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Physiological Effects of Negative Emotional States.

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ABSTRACT

In this paper, we sought to understand why some negative emotions can have a physiological effect on the body, so that we could learn to better manage, and normalize, our reactions in emotionally stimulating situations. Previous research has predicted that these physiological effects can include variables such as impaired immune system function, insula activity, inflammation, and decreased prefrontal cortical activity. In our first (correlational) study, we tested the strength of these relationships by examining naturalistic daily changes in their variables longitudinally over a one week period. We measured emotional trauma such as stress by using the Profile of Mood States (POMS) scale to track negative emotional states, and immune function with a daily body temperature measurement with a thermometer. Social rejection and anger levels were measured through the use of a negative emotions test called the Social Rejection Lab, insula activity was measured by the amount of times gut sensation were felt and prefrontal cortical activity with the Berg's Card Sorting Task. Fatigue levels were measured with a self-report Likert-style questionnaire, and inflammation measured by participants' bicep circumference. Based on the strength of correlation found between anger and prefrontal cortex activity in our correlational study, we then conducted a second (experimental) study to test for a causal relationship between these two variables. For the duration of the seven day study, participants alternated between the experimental meditation condition (4-days total) and the controlled non-meditation condition (3-days total) and measured the effect this manipulation had upon prefrontal cortex activity and subjective anger levels. Data pooled across participants in our correlational study showed the strongest correlation was between anger and cortical activity, although these results were not statistically significant. Data pooled across participants in our experimental study further showed that anger and cortical activity are not related in that inducing a state of calm does not necessarily enhance an individual's cognitive functioning. This research suggests that stress-reduction techniques do not lead to any large improvements in prefrontal functioning.

1. Introduction

1.1 Research Problem

Emotions cause a variety of physiological effects. Intense states of emotional stress can affect immune system function. Emotions such as guilt or shame can elicit a physical response, for example, stomach aches or other bodily discomfort. During depressive episodes, feelings of fatigue and lethargy tend to be overwhelming. Chronic resentment can cause behavior and relationship problems. We wish to explain the physiological effects of “negative” emotions such as fear and sadness. Understanding such effects will foster self-awareness, allowing us to develop tools to better manage our emotional states.

1.2 Literature Review

One previously found physiological effect of stress/trauma is upon immune function. For example, in a non-experimental study by Shirtcliff et al. (2009), researchers hoped to find a link between impaired immune system function and emotionally traumatized children by using results from testing HSV-1 (Herpes Simplex Virus -1) antibodies from emotionally traumatized adolescents. The researchers studied a combined group of 155 children who had been documented as targets of childhood trauma. Half of the children lived in homes with reported trauma and the other half experienced post-institutional trauma (adopted from institutions, orphanages, or hospitals). Two separate tests were conducted with the children. The first test was the “Measurement of Immune Competence”, calculated from the adolescent’s saliva samples that were collected six times a day for four days. The laboratory tested the saliva samples for the specific, “type sigA Assays”, (a specific type of immunoglobulin found in the body's mucous membrane) for the antibody that fights the HSV. The amount of antibodies was determined by ELISA (Enzyme-Linked Immunosorbent Assay), an analyzing tool. The second test was the Episodic Life Stress Interview (used to assess chronic and episodic stress), which was conducted with the adolescents and their parents separately to ascertain any existing or ongoing levels of stress. The outcomes from the post-institutionalized minors were higher in number than the minors who experienced trauma in the home, however both sets of results were higher than the unaffected control group who did not experience childhood trauma. The study did not find significant differences between the group’s herpes virus levels, but only in the increased amounts of antibodies for the herpes simplex-1 virus with the traumatized children. The results of the experiment clearly depict more immune system response which was evident by the unusually high levels of HSV-sigA antibodies. Based on these results, the researchers suggested that deprived children who suffer from childhood trauma not only have emotional wounds but have negative physiological symptoms such as impaired immune function.

A second previously found physiological effect of negative emotions is an increase in insula activity. For example, in an experimental study by Kross et al. (2011), researchers used fMRI technology to demonstrate the connection of a somatic response of rejection which encompasses many emotions that are described as social pain and compared to a physical pain response. Forty individuals who had experienced an unwanted breakup within a 6-month period were recruited to participate in the study. Participants in a social rejection task were presented with images of their ex-partner to whom they felt rejected, and a same-gendered friend that they, within a similar time frame, experienced a positive experience. Participants were then given a cue-phrase to associate to a specific experience and asked to visualize and focus on those moments. A physical pain task stimulus was delivered to participants' left forearm with a warm or hot thermal to stimulate distress during fMRI scanning. One physiological effect was an increase in insula activity. Participants then rated how they felt on a five-point scale (lower numbers meaning more distress). Participants reported experiencing greater distress in the ex-partner trial than the friend trial. Negative emotions were associated with an increase in insula activity.

A third previously found physiological effect of negative emotions is inflammation. For example, in a correlational study by Sharpley et al. (2019), researchers recruited individuals from rural Australia to measure the correlation between self-reports of fatigue-related depression, and the ratio of cortisol to C-reactive protein (CRP). Depression symptoms were measured using a 20-item Zung Self-rating Depression Scale. Specifically accounting for fatigue, item 10 stated “I get tired for now reason”; rated from 1 (none or a little of the time), to 4 (most or all of the time). They were then asked to provide saliva and blood samples to measure levels of cortisol and CRP respectively. The researchers found that elevated levels of CRP (which is produced when the body is experiencing higher levels of inflammation), rather than cortisol, had a higher correlation with those experiencing fatigue-related depression. Based on these results, the researchers suggested that those suffering from fatigue as a predominant symptom of their depression may be experiencing higher levels of inflammation, which would cause the influx of CRP within the bloodstream.

The literature has found that anger is related to prefrontal cortical activity. For example, in an experimental study by Ricciardi et al. (2013), researchers used fMRI technology to explore brain activity during forgiveness and unforgiveness. While in an fMRI scanner, ten healthy volunteers were verbally presented with a series of personalized narratives which described a neutral scenario (pre-hurtful condition) and a hurtful scenario (hurtful condition). Following each narrative, subjects were then instructed to either forgive the fictional offender or to harbour resentment and contemplate revenge (forgiving/unforgiving response condition). Using a five-point agreement scale ranging from 1 (not at all) to 5 (extremely), subjects gave self-assessments on their imaginative skills, anger levels, and ability to forgive/feel resentment while imagining hurtful events, as well as the degree of relief following forgiveness. Participants rated anger and frustration levels as significantly higher after imagining unforgiveness and contemplating revenge. Consistent with the hypothesis of Ricciardi et al. (2013), brain scans showed that forgiveness engages activation in the prefrontal cortex, part of the brain associated with information processing and emotion regulation. Subsequently during unforgiveness, significantly lower levels of activity in the prefrontal cortex were found. Based on these results, the researchers suggested that low prefrontal cortical activity is associated with resentment and unforgiveness.

1.3 Hypotheses

Based on the above literature review, we predicted the following hypotheses:

Hypothesis #1: If emotional trauma increases, immune system function will increase.

Hypothesis #2: If emotions elicited from social rejection increase then insula activity will increase.

Hypothesis #3: If fatigue increases then levels of inflammation will increase.

Hypothesis #4: If anger levels increase then prefrontal cortical activity will decrease.

2. Methods

2.1 Participants

The four authors of this paper served as the participants in its studies. The participants ranged in age from 22 to 57 years old, with an average age of 35 years, and included one cisgender man and three cisgender women. The participants were all undergraduate students at Camosun College who completed the current studies as an assignment for Psyc 215 (“Biological Psychology”) and were grouped together due to their mutual interest in the physiological effects of emotions. The majority of participants had a history of mental health issues and/or childhood trauma.

