Spring 2013

The effects of mindfulness meditation on rumination in depressed people

Rachel A. Sluder
University of New Hampshire - Main Campus

Rachel Sluder
May 22, 2013
NSB 797
Honors Thesis

The effects of mindfulness meditation on rumination in depressed people

Abstract
Mindfulness meditation is a practice of focus, awareness, and non-judgmental acceptance of one's thoughts (Deyo et al., 2009; Kenny et al., 2007). Rumination is a maladaptive pattern of thought that is common in people with depression and other mood disorders. It can lead to further episodes of depression, and can be very destructive in that way (Nolen-Hoeksema, 2008). This paper reviews several studies on mindfulness meditation, depression, and rumination, with a focus on certain areas and phenomena such as alpha asymmetry (Keune et al 2013) and gamma band activity (Berkovich-Ohana et al., 2012). Modalities such as fMRI and EEG are both used in these studies. Finally, directions for further research are considered, while accepting the challenges unique to this and inherent in any neuroscientific research.

Introduction

Purpose The purpose of this project is to explore the intersection of existing behavioral and biological research on mindfulness meditation, rumination, and depression, with a focus on neuroscience and imaging methods, in order to gain insight into the neuroanatomy of meditation and of rumination, in hopes of getting a better idea as to how meditation works to improve symptoms of depression, particularly rumination. Based on observations made from looking at the existing body of research, recommendations will be made for future research and study directions.

What is mindfulness meditation? The term "meditation" can refer to many different practices, many of which stem from Eastern religious traditions. In recent years, certain aspects of meditative practice have merged with Western psychology. For the purpose of this paper, mindfulness meditation will be the focus. It is difficult to master, partially because it is difficult to define and understand. Many researchers explain it differently, attempting to merge the Eastern mystical concepts with ones that complement Western psychological research, and each definition illuminates different aspects of how mindfulness meditation is performed and its desired effects. One simple view of meditation is entering the "being mode" rather than the "doing mode." More specifically, Kilpatrick et al define mindfulness as "an attentional state of openly and non-judgmentally observing one's moment-by-moment

experiences" (Kilpatrick, Suyenobu, Smith, Bueller, Goodman, Creswell, Tillisch, Mayer, & Naliboff, 2011). Deyo et al define mindfulness as "learning to intentionally bring one's attention back to the internal and external experiences occuring in the present moment." They also note that it is crucial to "decenter" oneself from their thoughts and emotions – that is, not attaching any importance or meaning to thoughts as they allow them to come and go (Deyo, Wilson, Ong, & Koopman, 2009). Indeed, the idea that one's thoughts do not necessarily indicate truth is crucial to the practice of mindfulness meditation (Segal 2002, cited in Nolen-Hoeksema et al., 2008). This idea lends itself well to Western psychotherapeutic interventions for depression and other illnesses: where cognitive-behavioral therapy focuses on changing thoughts, mindfulness is aimed at understanding that thoughts are just mental events and not necessarily truths (Kenny & Williams, 2007). These therapies are combined in an approach known as mindfulness-based cognitive therapy, or MBCT, which incorporates meditation sessions into therapy and encourages daily practices outside sessions. For the purposes of studies, MBCT courses tend to be eight weeks long (Chiesa & Serretti, 2010).

An important study that demonstrated the effects of meditation on rumination and depression in behavioral terms was performed by Kenny and Williams (2007). They state that patients who ruminate are more likely to be resistant to depression treatments, so their study utilized treatment-resistant patients. (Unfortunately, this can be a source of bias – patients who have not encountered any successful treatments may be more motivated for meditation to work as a treatment, thereby introducing bias into the experiment (Kenny & Williams, 2007).) Based on Beck Depression Inventory scores before and after the eight-week MBCT, it is clear that MBCT reduced depression in these patients, as represented in the following chart.

