Trauma and Emotional Processing: Does Subtype of Child Maltreatment Matter?

By

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Abstract

The present research looks at the processing of emotional faces in a sample of adults with childhood trauma to assess how the type of maltreatment reported (emotional, sexual, or physical), as well as the action of maltreatment (abuse or neglect), affects event-related potential (ERP) N170 peaks. More broadly, the paper assesses the relationship between scores on the 28-item Childhood Trauma Questionnaire (CTQ-28) and reactivity during an emotional face-processing task.

The present study emphasizes two research questions: (1) Does childhood trauma disproportionately impact the emotional processing of angry faces? (2) Does the subtype of childhood trauma have a significant effect on the value of N170 peaks in emotional processing tasks? These questions are answered through three hypotheses, analyzed using regression and ANOVA analysis.

H1: Higher rates of childhood maltreatment (represented by higher CTQ-28 scores) will have a greater effect on the slope of N170 peaks for the angry face condition than for the neutral face condition.

H2: A history of neglectful maltreatment will correlate with stronger ERP N170 frequencies during the face-viewing task than a history of physical and sexual abuse.

H3: Emotional types of maltreatment (emotional abuse and neglect) will correlate with stronger ERP N170 frequencies during the face-viewing task.

Statistical support is found for all three hypotheses, and implications are discussed.

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Introduction

From everyday interactions to dubious scientific claims about body language lie detection in courtrooms, our ability to interpret other individuals' emotions impacts how we understand the world around us. Unfortunately, facial processing is often impaired for individuals with a history of traumatic events (da Silva Ferreira et al., 2014). Facial processing is one of many areas that are markedly inhibited in individuals with a history of adverse childhood experiences, which are also associated with worse health outcomes (Widom et al., 2012). This may be because emotions function as a sensory modality that provides information about an individual (Rodriguez & Kross, 2023). Specifically, for an individual who is looking at another person, nonverbal cues in facial expression are used to assess the other person's state of mind. For example, in order to determine whether another individual is a threat, emotional processing determines whether negative emotions, such as anger, are present (Solms & Turnbull, 2002).

The impact of trauma on emotional processing disrupts normal risk assessment and can produce an oversensitivity to negative emotions, such as anger (Güntekin & Basar, 2007). Trauma researchers are increasingly observing how the presence of adverse childhood experiences affects emotional processing by subjecting patients to facial processing tasks, yet these studies often broaden all childhood trauma into one group (da Silva Ferreira et al., 2014). This study uses a facial processing task and specific trauma subtype coding to assess whether certain subtypes of trauma may have more weight on long-term emotional processing.

Childhood Trauma

Classifying Childhood Trauma

Child maltreatment is defined broadly by federal law, with the intention that states implement their own definitions for different domains. According to the amended Federal Child

Abuse Prevention and Treatment Act (CAPTA), child maltreatment is “Any act or failure to act on the part of a parent or caretaker which results in death, serious physical or emotional harm, sexual abuse or exploitation; or an act or failure to act which presents an imminent risk of serious harm” (42 U.S.C.A. §5106g). These definitions exist for the prevention of parental or familial abuse and neglect. Childhood trauma is often quantified for social science research using the Childhood Trauma Questionnaire (CTQ), which assesses a range of childhood trauma subtypes through a variety of questions and allows respondents to rank the severity of their maltreatment using a Likert scale (Bernstein et al., 2003).

Researchers are becoming increasingly aware of the differences between neglect and abuse, both in the communities they are prevalent in and in the outcomes they represent. Neglect, in particular, represents a much wider category of child harm that can exist without any malicious intent from the parent. Neglect is also rooted in extra-familial factors, such as community poverty. Clearly, defining the type of child maltreatment that impacts emotional processing can draw clearer connections between adverse outcomes and early adverse experiences in childhood.

Childhood Trauma and Obsessive-Compulsive Disorder

This study samples participants with both an Obsessive-Compulsive Disorder (OCD) diagnosis and childhood trauma. OCD is a neuropsychological disorder that is highly individualized, though affected individuals commonly experience uncontrollable, intrusive obsessions and compulsions at a distressing level (Dykshoorn, 2014). OCD symptom presentation is often affected by and can even be triggered by traumatic childhood experiences. A growing body of research demonstrates links between early traumatic experiences and OCD development, but whether trauma is a direct cause or a symptom amplifier is still under

investigation. A 2011 analysis of the relationship between childhood trauma, inability to identify emotions, attachment disorders, and OCD symptom severity found that childhood trauma did not directly impact OCD symptoms but was a contributing factor to alexithymia, or inability to identify emotions, which mediates the effect of childhood trauma on OCD presentation (Carpenter & Cheung Chung 2011).