2.2 Correlational Study Methods

We first performed a correlational study to test concurrently all four of our hypotheses by examining naturalistic daily changes in their variables longitudinally. Each participant kept a study journal with them at all times over this study’s one-week period in order to record self-observations of the four predictor variables (stress/trauma, social rejection, anger, and fatigue) and the four outcome variables (immune system activity, insula activity, inflammation, and prefrontal cortical activity).

2.2.1 Immune System Activity

To measure immune system activity, participants measured and documented fluctuations (increases or decreases) in their body temperature using an (oral or forehead) thermometer, at 5pm daily for seven days. The participants kept a daily journal of their temperatures (in Celsius degrees), where higher temperatures indicated greater immune system activity.

2.2.2 Social Rejection and Anger

To measure social rejection and anger levels, each participant completed a negative emotions test called the Social Rejection Lab (see Appendix B) at 5pm each day for a period of one week and recorded the results in their journals. The test described 9 situations with 2 questions per scenario for a total of 18 questions. For each scenario, participants first rated their concern level on a 1 to 6 scale with the following response anchors: 1 = very unconcerned, 6 = very concerned. Second, participants rated on a 1 to 6 scale, (1 = very unlikely, 6 = very likely) how likely they would expect the described response from the person in the scenario. We then totaled the individual item scores to create an overall score ranging from 18 to 108, with higher scores representing greater social rejection/anger levels.

2.2.3 Fatigue

To measure fatigue, participants were instructed to fill out a Likert-style questionnaire consisting of a single self-rated question. This questionnaire was to be filled out at the same time, 5pm, every day, for seven days. The question asked participants to rate their levels of fatigue between 0 and 10 (where 0 was not tired, and 10 was extremely tired), which they were instructed to record in their journals.

2.2.4 Trauma

To measure trauma, each participant evaluated their negative emotions such as anger, confusion, guilt, and worthlessness all taken from the POMS scale to measure their daily intensity on the scale (see Appendix A). The list of negative emotions were rated by each participant with a number scale, (1) being “not at all” and (5) being “extremely. Each participant recorded their daily scores, which were then tallied once the test was completed. The possible range of scores was between 18 to 90, with higher scores meaning more emotional trauma.

2.2.5 Insula Activity

To measure insula activity, each group member was instructed to keep track of the number of times they experienced gut sensation throughout the day for seven days. ‘Gut’ sensation can be defined by stomach pain, “gut feeling”, “butterflies”, cramps, or stomach tension. Once members have tracked the number of times throughout the day they experienced ‘gut’ sensations , this number was then tallied for each day.

2.2.6 Inflammation

To measure levels of inflammation, participants were instructed to measure the diameter of their right bicep, at the same time, 5pm, every day, for seven days. Participants were told to let their right arm hang relaxed by their side. They were then instructed to gently wrap a piece of string around their bicep, ensuring the string was tight enough to always be in contact with their skin, but not too tight as to make any depression in the skin. Participants were then told to measure the piece of string with a ruler and record the length, in cm, in their journals. Larger bicep diameters indicated greater inflammation.

2.2.7 Prefrontal Cortical Activity

To measure prefrontal cortical activity, participants completed the Berg’s Card Sorting Task through the Psych Lab 101 app at 5pm each day and recorded the results in their journals. Participants downloaded the app and used their cellphones to complete the task for the duration of the study. Participants sorted a series of cards and matched them to one of the four pile options. Each card had some number or coloured shapes and could be matched based on the number of shapes on the card, the color of the shapes, or the shape type. Participants were not told how to sort the cards but rather had to use their judgement to determine which feature of the card was most important. Based on these data, the daily average of prefrontal cortical activity was calculated for each participant by determining the degree of accuracy with which the card sorting task was completed. To do this, we divided the number of correct sorts by the total number of trials for each day of the study.

2.3 Correlational Study Planned Analyses

To assess the strength and statistical significance of associations between variables predicted by our four hypotheses, we performed Pearson product moment correlations of their predictor variables (stress/trauma, social rejection/anger, and fatigue) with their outcome variables (immune system activity, insula activity, inflammation, and prefrontal cortical activity). For testing Hypothesis #1, we correlated each participants' daily levels of stress/trauma with measurements of body temperature (which was an indicator of immune system function). For testing Hypothesis #2, we correlated each participant’s daily social rejection/anger score with that participant’s average self-reported gut sensation (which was an indicator of insula activity). For testing Hypothesis #3, we correlated self-reported levels of fatigue with bicep circumference (which was an indicator of inflammation). For testing Hypothesis #4, we correlated each participant's daily social rejection/anger score with that participant’s average Berg’s Card Sorting Task score (which was an indicator of prefrontal cortical activity). We performed all of the above correlations separately for each participant as well as using data pooled across all of the participants. For the correlations using pooled data, in addition to using the raw data, we also performed correlations after we had first transformed the data from each participant into *z*-scores in order to standardize differences in averages and variability seen between the participants in their data and thus make them more comparable. A correlation coefficient was considered statistically significant if the probability of its random occurrence (p) was < .05 (i.e., less than 5% of the time expected by chance alone).

2.4 Experimental Study Methods

Based on the strength of the correlation between anger and prefrontal cortex activity found in our correlational study, we then chose to conduct an experimental study to test for a causal relationship between these two variables from Hypothesis #4: If anger levels increase then prefrontal cortical activity will decrease.

We manipulated the independent variable, anger, over a one-week period by having participants alternate conditions (experimental “meditation” condition and control “no-meditation” condition using an ABAB design) across seven days. On experimental days, participants performed a five-minute meditation, laying on their backs on the floor in ‘corpse pose’ (arms by the side, with palms up) in an undisturbed room. Participants set a five-minute timer on their phones and listened to a healing frequency audio track while also following a basic breathing technique of 4-4-8 (four seconds of inhale, four seconds holding their breath in, and eight seconds of exhale) in order to induce a state of calm. Afterwards, they rated their levels of anger using the Social Rejection Lab test, with scores possibly ranging from 18 - 108 and higher scores indicating higher levels of anger. Participants then completed the Berg’s Card Sorting Task, a type of neuropsychological test, to measure levels of prefrontal cortex functioning. Participants were left with a percentage score, with higher percent scores indicating higher levels of prefrontal cortex activity. Both levels of anger and prefrontal cortex activity were recorded. On control days, no meditation was performed but the same Social Rejection Lab test and Berg’s Card Sort Task described above were taken.

Since participants were aware of on which days they were receiving experimental and control conditions, it was not possible to control for expectancy effects. Order effects were controlled for by alternating experimental days and control days (an ‘ABAB’ design). To account for time of day and environmental confounds, participants completed the neuropsychological test, subjective test, and meditation at the same time and place each day.

2.5 Experimental Study Planned Analyses

To assess the statistical significance of differences seen in prefrontal cortical activity on meditation experimental days vs. no-meditation control days, Student’s t-tests were performed. We performed t-tests separately for each participant as well as using data pooled across all of the participants. For the t-tests using pooled data, in addition to using the raw data, we also performed t-tests after we had first transformed the data from each participant into z-scores in order to standardize differences in averages and variability seen between the participants in their data and thus make them more comparable. An average difference between conditions was considered statistically significant if, using a one-tailed distribution (i.e., to determine if there is a difference between groups in a specific direction), the probability of its random occurrence (p) was < .05 (i.e., less than 5% of the time expected by chance alone).

3. Results

3.1 Correlational Study Results

Based on our correlation study results, it was determined that none of our correlations held any statistical significance ($p < .05$), refer to Table 1. For Hypothesis #1, no significant correlation was found between emotional trauma and immune system functioning using our pooled standardized data ($r = 0.15$, $p = 0.46$; see Figure 2). For Hypothesis #2, no significant correlation was found between emotions elicited from social rejection and insula activity using our pooled standardized data ($r = 0.07$, $p = 0.80$; see Figure 4). For Hypothesis #3, no significant correlation was found between fatigue and levels of inflammation using our pooled standardized data ($r = -0.10$, $p = 0.60$; see Figure 6). For Hypothesis #4, no significant correlation was found between anger levels and prefrontal cortical activity using our pooled standardized data ($r = 0.22$, $p = 0.26$; see Figure 8). Across all of these correlations using our pooled standardized data, Hypothesis #4 (prefrontal cortex activity and subjective states of anger) was found to have the highest correlation, with an r value of 0.22.

