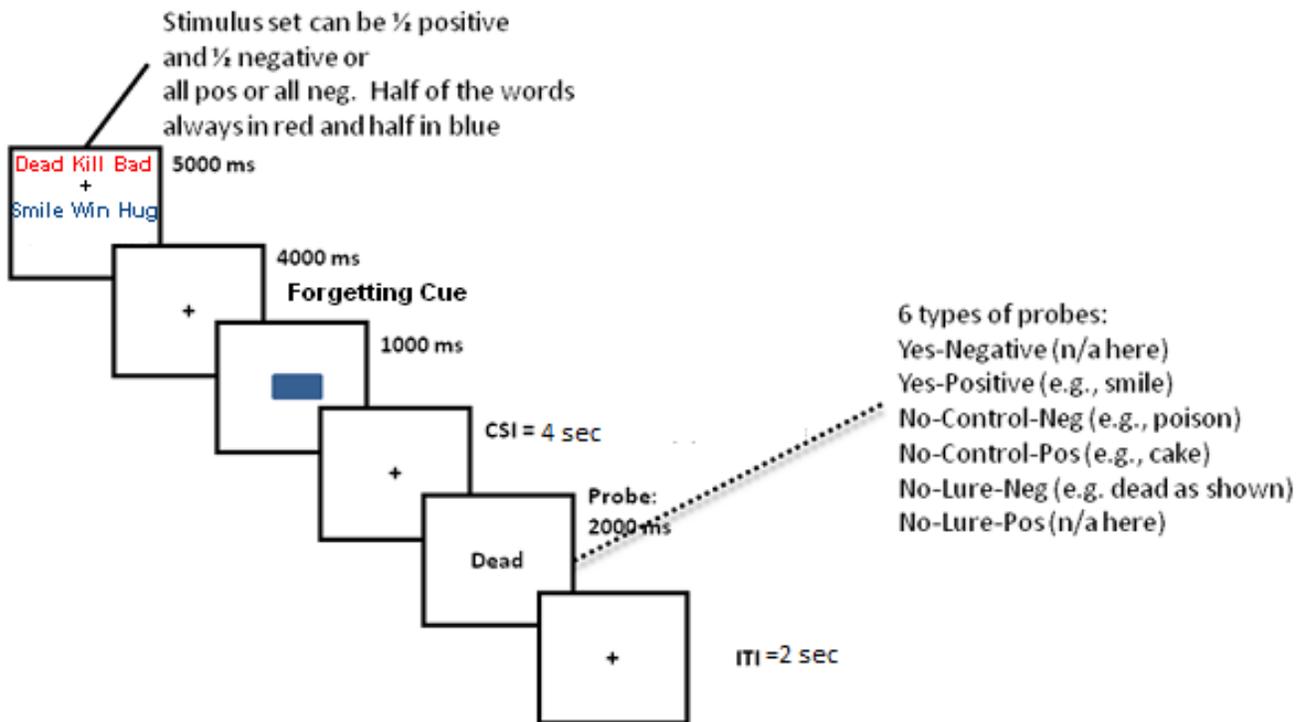


Figure 1. This figure displays a schematic of the behavioral task used by the Jonides Laboratory as a measure to assess the suppression of positively and negatively valenced stimuli in STM.

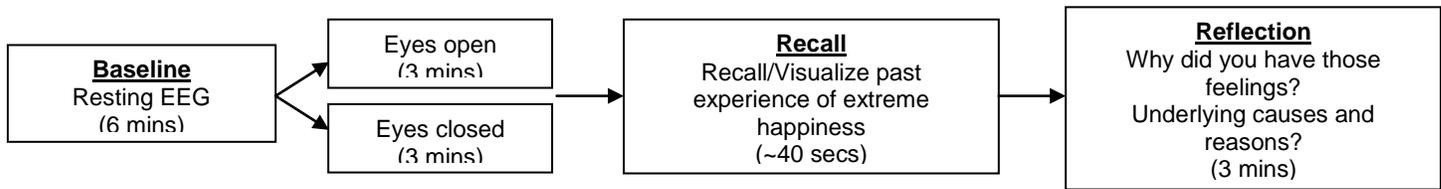


Figure 2. This figure shows a schematic diagram of the EEG task used to assess self-distancing and left frontal cortical activity used by the Kross Laboratory.