Childhood trauma has been found to predict aspects of OCD and has been linked to worse treatment outcomes in patients (Semiz et al., 2013). A recent meta-analysis (Ou et al., 2021) found that childhood maltreatment positively correlates with obsessive-compulsive symptom (OCS) severity and depressive symptoms. In addition, certain subtypes of childhood maltreatment, such as emotional abuse and sexual abuse, had a greater effect on OCS. The authors note that their results may fit into the posttraumatic obsessive-compulsive disorder modeling presented by Dinn et al. (1999), in which early childhood factors that cause hypersensitivity in the basal ganglia-orbitofrontal circuit contribute to the development of OCS and OCD.

Childhood Trauma and Health

Research is increasingly demonstrating the effect of early childhood neglect on biology. Lee et al. (2005) studied a sample of men who met the criteria for various personality disorders and found that higher childhood adversity correlated with higher biological markers of stress, specifically the presence of corticotrophin-releasing factor (CRF) in the cerebrospinal fluid (CSF) of participants. Higher levels of CRF can indicate stress, as CRF is a hypothalamus-produced hormone involved in a stress response that is also linked to extra hypothalamic neurons in depression and anxiety disorders (Arborelius et al., 1999).

Lee et al. (2005) found that total scores on the Childhood Trauma Questionnaire (CTQ) correlated with higher CRF CSF, but emotional neglect had the strongest effect on CRF CSF markers, and other factors were not significantly related to CRF CSF markers.

Emotional Processing

Event-related potential (ERP) stands out as a means of understanding how trauma affects the visual processing of emotions due to its ability to continuously measure processing between a stimulus and response. As opposed to behavioral procedures in data collection, ERP analysis can identify which stage of processing is being affected during the processing of stimuli. The American Psychological Association notes that childhood adversity and trauma are associated with ventromedial prefrontal cortical thinning, which are key areas in emotional and social processing (McLaughlin et al., 2020). The use of ERP, specifically on the N170 component, can help identify how specifically traumatic history impacts processing (Hinojosa et al., 2015).

Use of EEG and ERP

Electroencephalogram (EEG) analysis is an ideal unit for measuring emotional processing due to its high temporal resolution (Gevins et al., 1999). Further, EEG studies can capture cognitive processes using an exact time frame of when specific aspects of cognition are occurring. This timed measurement can be used to measure responses to stimuli, specifically by looking at an event-related potential (ERP) or specific changes in electrical signaling in the brain in direct response to a stimulus.

N170 Peaks and Faces

Facial recognition can be more precisely understood using the N170 peak component of ERP, as it focuses on the neural processing of faces. A meta-analysis by Hinojosa et al. (2015) of 57 studies using N170 analysis to evaluate participants' responses to neutral and emotional facial

expressions concluded that the N170 is sensitive to facial expressions, though it is heterogenous between different facial expression types. The study also found the N170 to have an amplitude more sensitive to unattended expressions, making it valuable for keeping track of the reference electrode when studying individuals' reactions. Overall, the authors conclude that N170 is a meaningful tool for studying how facial expressions are processed neurologically (Hinojosa et al., 2015).

The Emotional Oddball Task

The emotional oddball task measures how a brain responds to unexpected emotional stimuli, making it an optimal task for analyzing emotional processing. Rooted in cognitive neuroscience, the emotional oddball task provides clear stimuli for expected spatial dissociations that can be detected in temporal lobes by EEG electrodes. One variant of the emotional oddball task is the oddball face task, which uses unexpected emotional faces (angry, neutral, happy, and non-happy expressions) to assess these temporal responses through event-related potential, or ERP (Schlüter & Bermeitinger, 2017).

Current Study

The present study emphasizes two research questions using a dataset collected by an existing research team prior to this paper's analysis.

First, does childhood trauma disproportionately impact the emotional processing of angry faces? Second, does the subtype of childhood trauma have a significant effect on the value of N170 peaks in emotional processing tasks?

In response to the first question, I hypothesize that higher rates of childhood maltreatment (represented by higher CTQ-28 scores) will have a greater effect on the slope of N170 peaks for the angry face condition than for the neutral face condition. For the second question, I offer two

hypotheses (H2 and H3). First, I hypothesize that a history of neglectful maltreatment will correlate with stronger ERP N170 frequencies during the face-viewing task than a history of physical and sexual abuse. Further, I hypothesize that emotional types of maltreatment (emotional abuse and neglect) will correlate with stronger ERP N170 frequencies during the face-viewing task.

Method

Participants

Participants for this study were recruited using advertisements across the city of Chicago. Inclusion criteria included having an OCD diagnosis and a history of childhood trauma. Out of the participants sampled for a larger dataset, 15 were sampled for this study. The mean age of participants included in this sample is 35.77841113, and both sexes were included.