3.2 Experimental Study Results

There were some minor differences in group means from the Berg's Card Sorting Task test scores as a function of the meditation vs no meditation conditions (control M = 74.33 vs experimental M = 76.38; see Table 2). However, after performing the appropriate *t*-test using our pooled raw data, this difference in prefrontal cortex functioning did now show any statistical significance ($p = 0.13$; see Figure 9)). There were also differences found in group means of subjective anger as a function of the meditation vs no meditation conditions (control M = 33.08 vs experimental M = 29.31; see Table 3). After performing the appropriate *t*-test using our pooled standardized data, this difference in anger did show statistical significance ($p = 0.02$).

4. Discussion

4.1 Summary of Results

At the beginning of our research project, we sought to understand if negative emotional states (trauma, social rejection, fatigue, and anger) would affect physiological variables (immune system functioning, insula activity, inflammation, and prefrontal cortical activity). After testing it was concluded that none of our results were statistically significant.

4.2 Relation of Results to Past Research

Our current correlational study failed to find a relationship between emotional trauma and immune functioning as previously researched by Shirtcliff et al. (2008). Our study methods varied in the following ways. We tested immune response by monitoring fluctuations in body temperature with a thermometer for seven days, whereas the previous study by Shirtcliff et al. (2008) tested the subject's saliva for increased numbers of HSV-1 antibodies. Emotional trauma was measured as each participant evaluated their daily negative emotions with the POMS scale for seven days. It may be that these differences of measurement methods may have been responsible for the differences in results seen. Our study also differed from the original study with our participants being adults, where the previous study involved children from emotionally traumatized backgrounds and the number of the children studied was roughly 155, and our study involved four adults. These speculations could be tested in the future if the tests were closer to the original testing with saliva samples, along with a larger number of participants, with at least one half to one third of the subjects being survivors of childhood trauma.

Our current correlational study was not effective in predicting if insula activity increased when emotions elicited from social rejection increased as was previously found by Kross et al. (2011). In our methods we used gut sensation to calculate insula activity which varied considerably for each participant. In contrast, the Kross et al. (2011) study used physical pain using warm and hot pads to elicit insula and other brain activity measured using fMRI, which provided a much more accurate measurement and much more controlled environment as counting gut sensation in a day may be interpreted differently among group members and at different levels of sensation. This section was a challenge because there are no ways to ethically test (inflict pain) or gut sensation and measure the sensation response ethically in a class environment. In the future the insula activity (outcome variable) could have been better measured by measuring gut sensation on a scale from 1 to 10 as a way to see how strong the sensation was directly after the social rejection task. This way there would be less external variables involved and the measurement might be more accurate.

Our current correlational study was not effective in predicting levels of inflammation as a function of fatigue, as did previous research by Sharpley et al. (2019). In our methods, we used a measuring tape in order to calculate levels of inflammation in a specific part of the body, the arm (bicep), as opposed to Sharpley et al. (2019), who used blood samples to measure levels of CRP in the bloodstream; providing a more global measure of inflammation. Our method may have proven to be too localized, failing to account for inflammation in other parts of the body. The measure of inflammation itself was also subject to several confounding variables, such as the tightness of string on the participant’s arm, level of relaxation the subject could achieve while measuring their arm, and level of exercise the subject engaged in during any given day. Fatigue was also prone to several external factors. Although we used the same survey style questionnaire as previous research, the duration of participants' sleep was not controlled, leaving room for fatigue as a result of sleep deprivation, rather than inflammation. Other confounding variables included diet, amount of socialization, and other external emotional stressors that could have skewed the results. In the future, it would be effective to account for variables such as the participant’s hours of sleep per night, a more global measure of inflammation (blood or saliva samples), and other external emotional stressors.

Our correlational and experimental studies failed to find the relationship between prefrontal cortical activity and anger reported by previous research. Ricciard et al. (2013) found that unforgiveness (resentment/anger) of an imagined offender was associated with decreased prefrontal cortical activity (specifically in the dorsolateral prefrontal cortex). Conversely, all but one of our participants found that increased anger levels did not result in decreased prefrontal cortical activity, with anger scores resulting in much wider variations. The discrepancies in our findings may be the result of two methodological differences in our correlational study as compared to the Riccardi et al. (2013) study. First, the findings could have been affected by the different procedures used to measure cortical activity. While our experiment used the Berg’s Card Sorting Task (BCST) to measure cortical activity, measurements by Riccardi et al. (2013) were taken using fMRI technology. Second, the Riccardi et al. (2013) study used tailored scenarios that were specific to each participant, while our study relied on a non-personalized Likert scale. Consequently, our experimental study did not find any causal relationship between anger and prefrontal cortex activity. There are multiple confounds, similar to the correlational study, that could have skewed these results. Each participant performed the Berg's Card Sorting Task every day which could have led to test-retest biases, as well as expectancy biases. Participants were also not controlled for hours slept, daily caloric intake, total hours of exercise, or time spent with friends and family, all which could have an effect on anger levels.

4.3 Implications of Results

Our study indicates that anger-inducing situations are not enough to affect prefrontal cortex functioning. For some participants, we found that our manipulation (meditation) did significantly reduce anger, however, it was not enough to find a causal effect on prefrontal cortical activity.

In this paper, we sought to understand why some negative emotions can have a physiological effect on the body, so that we could learn to better manage, and normalize, our reactions in emotionally stimulating situations. Through experimentation, we found there was no causal relationship between anger and prefrontal cortex activity, despite showing that meditation was an effective strategy in mitigating anger. During both correlational and experimental studies of anger and prefrontal cortex activity, we did not find any significant relationship between these two variables. This may have implications on the nature of anger and cortical functioning, suggesting that other negative emotions may play a more critical role in cognitive functioning.

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Table 1

Correlations for Study Variables

Variables	Participant #1		Participant #2		Participant #3		Participant #4		Pooled raw data		Pooled standardized data	
	r	*n*	*r*	*n*	*r*	*n*	*r*	*n*	*r*	*n*	*r*	*n*
Trauma & Immune System Activity	0.37	7	-0.17	7	0.02	7	0.38	7	0.07	28	0.15	28
Social Rejection & Insula Activity			-0.29	7	0.46	7	0.05	7	0.39	21	0.07	21
Fatigue & Inflammation	0.30	7	0.19	7	-0.47	7	-0.43	7	0.12	28	-0.10	28
Anger & Prefrontal Cortical Activity	0.01	7	0.03	7	0.1	7	0.76	7	0.07	28	0.22	28

* $p < .05$.

Table 2

Descriptive Statistics for Card Sorting Task Across Different Meditation vs No Meditation Conditions

Condition	Statistic	Participant #1	Participant #2	Participant #3	Participar #4	Pooled standardized data	Pooled raw data
Meditation	*M*	77.00	76.25	74.25	78.00	0.15	76.38
	SD	2.45	2.22	5.12	4.08	0.89	3.58
	n	4.00	4.00	4.00	4.00	16.00	16.00
No Meditation	*M*	76.67	77.33	68.00	75.33	-0.20	74.33
	SD	4.73	2.52	6.08	2.52	1.01	5.31
	n	3.00	3.00	3.00	3.00	12.00	12.00

Note. *M*, *SD*, and *n*, represent mean, standard deviation, and sample size, respectively (% scores).

* $p < .05$ for comparison of meditation condition with its respective no meditation condition.