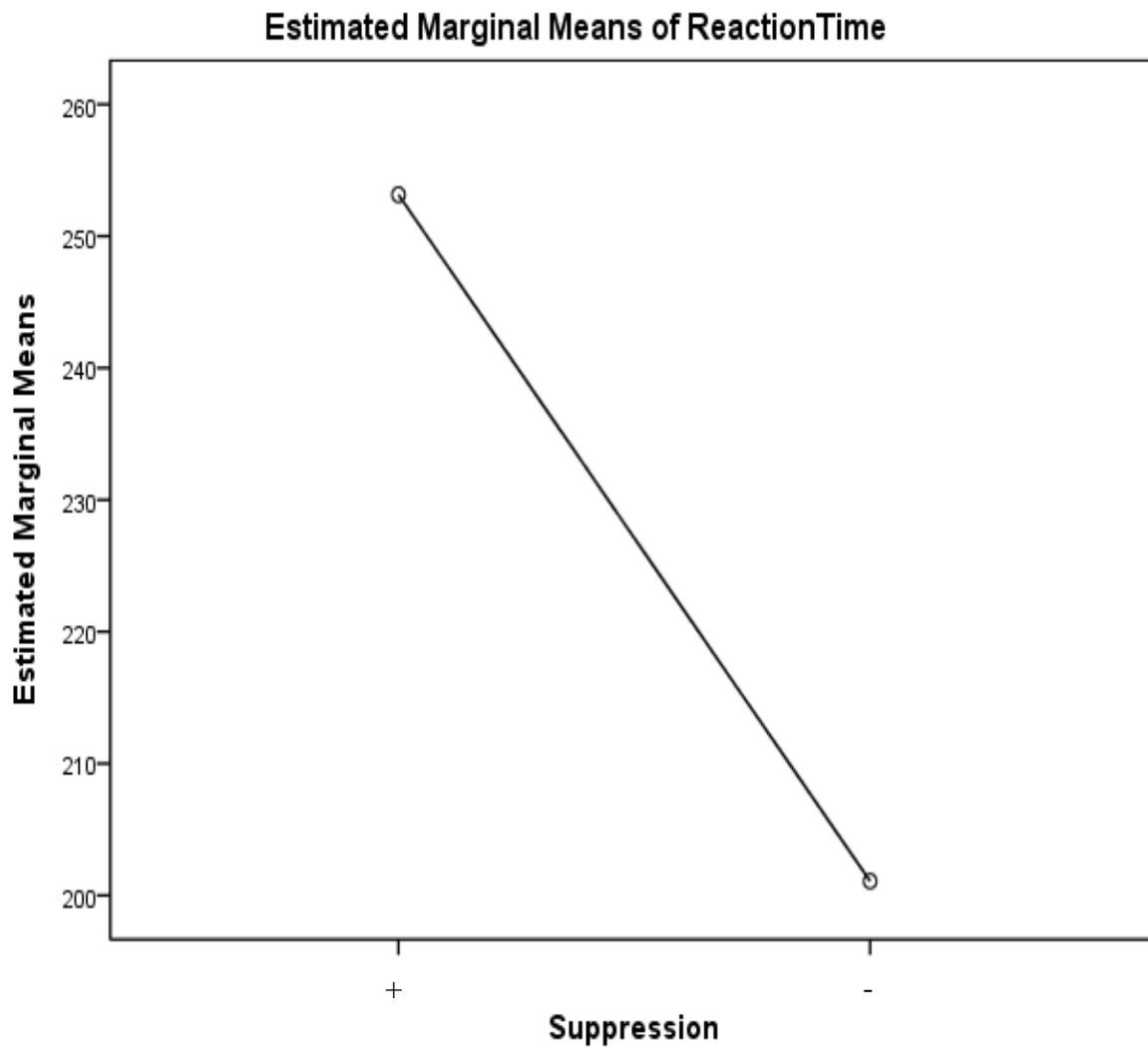


Figure 3. This figure shows greater overall suppression of positively valenced stimuli, with a p of .088. This p indicates a trend in the difference between positive and negative suppression.