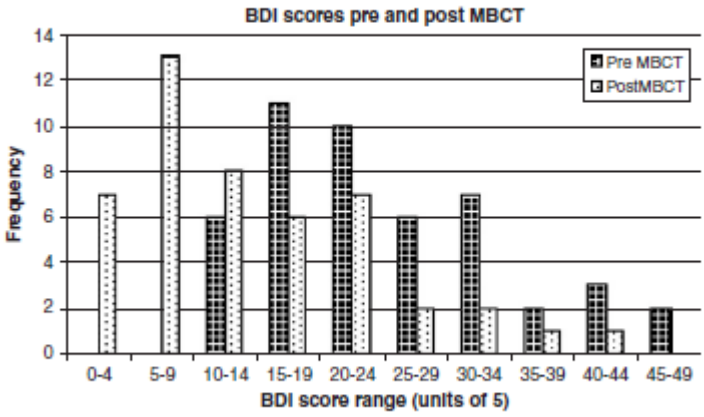

Fig. 1. BDI scores pre and post MBCT.

While this study had a larger sample than many similar studies, with 79 patients, there was no control group, so the inherent limitations in this field make it difficult to draw hard and fast conclusions (Kenny & Williams, 2007). Nonetheless, this evidence is very promising towards the effectiveness of mindfulness for depression.

Neural correlates of mindfulness meditation Understanding the thought processes – or lack thereof – that are important in meditation can indicate potential neuroanatomical areas or phenomena that may change or arise with meditation practice. Considering the features of meditation such as "breath awareness, body awareness, attention to the transient nature of sensory experience, and shifting attention across sensory modalities," Kilpatrick et al suggest that brain networks involved in "attention and sensitivity to internal and external sensations and emotions" may show altered functioning related to meditation practice (2011). They performed a study using fMRI specifically focused on connectivity, which will be discussed in more depth in the Discussion section of this paper.

Some researchers have focused on the "default mode network" (DMN) and mindfulness, since the DMN is active during self-referential processing (Berkovich-Ohana, Glicksohn, & Goldstein, 2012). It consists of the medial prefrontal cortex, medial temporal lobe (which incluces hippocampus and para-hippocampal gyrus), posterior lateral cortices, anterior and posterior cingulate cortex, and precuneus. Berkovich-Ohana et al note that data from several fMRI studies "support the idea of

meditation-induced DMN plasticity, although the exact changes are inconclusive, probably due to the engagement of various types of meditation and different study designs" (2012). In their own research, they compared EEG data with fMRI findings; specifically, a certain increase in gamma power which has been related to activity in the prefrontal node of the DMN, and as such is closely related to self-referential processing. This study will be discussed further in the Discussion section of this paper.

A very important study on the neuroanatomy of mindfulness meditation had a more general focus. Holzel et al performed a study of within-group changes following MBSR, based upon voxel-based morphometry analysis of fMRI (Holzel, Carmody, Vangel, Congleton, Yerramsetti, Gard, & Lazar, 2010). Their regions of interest were the hippocampus and insula, due to their general roles in memory and emotional control, respectively (Holzel et al 2010). After the eight weeks of MBSR, they found significant increases in gray matter density in five clusters: the posterior cingulate cortex, left tempoparietal junction, and two spots in the cerebellum, as well as a cluster in the hippocampus (Holzel et al 2010). Interestingly, some of these areas are also involved with the default mode network. Degree of change in gray matter density was not correlated with degree of self-reported improvement or meditation proficiency.

Although it may seem that there could be a close relationship between the DMN and meditation, the reality is likely not that simple. To that end, Chiesa, Serretti, and Jakobsen question the pathways of the emotion regulation that results from mindfulness in their 2012 review article. They propose two potential strategies of emotion regulation: one "top-down" wherein prefrontal regions regulate emotion-generative brain regions such as the amygdala, and a "bottom-up" strategy in which the emotion-generative brain regions can be directly modulated without "active recruitment" of higher regions such as the PFC (2012). According to their review, no consensus exists on which strategy is more correct. The top-down option would suggest that the neurobiological mechanisms in mindfulness meditation are very similar to those found in psychotherapy or other more traditional, Western approaches. This possibility carries important clinical implications: the authors suggest that

mindfulness options could thereby work for patients who are not responding to psychotherapy (Chiesa et al, 2012).

Overall, meditation is a free and relatively easy practice, for which research has shown very promising data as mood regulation aid and stress relief. Knowing the basic thought processes involved, as well as the behavioral effects, can shed light onto the neuroanatomy of meditation and even events such as mood regulation and rumination. In sum, mindfulness meditation practices merit further research, particularly as they continue to enter mainstream Western psychology.