Table 3

Descriptive Statistics for Anger (Social Rejection Lab Test) Across Different Meditation vs No Meditation Conditions

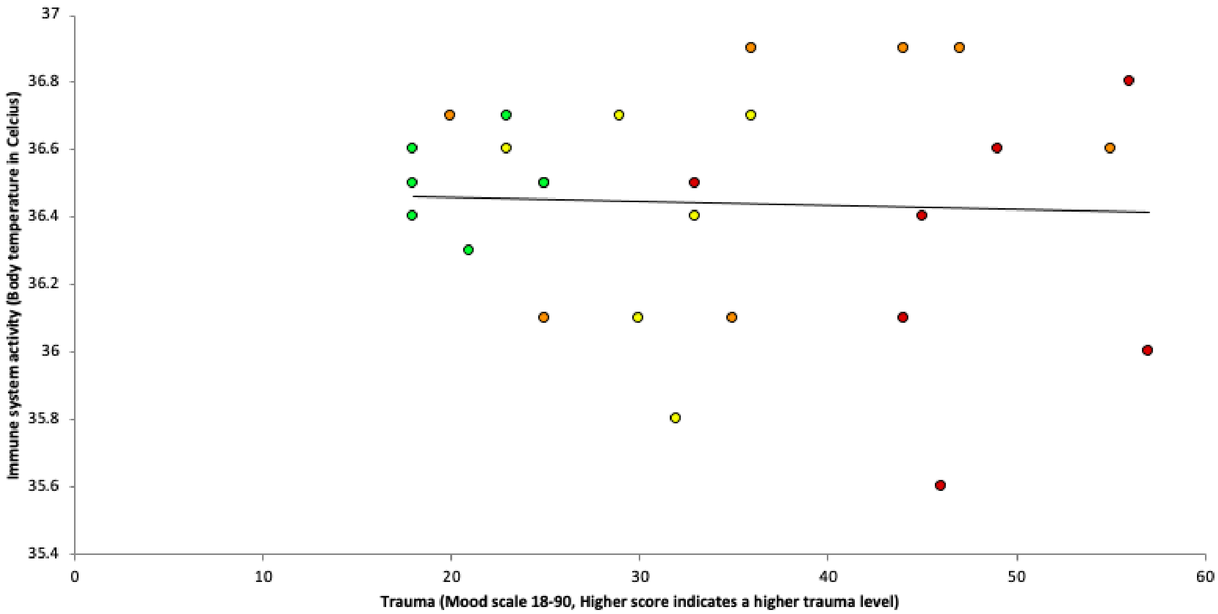
Condition	Statistic	Participant #1	Participant #2	Participant #3	Participar #4	Pooled standardized data	Pooled raw data
Meditation	*M*	29.00	28.50	26.50	33.25	-0.30	29.31*
	SD	1.83	5.92	4.51	20.21	0.86	9.99
	n	4.00	4.00	4.00	4.00	16.00	16.00
No Meditation	*M*	35.33	40.67	25.67	30.67	0.41	33.08
	SD	2.89	1.53	8.33	12.01	0.92	8.63
	n	3.00	3.00	3.00	3.00	12.00	12.00

Note. *M*, *SD*, and *n*, represent mean, standard deviation, and sample size, respectively.

* $p < .05$ for comparison of meditation condition with its respective no meditation condition.

Figure 1

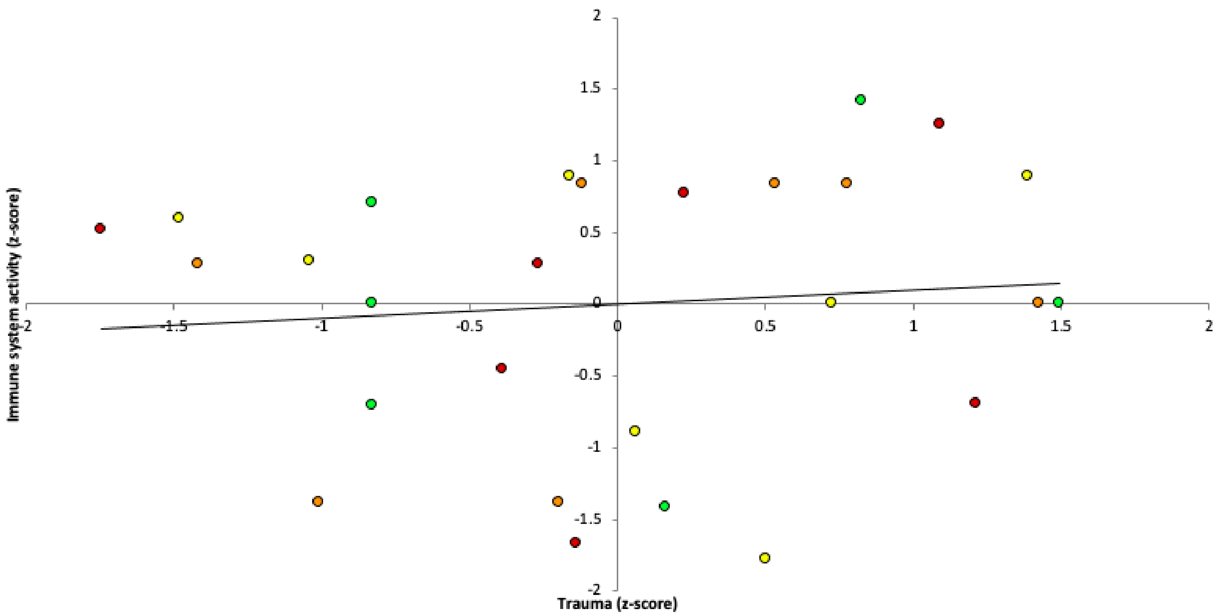
Association Between Trauma and body temperature in Celsius Using Pooled Raw Data



Notes. Marker colour differentiates participants: red = participant #1, orange = participant #2, and yellow = participant #3, green = participant #4. Some data might not be visible in the figure due to overlapping markers.

Figure 2

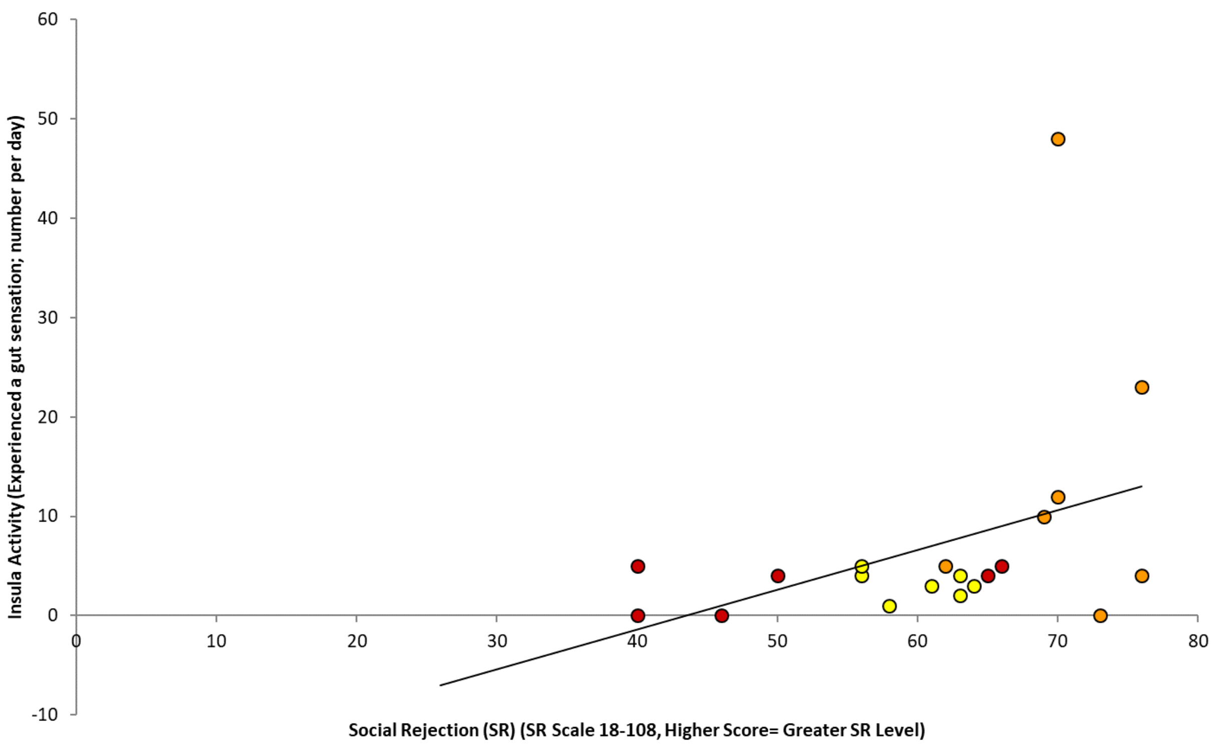
Association Between immune system activity and Mood scale 18-90, Higher score indicates a higher trauma level Using Pooled Standardized Data