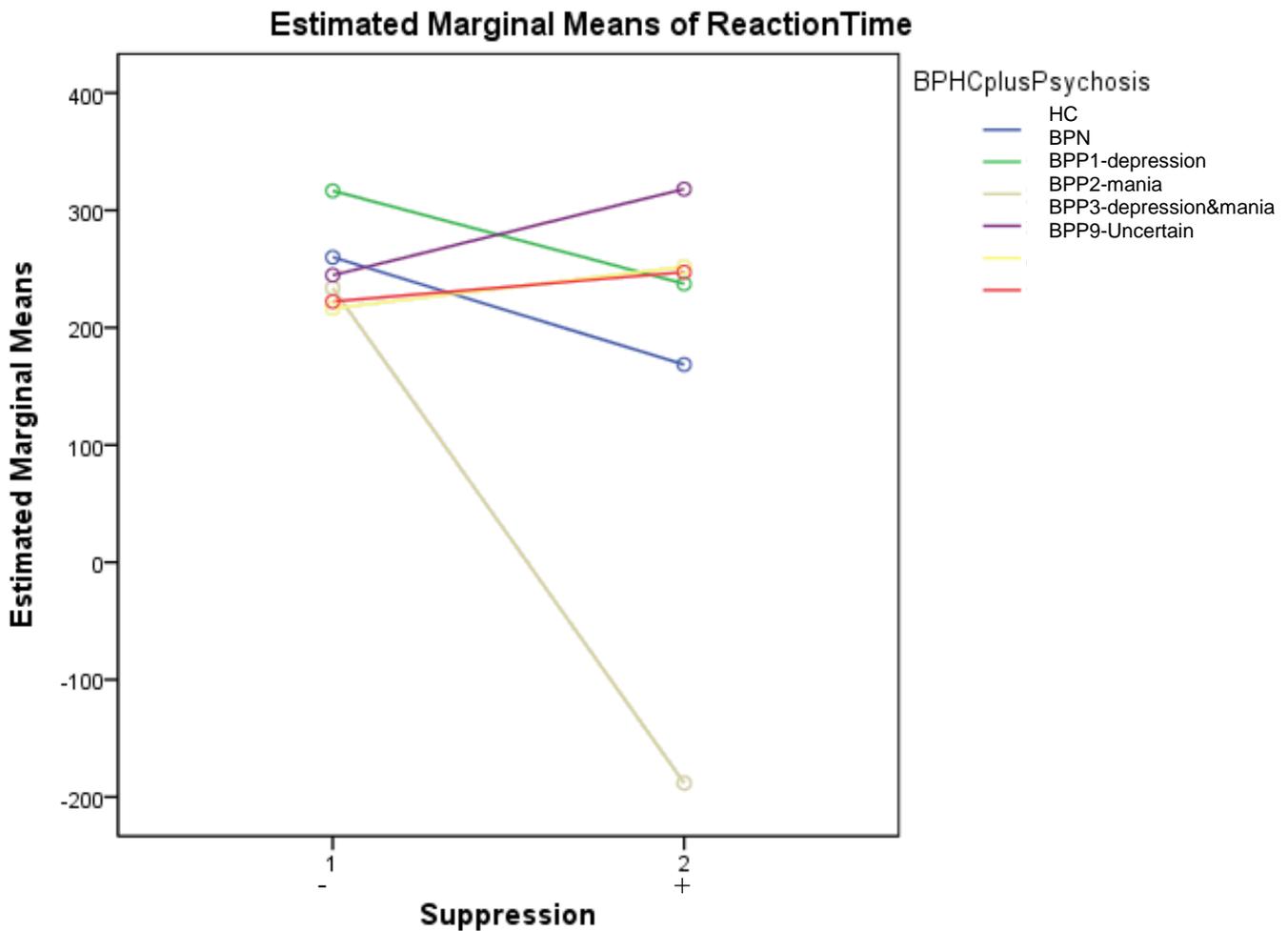


Figure 4. This figure displays the analysis of positive and negative suppression based on sub-subject groups. The word following each hyphen in the legend specifies the environment during which subjects experienced episodes of psychosis. HC (blue), BPN (green), and BPP1-depression (tan) subjects showed greater suppression of negatively valenced stimuli than positively valenced stimuli. BPP2-mania (purple), BPP3-depression and mania (yellow), and BPP9-uncertain (red) subjects showed greater suppression of positively valenced stimuli than negatively valenced stimuli. BPP9-uncertain is likely an individual who had episodes of psychosis during both times of depression and mania. The p was significant at .047.