What is rumination? Rumination is a maladaptive pattern of thinking, commonly found in depression, anxiety, and similar disorders. It tends to be intrusive, and focused on one or more distressing events or ideas (Deyo et al., 2009). Commonly accepted theory suggests that it is a way of responding to distress through perseverative thoughts on the cause of distress, as well as possible causes and consequences of it. This theory is known as the "response styles" theory (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). The thoughts can be overwhelming, and thereby interfere with successful, effective problem solving; indeed, those who ruminate rarely take action to solve problems, instead remaining fixated upon them and obsess over them in thoughts (Nolen-Hoeksema et al., 2008). Additionally, Nolen-Hoeksema and Davis argue that the problems stemming from ruminating compound when chronic ruminators lose social support, which in turn fuels their depression (1999).

Nolen-Hoeksema suggests that, in accordance with the response styles theory, distraction can be an effective and constructive way of halting rumination, provided that the distraction is sufficiently absorbing, and not self-destructive. It is possible that meditation can serve as a "distraction," in a sense, since it provides awareness of the ruminative thoughts as just thoughts, and could make it easier for sufferers to break away from the pattern. Indeed, rumination is habit-forming - converging evidence has shown that it those with depression and dysphoric tendencies are more easily induced to ruminate than those who do not have said tendencies (Nolen-Hoeksema et al., 2008).

Neuroanatomical data on rumination is limited, but the data that is present does indicate a few

common areas, such as the anterior cingulate cortex and medial prefrontal cortex. The importance of the anterior cingulate cortex (ACC) was emphasized in a study by Joorman and Gotlib, who found that greater activity in the rostral ACC was associated with a greater ability to inhibit negative distracters in depressed and non-depressed patients, and ruminators showed lower rostral ACC activity when attempting to inhibit negative distractors (2005, cited in Nolen-Hoeksema, 2008). The medial prefrontal cortex (mPFC) was studied by asking subjects – non-ruminators and ruminators alike – to look at photographs of themselves, thus creating a "self-referential" task, mimicking the type of thoughts that take place in rumination. It was found that ruminators had increased mPFC activity in this task, indicating a greater propensity for self-referential thinking and a lower "threshold" for doing so (Ray et al., 2005). A related area was highlighted in another study that showed lower activity in the anterior mPFC during rumination following certain self-referential cues (Johnson, Nolen-Hoeksema, Mitchell, & Levin, 2008). Kuhn et al suggested a relationship between these areas, and the default mode network, indicating that rumination may be an overactivity of the default mode network (Kuhn, Vanderhasselt, De Raedt, & Gallinat, 2012). Interestingly, they found no connection with rumination in depression and the amygdala or hippocampus (Kuhn et al., 2012).

It is clear that the nuances of cues and brain activity become difficult to parse; variations within subjects may create issues with determining specific neural correlates for certain thought processes and depressive or ruminative symptoms. Overall, it is clear that rumination is a problematic pathological response to depression and similar disorders, and prevention of it may help relieve symptoms of depression.

Methods

This project was done by performing literature searches on the ScienceDirect databases, utilizing search terms such as "mindfulness meditation and rumination," "mindfulness meditation and imaging," and "rumination," and extracting relevant seeming articles. Studies that utilized meditation-naive patients and looked at the short term were considered ideal for the purpose of this project.

Criteria for relevance included coverage of mindfulness meditation; imaging methods; discussion of rumination or depression; and some behavioral data on meditation and/or rumination. Since the goal was to explore the intersection of mindfulness meditation and the rumination response in depression, most studies that incorporated at least one of the above criteria were used. Additionally, some articles were found via citations in articles gathered from literature searches.

Within the articles, imaging methods were also considered, primarily fMRI and EEG. fMRI studies can reveal differences in gray matter density and localization of these differences, so these studies are good for looking at changes across a short time period, such as 8 weeks. EEG studies are good for changes across time as well, but are also useful for looking at changes and activity within a single session, since they have greater temporal acuity compared with fMRI.

Another commonality between articles was the type of mindfulness meditation used. The intervientionwas either the Mindfulness-Based Stress Reduction (MBSR) program, or MBCT. Each of these programs involve eight weeks of meditation practice, and all studies that incorporated these used meditation-naive subjects. MBSR differs from MBCT in that it is most commonly offered in a class format, and is usually for those who wish to improve their stress relief capabilities. Otherwise, it also includes weekly meditation instruction, and the expectation of daily practice outside the course (Kenny & Williams, 2007).