Notes. Marker colour differentiates participants: red = participant #1, orange = participant #2, and yellow = participant #3, green = participant #4. Some data might not be visible in the figure due to overlapping markers.

Figure 3

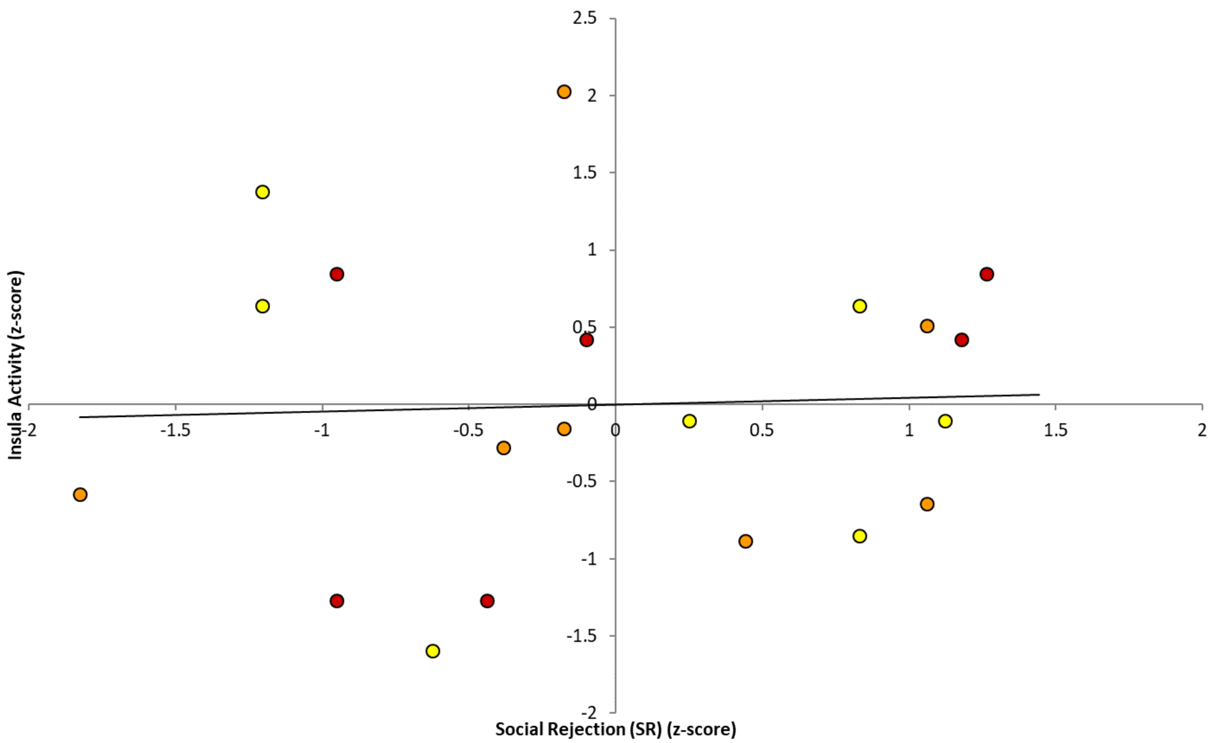
Association Between social rejection scale and gut sensation Using Pooled Raw Data



Notes. Marker colour differentiates participants: red = participant #1, orange = participant #2, and yellow = participant #3. Some data might not be visible in the figure due to overlapping markers.

Figure 4

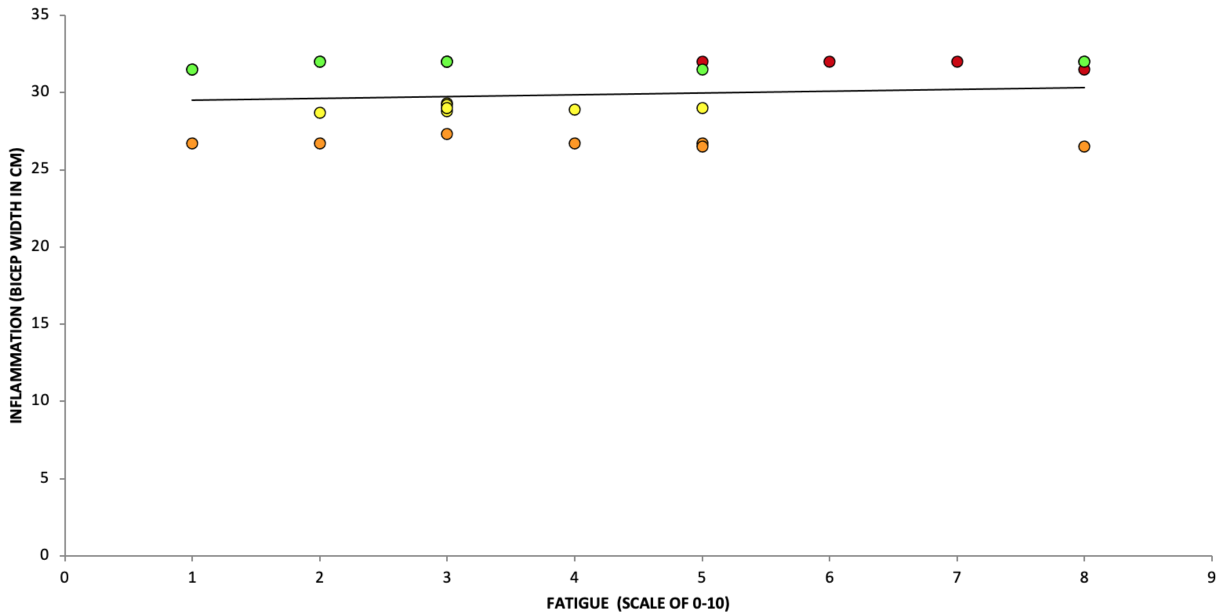
Association Between social rejection scale and gut sensation Using Pooled Standardized Data



Notes. Marker colour differentiates participants: red = participant #1, orange = participant #2, and yellow = participant #3. Some data might not be visible in the figure due to overlapping markers.