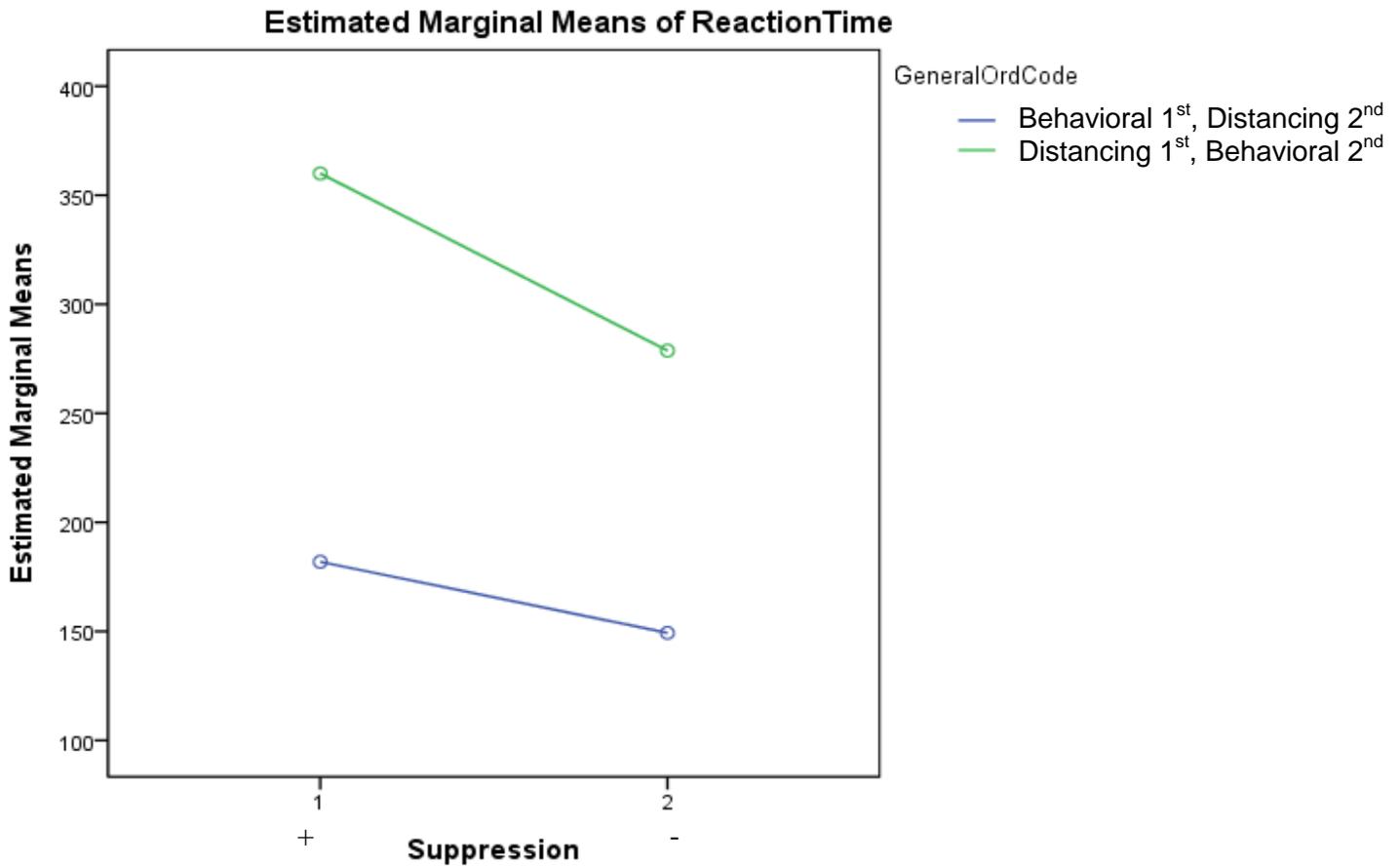


Figure 5. This figure shows the analysis of task order (behavioral or distancing first) and suppression, in order to assess if task order was a confounding variable. While the p indicated a trend (.061), it was not significant, and therefore it was not a confounding variable.