Results

A total of 19 peer-reviewed articles were referenced in constructing this paper. These articles consisted of both review articles and research reports, covering multiple modalities within behavioral and neuroimaging research. Four studies will be highlighted in the discussion section that contain methods, design, and findings (mainly related to mindfulness and rumination) that give promising and interesting insight for future research in the suggested direction.

Discussion

Given the deliberate nature of the focus implicit in meditation, Kilpatrick et al suggest that a

difference can be found in neural networks following MBSR training (2011). They chose to investigate "intrinsic connectivity networks," or ICNs, of which the DMN is one. Others include networks involved in working memory, attention, and sensation. ICNs are identifiable based upon the characteristic slow fluctuation (less than 0.1 Hz) of the BOLD response in fMRI signals, so the authors referred to this method as "fcMRI" for functional connectivity MRI (Kilpatrick et al, 2011). The DMN is among the networks most readily identified by this type of fMRI. Following an 8-week MBSR training for 32 women who had never meditated, as well as a control group who were on a waitlist for the MBSR course, the authors found increased activity in the auditory ICN and in an ICN they called the "salience" network. Due to the concurrent activity of these networks, the authors called them together the "auditory/salience network." The brain regions that were the most crucial to this network were the primary auditory region, the superior temporal gyrus, and the posterior insula. The combination of these particular networks is interesting because the distractor in the meditation task (which participants were asked to ignore so that they could exercise mindfulness) was an auditory distraction. Another interesting observation was the anticorrelation between activity in this network and activity in the visual network, suggesting an attentional shift (Kilpatrick et al, 2011).

The study of attention as it relates to mindfulness meditation is complementary to the study of rumination in the same. One unique study investigated event-related potentials (ERPs) following MBCT training in such a way that tested depressed subjects' concentration abilities, both during rumination and not (Bostanov, Keune, Kotchoubey, & Hautzinger, 2012). As it relates to this study, ERP is a brain response extracted from EEG that can reflect re-allocation or allocation of attentional resources in real time. Since it is part of normal mentation to some degree, it can be elicited with no task (under "passive conditions"), so this method is well suited for testing the "being mode" that is so crucial to meditation. The researchers looked at the "contingent negative variation" (CNV), a certain signal that always precedes another; the two together indicate mobilization of attentional resources (Bostanov et al, 2011). They found that the CNV increased following MBCT, while subjects were

asked to attempt to remain in a mindful state while auditory distractors were presented, and was present even when rumination was induced. This is strong evidence that meditation practice improves one's ability to shift or maintain attention. In the context of rumination, this indicates that practitioners are more readily able to stop ruminating and bring their attention back to the breath (or whatever the previous locus of attention had been).

A recent paper covered EEG in a different way, with a focus on frontal brain asymmetry of the alpha signal (Keune, Bostanov, Hautzinger, & Kotchoubey, 2013). The alpha power with respect to EEG is found at 8-13 Hz, and is often indicative of decreased cortical activity (Keune et al.,, 2013). The authors of this study wished to follow up on research that had shown greater asymmetry in this signal following MBCT, since it was evident from other studies that such asymmetry is not simple: certain types of asymmetry are indicative of a withdrawal response to a situation, while others indicate an approach response, and the specifics of anatomy or signals of these responses are not yet clear (Keune et al., 2013). Knowing that asymmetry is subject to state influences, the authors performed a study with similar conditions to earlier studies. The subjects were 57 recurrently depressed, meditation-naive women in remission from depression, who were divided into a mindfulness support group and a rumination challenge group. Neither group received mindfulness training of any kind in this study. Both groups received EEG during neutral rest, then a negative mood was induced. At this point, the mindfulness group was given mindfulness instructions, whereas the rumination challenge group was exposed to “distracting ruminative statements” (Keune et al., 2013). They charted their results as follows, and stated that these results were indicative of increased “approach motivation” in the mindfulness group.