Figure 5

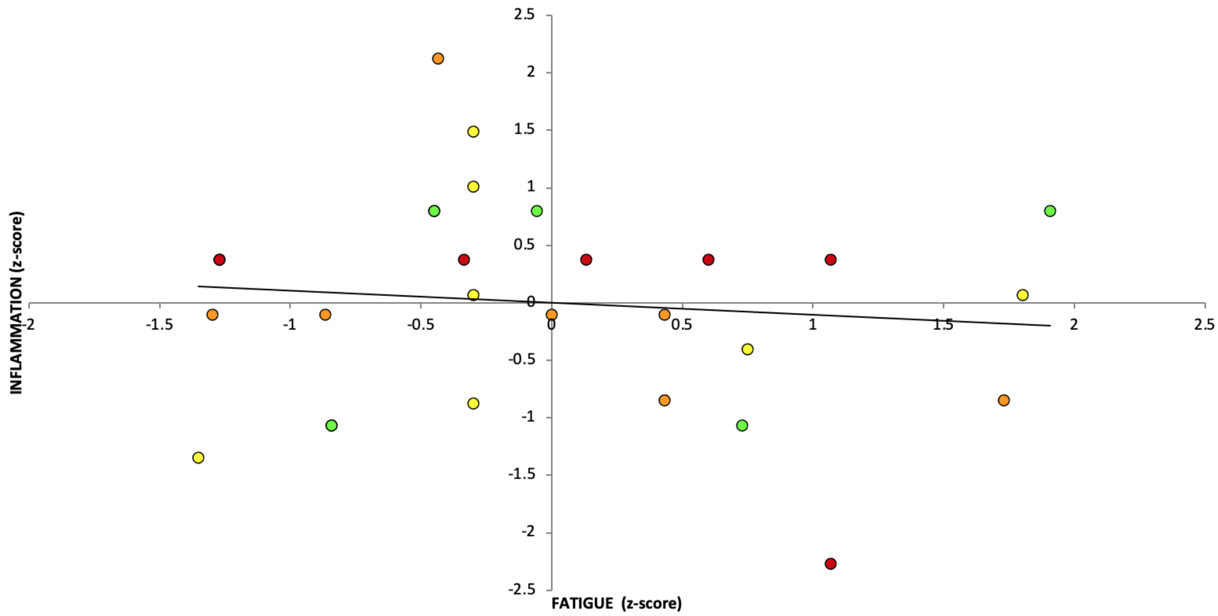
Association Between inflammation and fatigue Using Pooled Raw Data



Notes. Marker colour differentiates participants: red = participant #1, orange = participant #2, yellow = participant #3, and green = participant #4. Some data might not be visible in the figure due to overlapping markers.

Figure 6

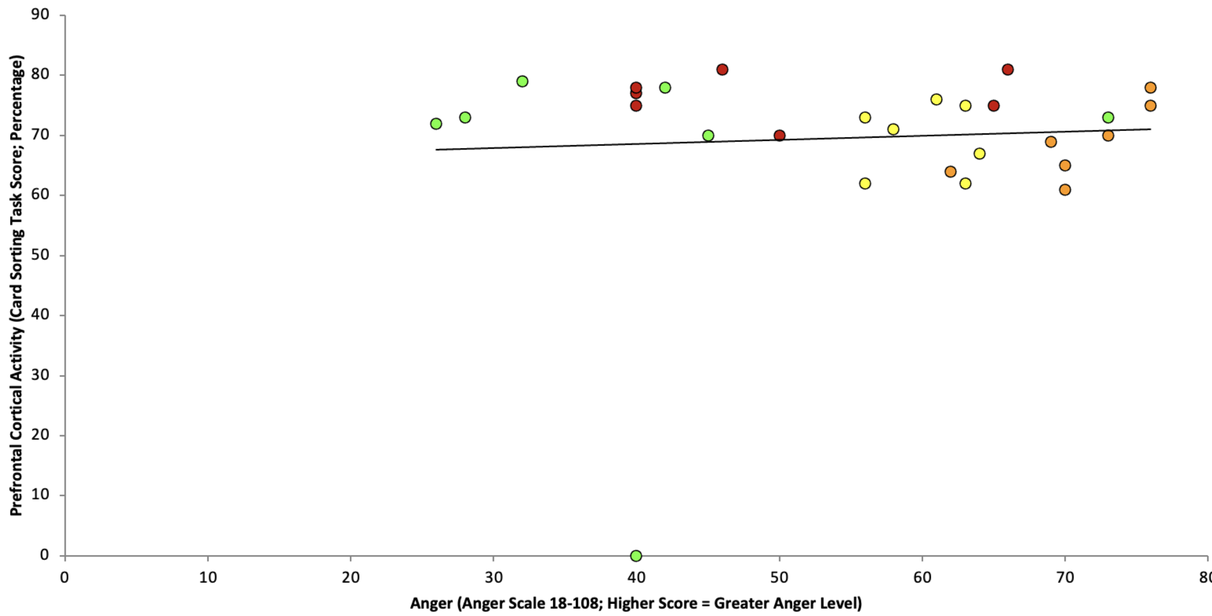
Association Between inflammation and fatigue Using Pooled Standardized Data



Notes. Marker colour differentiates participants: red = participant #1, orange = participant #2, yellow = participant #3, and green = participant #4. Some data might not be visible in the figure due to overlapping markers.

Figure 7

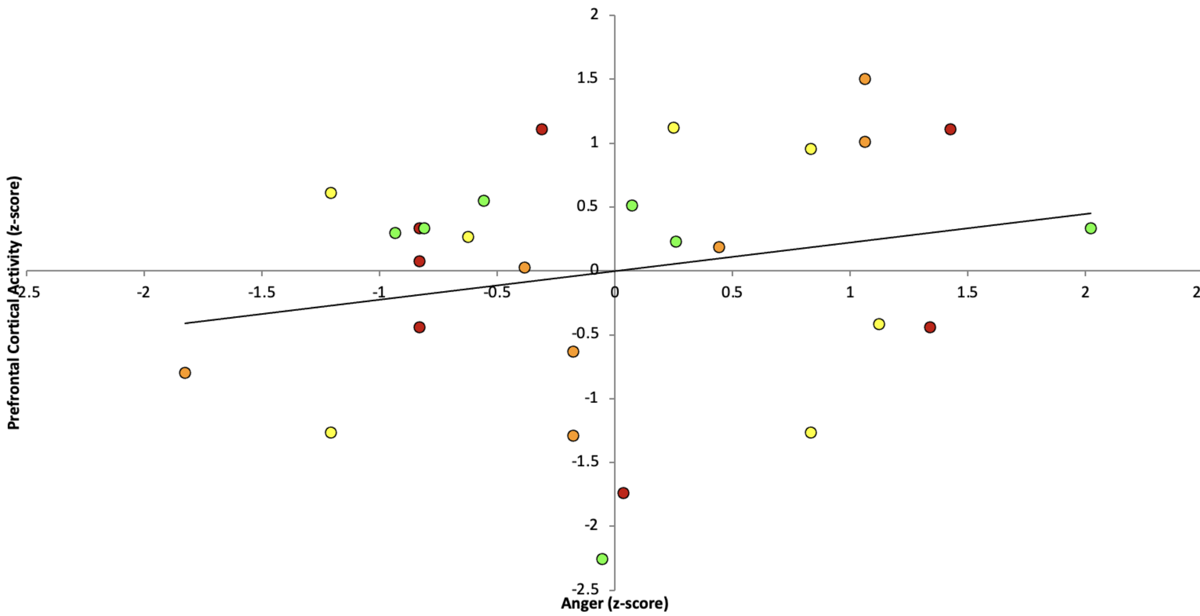
Association Between Anger and Prefrontal Cortical Activity Using Pooled Standardized Data



Notes. Marker colour differentiates participants: red = participant #1, orange = participant #2, and yellow = participant #3, green = participant #4. Some data might not be visible in the figure due to overlapping markers.