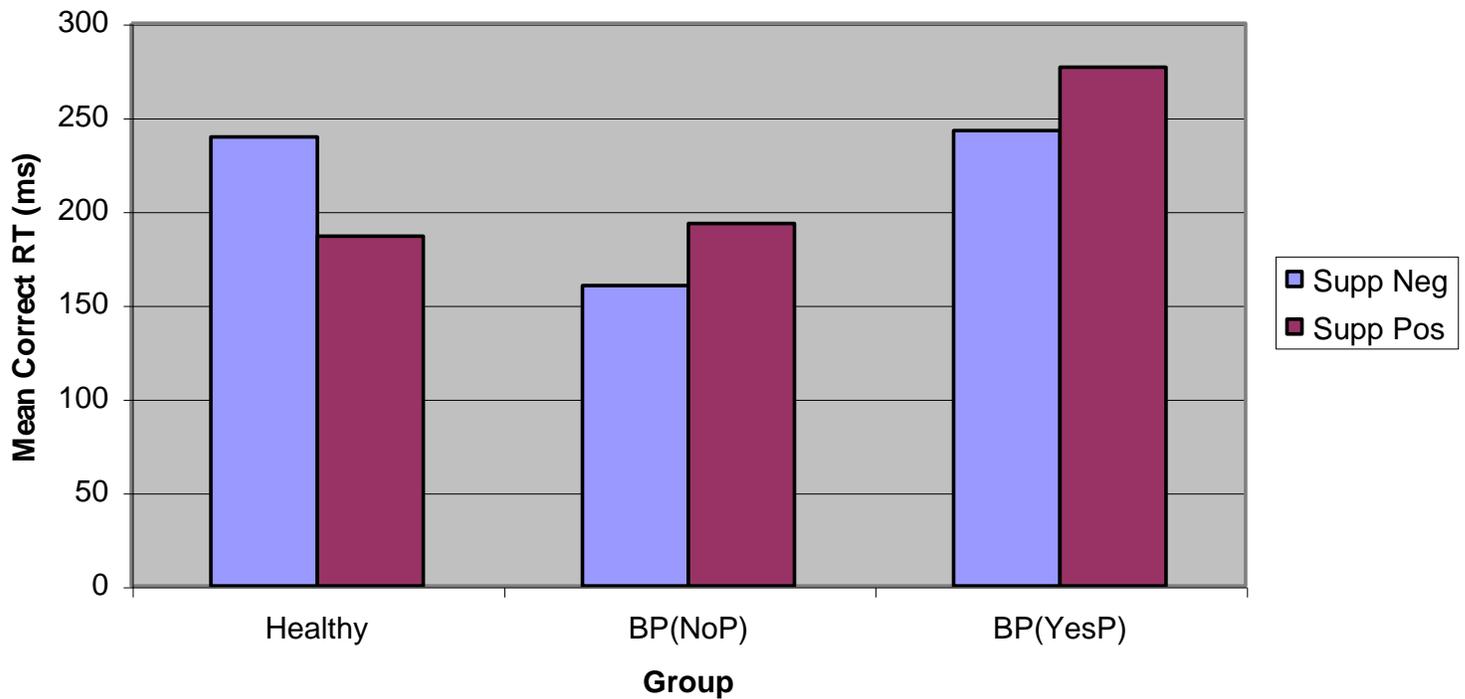
Suppression RT by Group and Valence

Figure 6. This figure displays the analysis of major subject groups and suppression. As our hypothesis predicted, there was a trend ($p = .12$) between HC and BPP subjects for the suppression of positively valenced stimuli. Only subjects with a task accuracy of $> 50\%$ were used in this analysis.