Procedure

Questionnaire

Participants were assigned a unique numerical ID for anonymity. All data collected in the study, including survey responses and EEG data, were attached to these IDs and stored such that no personally identifying information was accessible. Participants reported demographic information as well as responses to a 28-question Childhood Trauma Questionnaire (CTQ-28; Bernstein et al., 2003). The CTQ-28 is a retrospective assessment of maltreatment experienced by the individual completing the questionnaire before the age of 18. Five subtypes of trauma were assessed with five prompts each (a total of 25; the remaining 3 questions were not relevant to one of the five subtypes studied and instead focused on minimization and denial). The subtypes were physical neglect (for example, “not enough to eat”); emotional neglect (for example, “called names by family”); physical abuse (for example, “hit hard enough to leave

bruises"); emotional abuse (example, "felt loved [not often]"—this prompt is reverse-coded in the CTQ-28); and sexual abuse (example, "was molested") are reported quantitatively using a Likert scale. Some items were reverse-coded. Responding 1 indicated "never true," and responding 5 indicated "very often true" These questionnaires are scored in the present study across both domains and actions of maltreatment.

EEG Data Collection

To assess facial and emotional processing, participants completed the oddball face task. Participants' brain activity was recorded using 128 sintered Ag/AgCl active electrode head caps to assess cognitive activation during a series of preliminary tasks. Data were collected continuously while participants rested with their eyes closed, rested with their eyes open, and completed the facial recognition task. Here, participants were asked to state whether the face they were presented from the Ekman photo series was a happy or non-happy face (Ekman & Friesen, 2003). Happy faces were presented at a 3:1 ratio to angry and neutral faces. To remove noise, signal averaging was performed prior to data collection.

Analysis

EEG Data Processing

Raw EEG data previously collected by members of the lab were processed in MATLAB using the extension EEGLAB. Initial steps included filtering at 0.5 Hz to remove low-frequency noise and artifacts, down-sampling to reduce the file size from 1024 Hz to 512 Hz, and visual inspection of data to reject blocks of movement or other artifacts. Machine learning was used to identify brain and non-brain sources of data using independent component analysis (ICA), a linear decomposition technique. For example, blinking or grinding teeth together can be identified through the evaluation of the identified components based on temporospatial

properties. Removal of noise components was done linearly and minimized statistical impacts of non-relevant cognitive activity picked up by the EEG cap.

Next, ERPLAB was used to analyze differences in ERP between participants (Luck, 2014). An event list was created to allow for analysis of N170 peaks at specific events during the study or exposure to emotional faces. A BINLIST was created for each condition in order to properly capture relevant events for the angry and neutral face conditions. The data were then epoched to allow for further organization, and the average ERP was computed for each point. ERPs were then plotted to allow for a determination of which electrode the N170 peak was most prominently recorded by, and this peak was subsequently measured using ERPLAB and exported into a .txt file for later analysis. Two participants were removed at this point due to corrupted files that caused definitively abnormal N170 peaks. Their uncorrupted data was still used where applicable, but the participants were ineligible for comparison between the angry and neutral faces conditions as each only had one uncorrupted condition file.

Childhood Trauma Measures

Participants' responses to the CTQ-28 are scored across subtypes of physical abuse, physical neglect, emotional abuse, emotional neglect, and sexual abuse. These subtypes are used to form broader groups for analysis, specifically of domains and actions of childhood maltreatment. Domains of childhood maltreatment can be sexual, physical, or emotional, whereas actions of childhood maltreatment are either abuse or neglect. There is an ongoing investigation into the differences between the two actions, but neglect is definitionally a less active process than abuse and is often a result of non-action, as opposed to harmful action (Avdibegoviü & Brkiü, 2020).

Table 1

Table Showing Subtype Groups, by Category, with Included Subtypes

Category	Groups	Included Subtypes
Domain of Maltreatment	Sexual	Sexual Abuse
	Physical	Physical Abuse, Physical Neglect
	Emotional	Emotional Abuse, Emotional Neglect
Action of Maltreatment	Abuse	Sexual Abuse, Physical Abuse, Emotional Abuse
	Neglect	Physical Neglect, Emotional Neglect

Statistical Tests

After exporting N170 peaks from ERPLAB and calculating CTQ-28 sub-scores, statistical tests were run on the N170 peaks against existing CTQ-28 scores and sub-scores for each participant. Linear regression was performed across the dataset, and F-tests were performed to determine statistical significance. Analysis of Variance (ANOVA) was also used to determine the slope's statistical distinction from 0 ($p<0.05$). All statistical tests were run in OriginLab.