Figure 8

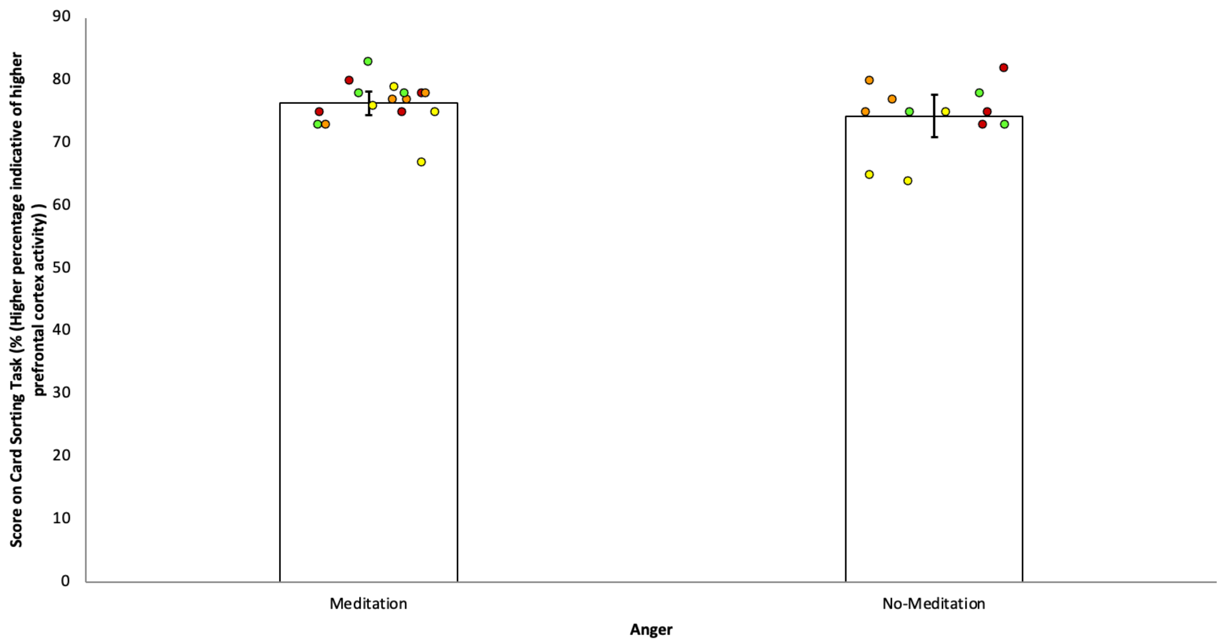
Association Between Anger and Prefrontal Cortical Activity Using Pooled Standardized Data



Notes. Marker colour differentiates participants: red = participant #1, orange = participant #2, and yellow = participant #3. Some data might not be visible in the figure due to overlapping markers.

Figure 9

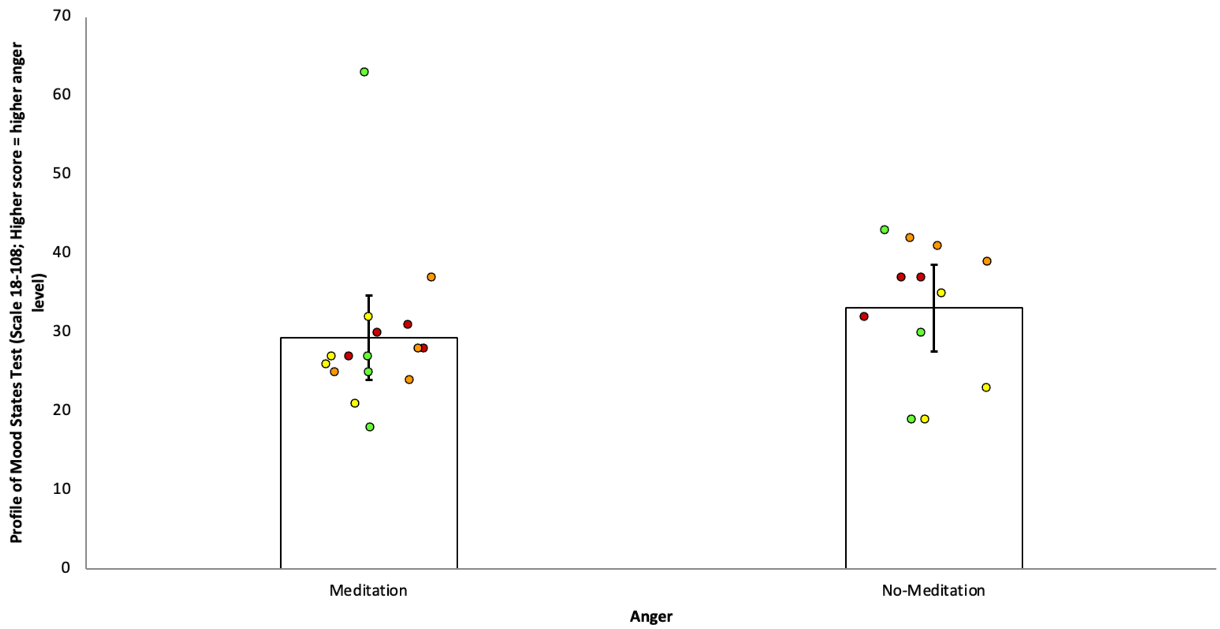
Average Score on Berg's Card Sorting Task Across Different Meditation Conditions Using Pooled Raw Data



Notes. Berg's Card Sorting Task scores are shown for meditation and no-meditation conditions using pooled raw data from all participants. Error bars show ± 95% confidence levels. Overlapping scatterplot shows data from each participant. Marker colour differentiates participants: red = participant #1, orange = participant #2, yellow = participant #3, and green = participant #4.

Figure 10

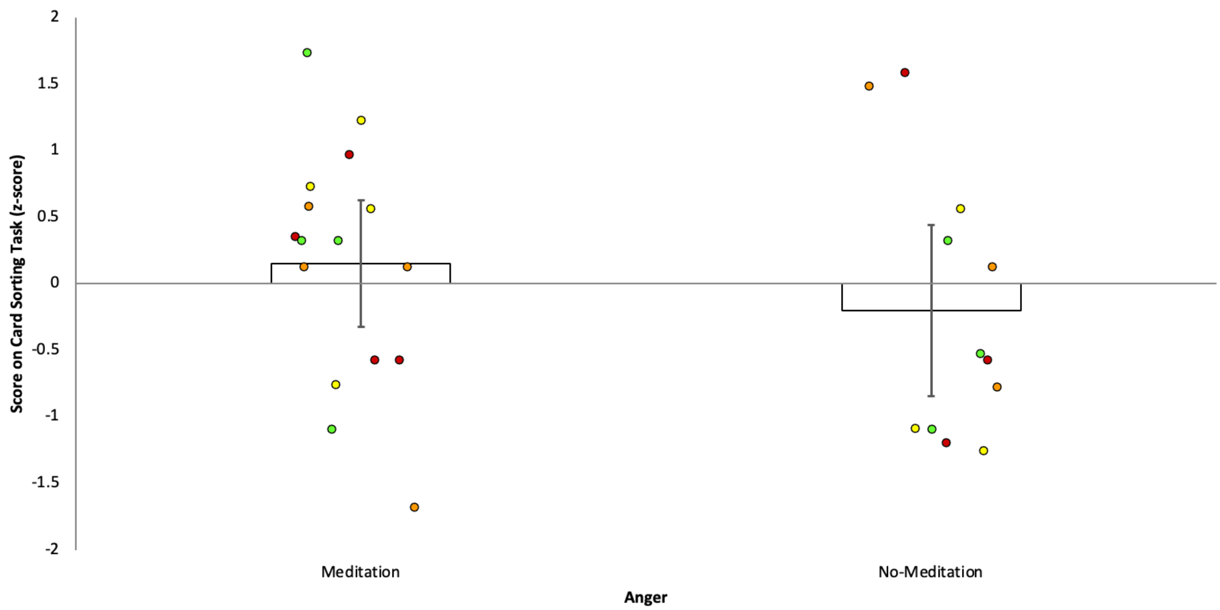
Average Score of Mood States Test Across Different Meditation Conditions Using Pooled Raw Data



Notes. Mood States Test scores are shown for meditation and the no-meditation conditions using pooled raw data from all participants. Errors bars show ± 95% confidence levels. Overlapping scatterplot shows data from each participant. Marker colour differentiates participants: red = participant #1, orange = participant #2, yellow = participant #3, and green = participant #4.