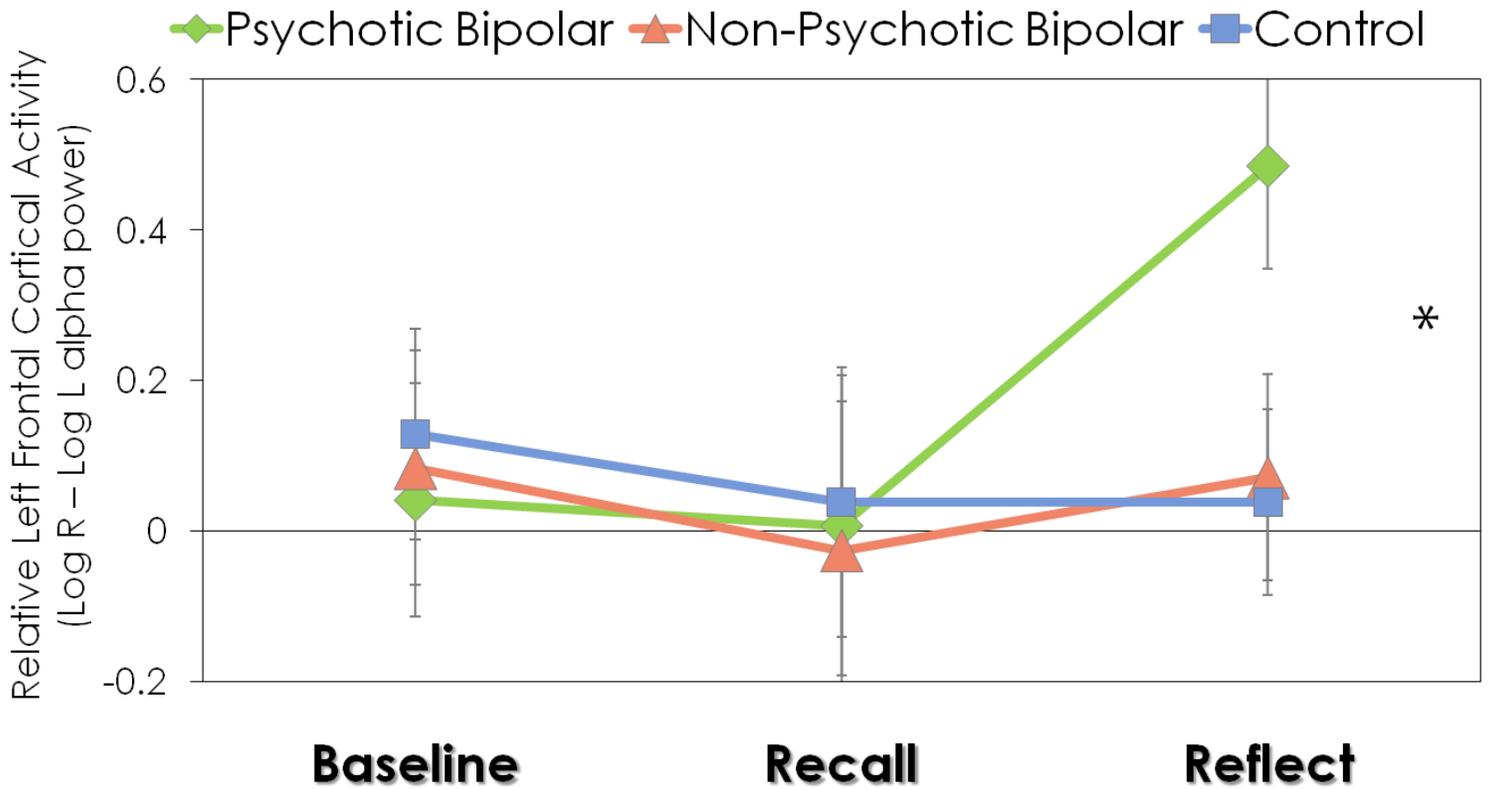


Figure 7. This figure displays the significant ($p < .05$) difference between reflection of BPP and BPN subjects found during the Kross Laboratory's distancing task. The significant difference was only found during the reflection portion of the task, and was a measure of the greater relative left frontal cortical activity of BPP subjects when compared to BPN subjects. The Kross Laboratory completed this analysis.