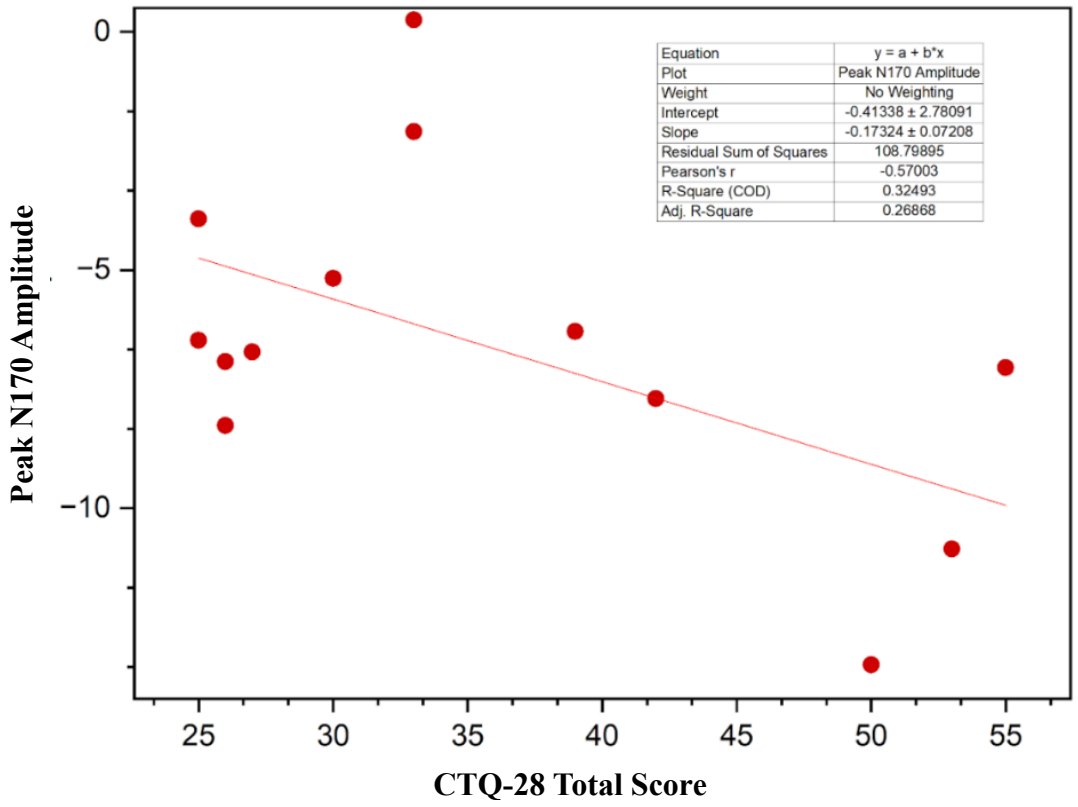
Results

Once N170 amplitudes were extracted from ERPLAB, they were input into a spreadsheet with the participant's CTQ-28. N170 regressions were compared with predictors such as the total CTQ-28 score and sub-scores. Additionally, analysis was done across experiments between N170 peaks viewing angry faces and neutral faces. All statistical analyses were done in OriginLab.

Pursuant to the first hypothesis regarding the difference in the processing of angry and neutral faces, CTQ-28 total score was linearly regressed against N170 peak amplitudes in both. In the angry face condition, the slope is -0.173 (±0.072), and the intercept is -0.413 (±2.781). The slope is significantly different from zero, with an ANOVA test yielding an F-value of 5.776, making the retaining of the null hypothesis 3.3%, lower than the cutoff at 5%. Hence, at the 0.05 level, the slope significantly differs from 0. For neutral faces, the slope is 0.0358 (±0.126), and the intercept is -7.877 (±4.534). With the error bar in the slope encompassing 0, the slope cannot be statistically differentiated from 0. Indeed, an ANOVA test showed that the F-value is 0.081, so there is a 78.1% confidence in retaining the null hypothesis, supporting the first hypothesis. Total CTQ-28 regressions are depicted in Figures 1 and 2 below (see Appendix A for residual plots).

Figure 1

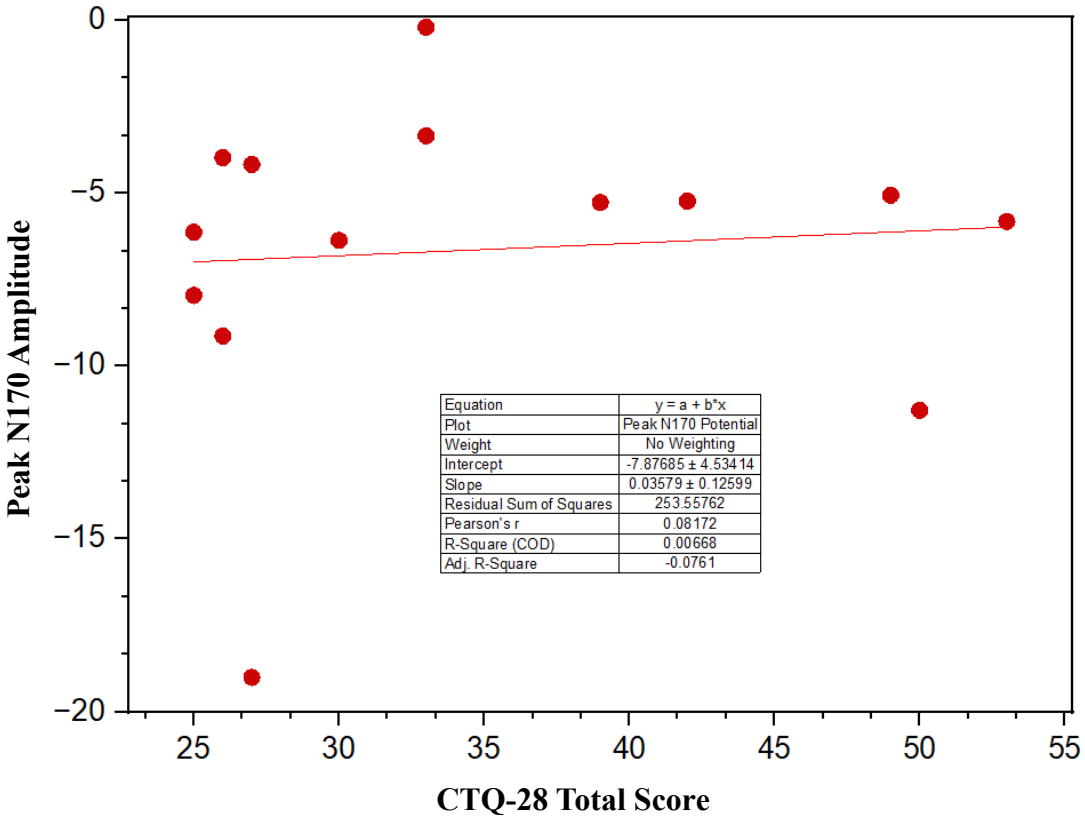
Changes in N170 Amplitude as a Function of Total CTQ-28 Score (Angry Face Modality)