Figure 11

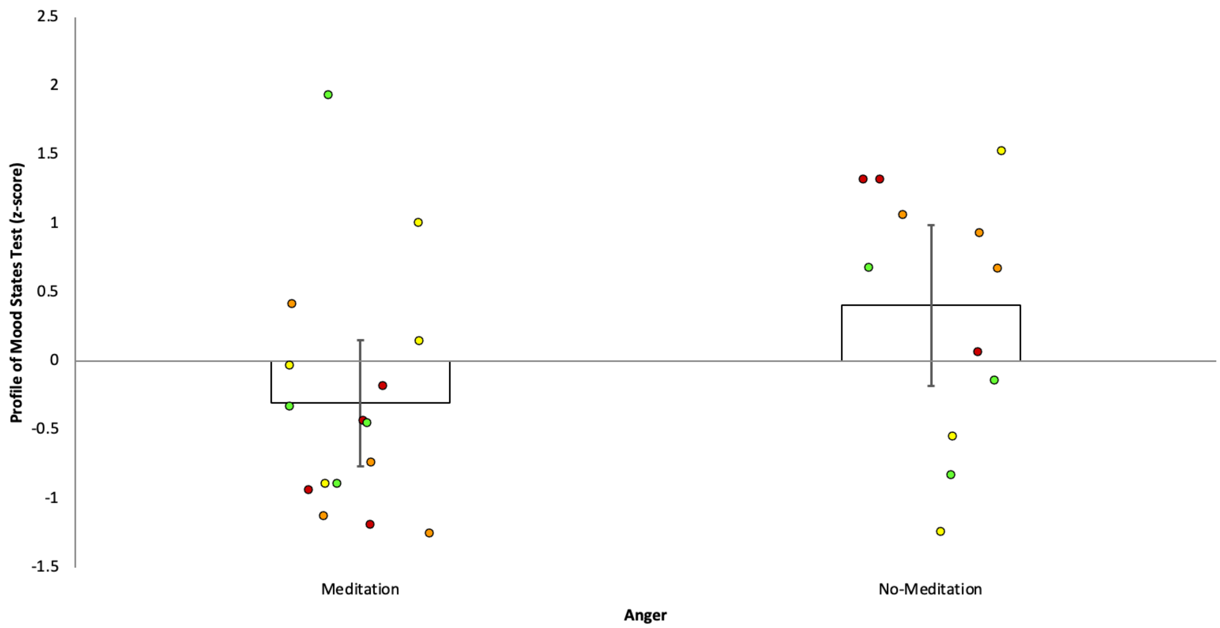
Average Score of Berg's Card Sorting Task Across Different Meditation Conditions Using Pooled Standardized Data



Notes. Berg's Card Sorting Task scores are shown for meditation and the no-meditation conditions using pooled standardized data from all participants. Errors bars show ± 95% confidence levels. Overlapping scatterplot shows data from each participant. Marker colour differentiates participants: red = participant #1d, orange = participant #2, yellow = participant #3, and green = participant #4.

Figure 12

Average Score of Moods States Test Across Different Meditation Conditions Using Pooled Standardized Data



Notes. Mood States Test scores are shown for meditation and the no-meditation conditions using pooled standardized data from all participants. Errors bars show ± 95% confidence levels. Overlapping scatterplot shows data from each participant. Marker colour differentiates participants: red = participant #1, orange = participant #2, yellow = participant #3, and green = participant #4.

Appendix A

The Profile Of Mood States (POMS) Scale

Profile of Mood States

Subject's Initials _______
Birth date _______
Date _______

Directions: Describe HOW YOU FEEL at 5pm daily for seven days, by checking one space after each of the words listed below:

FEELING	Not at all	A little	Moderate	Quite a bit	Extremely
Tense	1	2	3	4	5
Angry	1	2	3	4	5
Worn Out	1	2	3	4	5
Confusion	1	2	3	4	5
Guilt	1	2	3	4	5
Panicky	1	2	3	4	5
Unworthy	1	2	3	4	5
Spiteful	1	2	3	4	5
Uneasy	1	2	3	4	5
Fatigued	1	2	3	4	5
Annoyed	1	2	3	4	5
Exhausted	1	2	3	4	5
Anxious	1	2	3	4	5
Ready to fight	1	2	3	4	5
Worthlessness	1	2	3	4	5
Desperate	1	2	3	4	5
Weary	1	2	3	4	5
Deceived	1	2	3	4	5

Appendix B

Social Rejection Lab Test. Retrieved October 14, 2021, from https://socialrelationslab.psychology.columbia.edu/content/measures.

When using the Social Relations scale, imagine the scenario personal to your own experiences in order to get a more accurate rating when testing.

The items below describe situations in which people sometimes ask things of others.
For each item, **imagine that you are in the situation, and then answer the questions that follow it**.

1. You ask your parents or another family member for a loan to help you through a difficult financial time.

How concerned or anxious would you be over whether or not your family would want to help you? — very unconcerned 1 2 3 4 5 6 very concerned

I would expect that they would agree to help as much as they can. — very unlikely 1 2 3 4 5 6 very likely

2. You approach a close friend to talk after doing or saying something that seriously upset him/her.

How concerned or anxious would you be over whether or not your friend would want to talk with you? — very unconcerned 1 2 3 4 5 6 very concerned

I would expect that he/she would want to talk with me to try to work things out. — very unlikely 1 2 3 4 5 6 very likely

3. You bring up the issue of sexual protection with your significant other and tell him/her how important you think it is.

How concerned or anxious would you be over his/her reaction? — very unconcerned 1 2 3 4 5 6 very concerned

I would expect that he/she would be willing to discuss our possible options without getting defensive. — very unlikely 1 2 3 4 5 6 very likely

4. You ask your supervisor for help with a problem you have been having at work.

How concerned or anxious would you be over whether or not the person would want to help you? — very unconcerned 1 2 3 4 5 6 very concerned

I would expect that he/she would want to try to help me out. — very unlikely 1 2 3 4 5 6 very likely

5. After a bitter argument, you call or approach your significant other because you want to make up.

How concerned or anxious would you be over whether or not your significant other would want to make up with you? — very unconcerned 1 2 3 4 5 6 very concerned

I would expect that he/she would be at least as eager to make up as I would be. — very unlikely 1 2 3 4 5 6 very likely

6. You ask your parents or other family members to come to an occasion important to you.

How concerned or anxious would you be over whether or not they would want to come? — very unconcerned 1 2 3 4 5 6 very concerned

I would expect that they would want to come. — very unlikely 1 2 3 4 5 6 very likely

7. At a party, you notice someone on the other side of the room that you'd like to get to know, and you approach him or her to try to start a conversation.

How concerned or anxious would you be over whether or not the person would want to talk with you? — very unconcerned 1 2 3 4 5 6 very concerned

I would expect that he/she would want to talk with me. — very unlikely 1 2 3 4 5 6 very likely

8. Lately you've been noticing some distance between yourself and your significant other, and you ask him/her if there is something wrong.

How concerned or anxious would you be over whether or not he/she still loves you and wants to be with you? — very unconcerned 1 2 3 4 5 6 very concerned

I would expect that he/she will show sincere love and commitment to our relationship no matter what else may be going on. — very unlikely 1 2 3 4 5 6 very likely

9. You call a friend when there is something on your mind that you feel you really need to talk about.

How concerned or anxious would you be over whether or not your friend would want to listen? — very unconcerned 1 2 3 4 5 6 very concerned

I would expect that he/she would listen and support me. — very unlikely 1 2 3 4 5 6 very likely