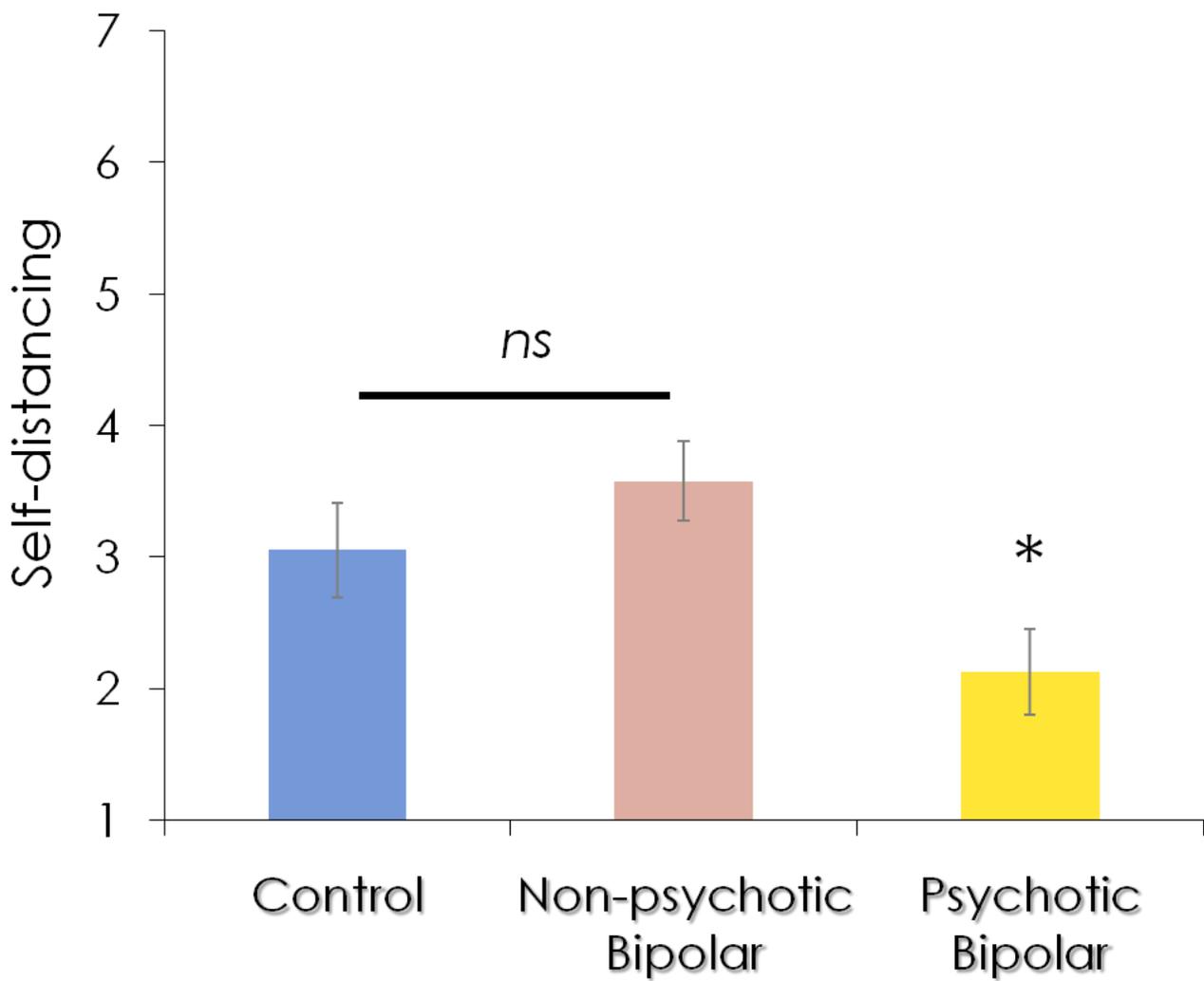


Figure 8. This figure displays the significant difference in self-distancing found when BPP subjects were compared with HC and BPN subjects. BPP subjects self-distance less, and immerse more during the recollection of positive memories. The Kross Laboratory completed this analysis.