Note. This figure describes the relationship between total CTQ-28 scores and peak N170 amplitude in response to a sudden showing of an angry face. A linear regression is overlaid on the graph, and relevant statistical values are given in the figure.

Figure 2

Changes in N170 Amplitude as a Function of Total CTQ-28 Score (Neutral Face Modality)



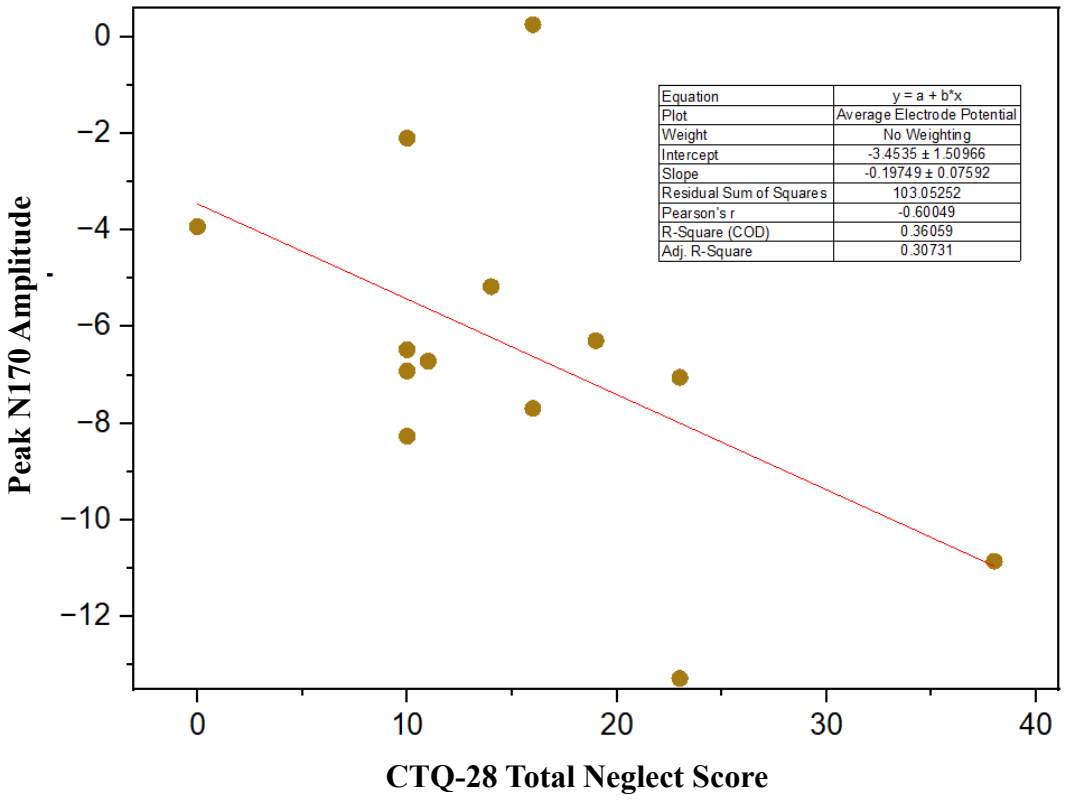
Note. This figure describes the relationship between total CTQ-28 scores and peak N170 amplitude in response to a sudden showing of a neutral face. A linear regression is overlaid on the graph, and relevant statistical values are given in the figure.