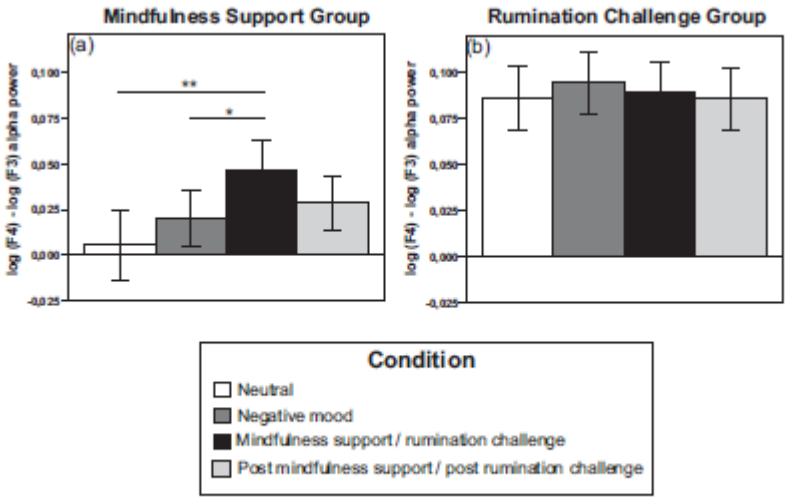

Fig. 3. Electroencephalographic (EEG) mid-frontal alpha asymmetry in log-transformed μV^2, displayed separately for the "mindfulness support group"($n = 25$; a), and the "rumination challenge group"($n = 31$; b). Higher values reflect stronger relative right-hemispheric alpha activity. Error bars reflect standard errors. **$p < .01$, *$p < .05$.

(Keune et al, 2013)

Rather than finding asymmetry to the degree expected, they found that the mindfulness group experienced a shift in asymmetry, thus supporting the idea of a different "approach," perhaps a more positive, proactive one (Keune et al., 2013). This data was verified by questionnaires about subjects' mood following the tests – mindfulness support subjects were in a better mood than the rumination challenge subjects.

In their 2007 study, Farb, Segal, Mayberg, Bean, McKeon, Fatima, and Anderson add an additional nuance to the neural correlates of mindfulness meditation by exploring two types of awareness: "narrative focus" (NF) and "experiential focus" (EF) (Farb et al, 2007). The "narrative focus" is a focus on "cognitive elaboration" of a given thought – very similar to the process of rumination and the default mode (Gusnard et al, 2001; Raichle et al, 2001, cited in Farb et al., 2007) - while "experiental focus" is essentially the opposite: conscious inhibition of further elaboration following a thought, with a focus on current and momentary sensory experiences (Farb et al 2007). Of two groups of subjects, one received MBSR training and the other remained a waitlist control group. They were both educated in the NF and EF states, and asked to recreate them with the help of stimuli under fMRI. The authors compared NF and EF states within groups, and among their more important findings was decreased activity in the anterior cortical midline within mPFC, and decreased activity in

the left dorsal amygdala in the mindfulness group's EF state relative to the NF state. They noted increased activity under the same conditions in “a right lateralised cortical network,” which primarily included the dorsal and inferolateral PFC and the insular cortex (Farb et al, 2007).

In their aforementioned study, Berkovich-Ohana et al did find the decrease in DMN activity that they expected. They suggest that this could be related to the “increased attentional skills” many mindfulness practitioners report (2012). Indeed, taken with evidence from studies focusing specifically on rumination, this conclusion supports the idea of “shifting” attention as a means to stop the rumination process.

Future Directions

As with many neuroscientific research efforts, progress made in the field of mindfulness meditation research is very gradual. Inherent limitations in this field – such as selection bias, small sample size, and difficulty of finding a suitable control group – cause research to move slowly. However, based upon the above studies, converging evidence is clear. Essentially, it has become evident that mindfulness meditation can help control rumination by aiding ability to shift attention back to the mindful state more readily following training. The studies with the most evidence of this attentional shift have used EEG (Kilpatrick et al., 2011; Berkovich-Ohana et al., 2012; Keune et al., 2013; Bostanov et al., 2012), so perhaps a study using fMRI to corroborate this research would help round out understanding and awareness of the specifics of the attentional shift. Given that certain areas of interest have come forward repeatedly, such as the anterior cingulate cortex and medial prefrontal cortex, a study similar to that of Holzel et al (2010) on gray matter density in these areas, rather than simply activity, could enrich knowledge of neuroplasticity as it relates to mindfulness meditation and depression. Such a study would need a relatively large sample (>50 subjects), preferably of one gender, who have struggled with depression and rumination, and who would undergo MBSR training, as well as an age-matched waitlist control group. An interesting addition to this study could be a three-month follow-up to the MBSR group to see if any additional gray matter changes had taken place, although

this would make the compliance issue even greater.