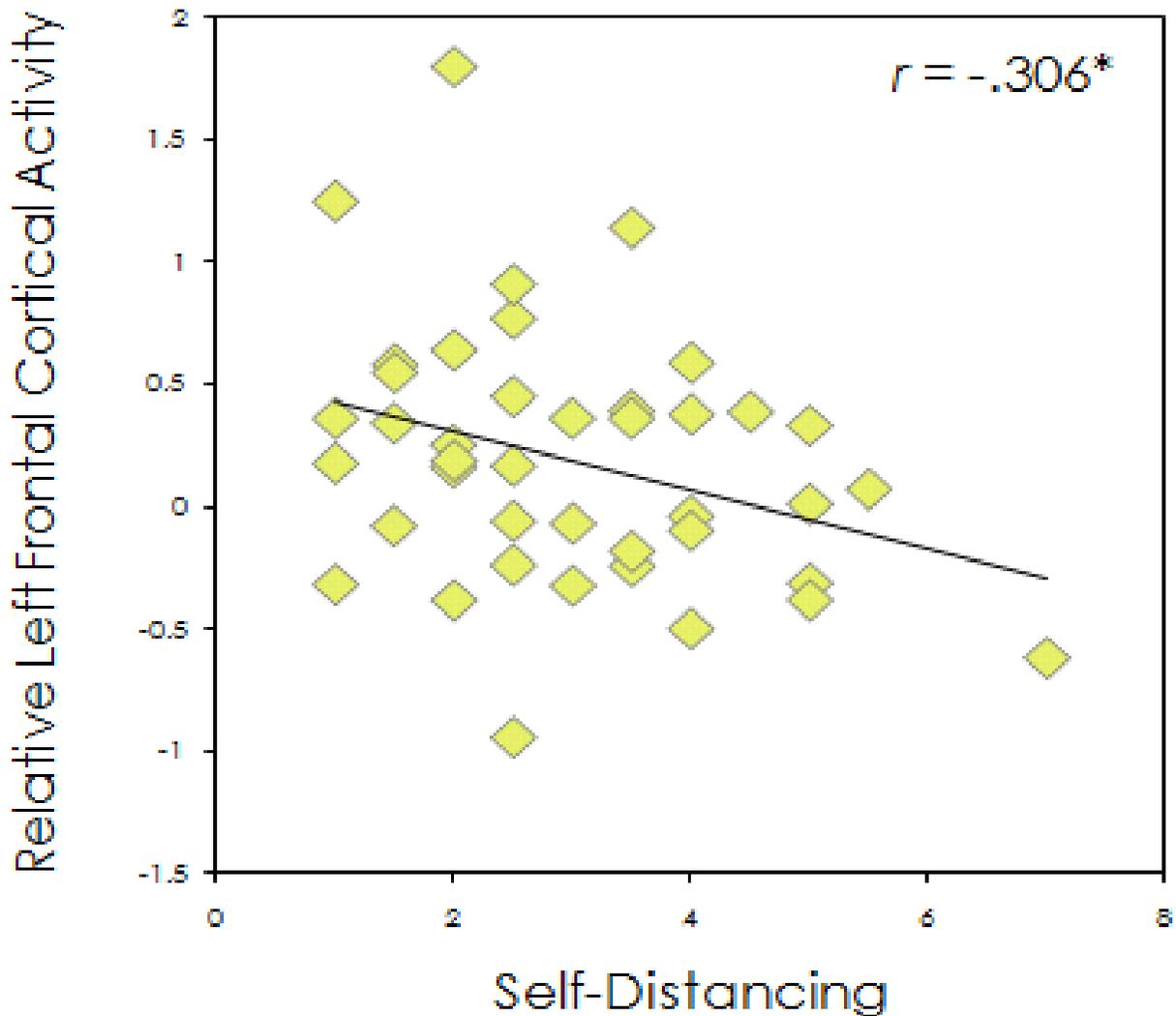


Figure 9: This figure displays the regression analysis of self-distancing and relative left frontal cortical activity. The value for r ($-.306$) was significant ($p < .05$). This means that self-distancing and relative left frontal cortical activity are inversely dependent upon each other; when a person self-distances more, he or she will have less relative left frontal cortical activity. The Kross Laboratory completed this analysis.