Pursuant to the second hypothesis, CTQ-28 total neglect scores and CTQ-28 total abuse scores were calculated and linearly regressed against N170 peak amplitudes in the angry face modality. In the case of total abuse scores, the slope is -0.109 (±0.131), and the intercept is -4.841 (±2.565). With the error bar in the slope encompassing 0, the slope cannot be statistically

differentiated from 0. Indeed, an ANOVA test showed that the F-value is 0.684, meaning that there is a 42.4% confidence in retaining the null hypothesis. In the case of total neglect scores, the slope is -0.197 (±0.074), and the intercept is -3.454 (±1.510). The slope is significantly different from zero, with an ANOVA test yielding an F-value of 6.767, meaning that the retaining of the null hypothesis is 2.3%, lower than the cutoff at 5%. Hence, at the 0.05 level, the slope is significantly different from zero. The difference between these results indicates support for the second hypothesis. The regressions for total CTQ-28 scores for neglect and abuse, categorized by previously identified sub-scores, are depicted in Figures 3 and 4 below (see Appendix B for residual plots).

Figure 3

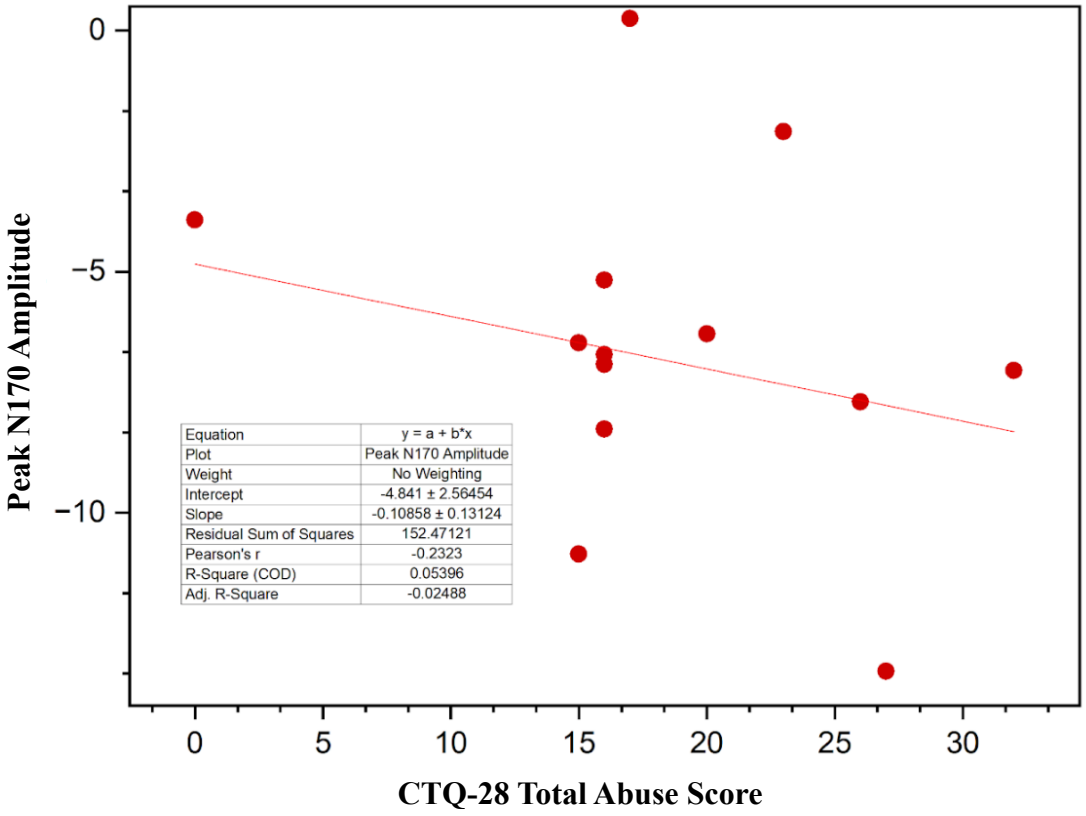
Changes in N170 Amplitude as a Function of CTQ-28 Neglect Score (Angry Face Modality)



Note. This figure describes the relationship between total CTQ-28 neglect scores (including emotional and physical neglect) and peak N170 amplitude in response to a sudden showing of a neutral face. A linear regression is overlaid on the graph, and relevant statistical values are given in the figure.

Figure 4.

Changes in N170 Amplitude as a Function of Total CTQ-28 Abuse Score (Angry Face Modality)