Overall, there is clear evidence supporting the ability of meditation practice to reduce rumination and thereby perhaps reduce episodes of depression. Given that depression is such a common problem, further research on this phenomenon is very important, and could be very significant clinically. It faces many of the challenges and limitations typical of neuroscience research with human subjects, but it is well worthwhile.

Works Cited

Berkovich-Ohana, A., Glicksohn, J., & Goldstein, A. (2012). Mindfulness-induced changes in gamma band activity – Implications for the default mode network, self-reference and attention. Clinical Neurophysiology, 123, 700-710.

Bostanov, V., Keune, P.M., Kotchoubey, B., & Hautzinger, M. (2012). Event-related brain potentials reflect increased concentration ability after mindfulness-based cognitive therapy for depression: A randomized clinical trial. Psychiatry Research, 199, 174-180.

Chiesa, A., & Serretti, A. (2009). A systematic review of neurobiological and clinical features of mindfulness meditations. Psychological Medicine, 40, 1239-1252.

Chiesa, A., Serretti, A., & Jakobsen, J.C. (2012). Mindfulness: Top-down or bottom-up emotion regulation strategy? Clinical Psychology Review, 33, 82-96.

Farb, N.A.S., Segal, Z.V., Mayberg, H., Bean, J., McKeon, D., Fatima, Z., & Anderson, A.K. (2007). Attending to the present: Mindfulness meditation reveals distinct neural modes of self-reference. SCAN, 1-10. doi: 10.1093/scan/nsm030

Deyo, M., Wilson, K.A., Ong, J., & Koopman, C. (2009). Mindfulness and rumination: Does mindfulness training lead to reductions in the ruminative thinking associate with depression? Explore, 5, 265-271.

Holzel, B.K., Carmody, J., Vangel, M., Congleton, C., Yerramsetti, S.M., Gard, T., & Lazar, S.W. (2011). Mindfulness practice leads to increases in regional brain gray matter density. Psychiatry Research: Neuroimaging, 191, 36-43.

Johnson, M.K., Nolen-Hoeksema, S., Mitchell, K.J., & Levin, Y. (2009). Medial cortex activity, self-reflection and depression. SCAN, 4, 313-327. doi: 10.1093/scan/nsp022

Kenny, M.A., & Williams, J.M.G. (2007). Treatment-resistant depressed patients show a good response to mindfulness-based cognitive therapy. Behaviour Research and Therapy, 45, 617-625.

Keune, P.M., Bostanov, V., Hautzinger, M., & Kotchoubey, B. (2013). Approaching dysphoric mood: State-effects of mindfulness meditation training on frontal brain asymmetry. Biological Psychology, 93,

105-113.

Keune, P.M., Bostanov, V., Hautzinger, M., & Kotchoubey, B. (2011). Mindfulness-based cognitive therapy (MBCT), cognitive style, and the temporal dynamics of frontal EEG alpha asymmetry in recurrently depressed patients. Biological Psychology, 88, 243-252.

Kilpatrick, L.A., Suyenobu, B.Y., Smith, S.R., Bueller, J.A.B., Goodman, T., Creswell, J.D., Tillisch, K., Mayer, E.A., & Naliboff, B.D. (2011). Impact of mindfulness-based stress reduction training on intrinsic brain connectivity. NeuroImage, 56, 290-298.

Kuhn, S., Vanderhasselt, M.A., De Raedt, R., & Gallinat, J. (2012). Why ruminators won't stop: The structural and resting state correlates of rumination and its relation to depression. Journal of Affective Disorders, 141, 352-360.

Nolen-Hoeksema, S., & Davis, C.G. (1999). ‘‘Thanks for sharing that’’: Ruminators and their social support networks. Journal of Personality and Social Psychology, 77, 801–814.

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

Ray, R.D., Ochsner, K.N., Cooper, J.C., Robertson, E.R., Gabrielli, J.D.E., & Gross, J.J. (2005). Individual differences in trait rumination and the neural systems supporting cognitive reappraisal. Cognitive, Affective, and Behavioral Neuroscience, 5, 156–168.