Mindfulness Meditation as a Stress Reactivity Intervention: An Event-Related Potential Study

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Chronic stress has been shown to adversely affect cardiovascular, neurological, and mental health, especially in older populations. The success of alternative therapies in combating stress has been well-supported in neuroscience thus far. In this experiment, the Portland Arithmetic Stress Task (PAST) was used to examine stress reactivity in older adults who received Mindfulness Meditation (MM) training. This was done in order to determine whether event-related potentials (ERP's) and autonomic biomarkers may be impacted by this MM intervention. Thirty-six older adults were enrolled and randomized into the six-week program groups: MM, Health/Wellness Education (H/W), and no program (no training control). All groups were brought in for testing before and after their intervention. At each visit, the PAST was administered, and an ERP was recorded in feedback-related negativity (FRN), an event-related potential (ERP). This was repeated for incorrect answers as demonstrated in the Portland Arithmetic Stress Task, which uses complicated mathematics under a time-constraint to create a measurable difference in stress reactivity via this ERP measure. We expect, given previous literature on ERP's, that the MM group would show a decrease in physiological and ERP stress reactivity measures during the task, as well as a further rebound to baseline after the test was administered.

**Methods & Materials**

**Intervention Programs**

- **MM** and H/W groups receiving weekly, 1-hour training videos, as well as autonomic biomarkers and ERP's measured, leaving a small range to work with in future studies. It is unclear if MM will be effective enough, in such a short time, to create a measurable difference in stress reactivity via this ERP measure. The PAST Task

- Control group did not receive any training and was assigned to a waiting list.

**The PAST Task**

- **ECG monitors heart rate before, during, and after task.**
- **Participants were asked to respond to incorrect answers using a keyboard.**
- **EEG records FRN potentials to incorrect answers.**

**Literature Review**

The biological and neural mechanisms as well as the psychological processes involved in stress have been thoroughly studied and supported over the past several decades. Stress is typically evaluated before and after a stress test. While the mechanisms are still being discovered, there are certain patterns, including error-related negativity (ERN) and more recently, feedback-related negativity waves that are seen in an event-related potential (ERP) during a stressful event. While the two are closely related, ERP curves are specific to “incorrect responses,” as demonstrated in the Portland Arithmetic Stress Task, which uses complicated mathematics under a time constraint to evaluate measures which are the subject of a wrong answer. (See Figure 1). The psychological mechanisms between ERPs and stress responses offers an explanation for the relationship between ERPs and stress responses in the anterior cingulate cortex (ACC). The mechanisms of stress and cognition, such as stress responses in the anterior cingulate (ACC) and the amygdala, are subject to incorrect answers in providing a visual sample of the stress response. The ACC has been shown to be a marker of stress reactivity in the brain, as demonstrated in the Portland Arithmetic Stress Task, which uses complicated mathematics under a time constraint to evaluate measures which are the subject of a wrong answer. (See Figure 1). It is this ability for the recognition of the ACC, which has a major output in the locus coeruleus (LC). It is vital because it is the activation of the ACC that leads to the activation of the LC, which is then translated to autonomic responses. This would further lead to the activation of the HPA axis, release of cortisol, and the biological effects that follow, including increased heart rate and blood pressure. These are the characteristic biomarkers of measures of stress. This latter cascade theoretically stems from a single ERP, in this case a FRN potential, elicited from the PAST Task. To relate this back to disorders, an explanation for stress response could be explained by an excess of these specific family of ERPs, which is supported by the findings of psychiatric sites, which include measurement of the stress hormone (in order to diagnosis a broken stress response) or the brain, including measurement of the stress hormone (in order to determine how the brain is functioning). While the two are closely related, FRN curves are specific to an “incorrect response,” as demonstrated in the Portland Arithmetic Stress Task, which uses complicated mathematics under a time-constraint to evaluate measures which are the subject of a wrong answer. (See Figure 1). In order to disrupt a broken stress response, one could lead to the activation of the ACC, which is vital because it is the activation of the ACC that leads to the activation of the LC, which results in changes to the brain, such as to strength our comparison between the control and experimental groups. For example, if we see a decrease in physiological and ERP stress reactivity measures after a stress test, the ACC a major output is to the locus coeruleus (LC). This is vital because it is the activation of the ACC that leads to the activation of the LC, and as a major output of the LC in the hypothalamus, this would further lead to the activation of the HPA axis, release of cortisol, and the biological effects that follow, including increased heart rate and blood pressure. These are the characteristic biomarkers of measures of stress. This latter cascade theoretically stems from a single ERP, in this case a FRN potential, elicited from the PAST Task. The PAST Task

**Experiment Predictions**

1. Noticeable FRN curve is generated from stress event (incorrect answer)
2. With MM training: smaller amplitude of FRN curve, returns to baseline in a shorter amount of time
3. An analysis of average reactivity over time may be better suited for this study

**Implications**

1. MM could show considerable improvement in lowering stress reactions and emotional responses to errors in healthy EEG analysis
2. Would add to the scientific data to support MM as an effective stress management technique to reduce the physiological effects of chronic stress
3. Reduction in stress reactivity controls symptoms of PTSD, anxiety, depression, and other disorders associated with these chemical/physical pathways
4. Adoption of MM could reduce the use of pharmacological treatment in patients when medication is contraindicated or not desired

**Literature Citations**