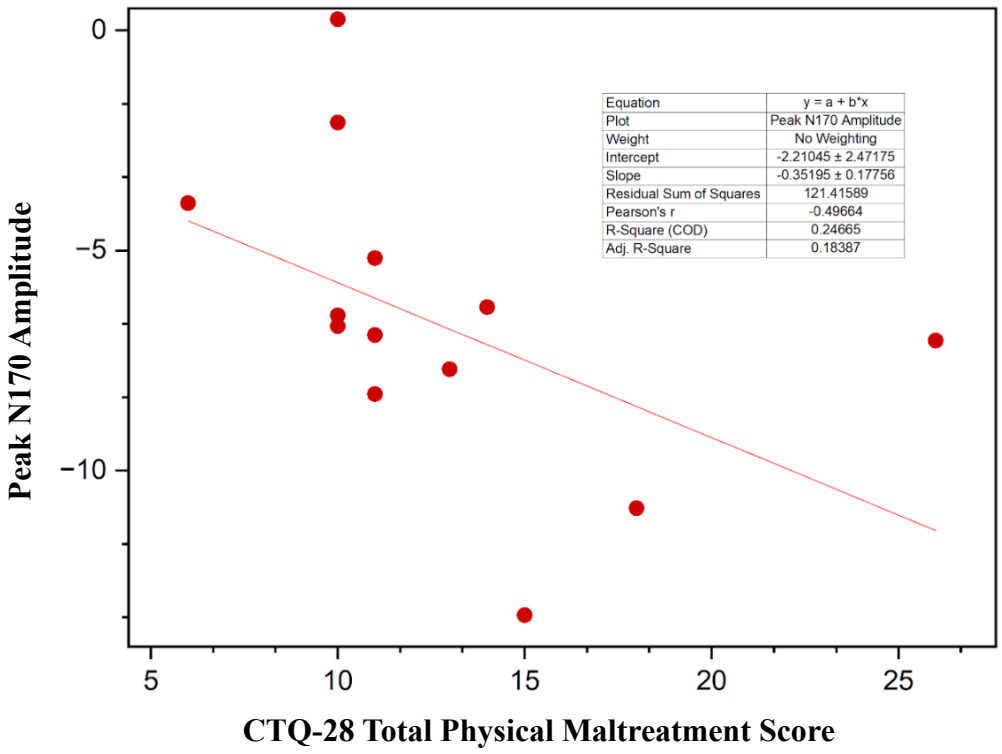
Note. This figure describes the relationship between total CTQ-28 abuse scores (including emotional, physical, and sexual abuse) and peak N170 amplitude in response to a sudden showing of an angry face. A linear regression is overlaid on the graph, and relevant statistical values are given in the figure.

Pursuant to the third hypothesis, total CTQ-28 scores for physical and emotional maltreatment were linearly regressed against N170 peak amplitudes in the angry face modality.

For total emotional scores, the slope is -0.273 (±0.100), and the intercept is -1.814 (±1.978). The slope is significantly different from 0, with an ANOVA test yielding an F-value of 7.512, meaning that the retaining of the null hypothesis is 1.8%, lower than the cutoff at 5%. Hence, at the 0.05 level, the slope is significantly different from 0. For physical scores, the slope is -0.352 (±0.178), and the intercept is -2.21 (±2.472). An ANOVA test showed that the F-value is 3.923, meaning that there is a 7.1% confidence in retaining the null hypothesis, supporting the third hypothesis. The regressions for total CTQ-28 scores for physical and emotional maltreatment are depicted in Figures 5 and 6 below (see Appendix C for residual plots).

Figure 5.

Changes in N170 Amplitude as a Function of Total CTQ-28 Physical Maltreatment Score (Angry Face Modality)

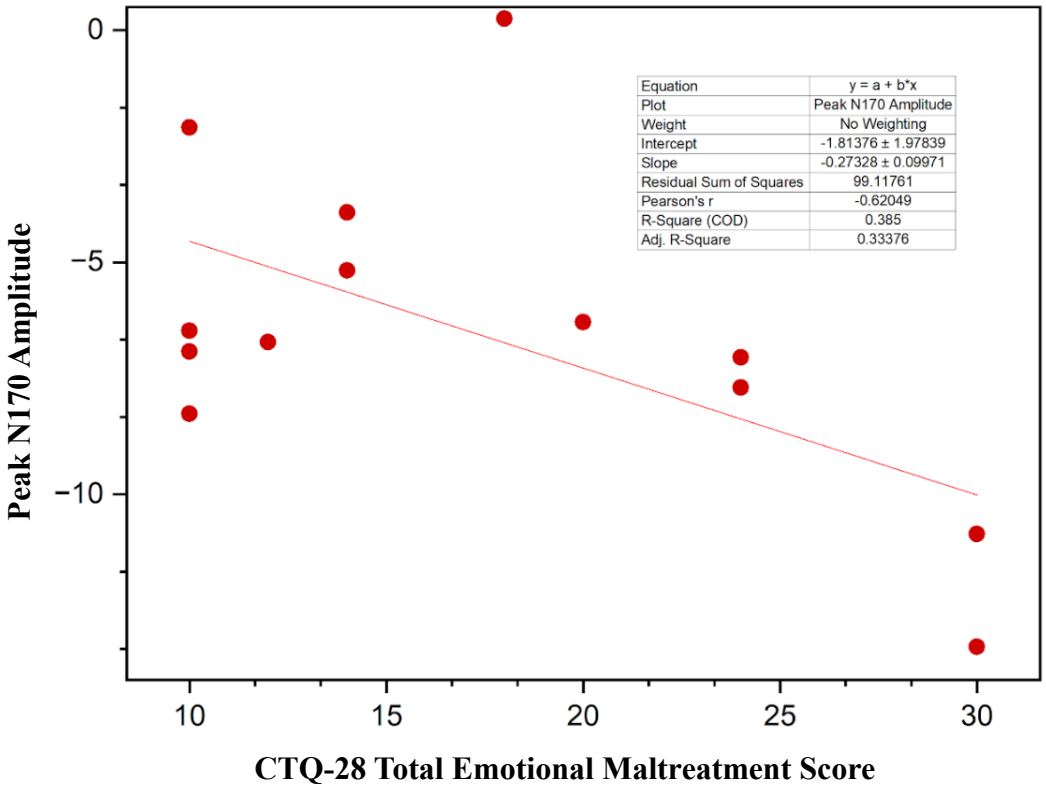


Note. This figure describes the relationship between total CTQ-28 physical maltreatment scores (including physical abuse and neglect) and peak N170 amplitude in response to a sudden

showing of an angry face. A linear regression is overlaid on the graph, and relevant statistical values are given in the figure.

Figure 6.

Changes in N170 Amplitude as a Function of Total CTQ-28 Emotional Maltreatment Score



Note. This figure describes the relationship between total CTQ-28 emotional maltreatment scores (including emotional abuse and neglect) and peak N170 amplitude in response to a sudden showing of an angry face. A linear regression is overlaid on the graph, and relevant statistical values are given in the figure.

Finally, given the power of emotional maltreatment and neglect vs. abuse, CTQ-28 emotional neglect was linearly regressed against N170 peak amplitudes in the angry face modality. The slope is -0.300 (±0.121), and the intercept is -3.595 (±1.521). The slope is significantly different from zero, with an ANOVA test yielding an F-value of 6.161, meaning that

the retaining of the null hypothesis is 2.8%, lower than the cutoff at 5%. Hence, at the 0.05 level, the slope is significantly different from zero.

Discussion

When participants were shown angry faces at random intervals, differences between CTQ-28 scores did demonstrate a significant difference between N170 peaks. However, when shown neutral expressions, there was no significant difference between N170 peaks. This suggests that differences in childhood trauma do impact how people perceive angry faces on a neurological level. This confirms findings that trauma may produce oversensitivity to anger (Güntekin & Basar, 2007). However, the finding that this may be related to trauma subtype is unique, as it begins to highlight that certain types of trauma may lead to poorer performance in areas like facial recognition and hypervigilance around detecting potential threats where there are none (Rodriguez & Kross, 2023; Solms & Turnbull, 2002).

The F-test between the slopes of the total score against the peak N170 potential of people reacting to neutral and angry facial expressions yielded inconclusive results. This may be due to the wide variance of N170 results in the neutral trials, which yielded a slope with a very high standard error. With large standard errors in one of the slopes, an F-test generally returns inconclusive results. Despite this, there is a clear and significant trend in angry face trials and no significant trend in the neutral trial, suggesting childhood trauma does impact how people perceive anger more than how people perceive neutral expressions. This confirms findings regarding oversensitivity to anger and supplants the additional understanding that angry-face responses outweigh neutral-face responses (Güntekin & Basar, 2007).

Interestingly, the main component that contributes to changes in peaks seems to be emotional neglect. While emotional neglect does have a statistically significant impact on N170

amplitude, neither emotional abuse nor other types of neglect yield similar results. This suggests that a leading cause of divergent facial processing is emotional neglect in childhood.

Limitations

This study sampled participants with OCD and adverse childhood experiences. However, OCD patients with a history of childhood maltreatment may represent a specific adaptive response to the trauma (Ou et al., 2013; Dinn et al., 1999). Thus, there may be significant differences between patients with OCD and without OCD in how their childhood trauma affects emotional processing.

The internal validity of the study may be improved through the inclusion of additional participants from the original data set. The lab is currently working on implementing the methods composed for this paper across the entire data set from both the participants with OCD and additional participants from a similar EEG study.

Another consideration is the present study's use of N170 peaks exclusively for measuring emotional reactivity to and processing of faces. The N170 is a useful reference electrode due to its sensitivity to facial processing, but it is possible that other choices may be more fine-tuned to detect disruptions caused by childhood trauma (Hinojosa et al., 2015). Future studies may consider evaluating the P300 peaks in a similar method to this study, which may further elucidate differences in emotional processing that are not as observable in the N170 peaks.

Conclusion

The present study asks two research questions: (1) Does childhood trauma disproportionately impact the emotional processing of angry faces? (2) Does the subtype of childhood trauma have a significant effect on the value of N170 peaks in emotional processing tasks? The study concludes that, yes, heightened childhood trauma scores increase reactivity to

angry faces compared to neutral face exposure, as measured using N170 peak amplitude. The study also presents evidence of specific subtypes of childhood trauma and finds a statistically significant effect of neglect compared to abuse and emotional maltreatment compared to physical maltreatment.

Understanding the role of specific subtypes, especially emotional domains, of maltreatment can inform future interventions. Researchers ought to consider the specific effects of different types of maltreatment when conducting EEG and ERP analysis to ensure potential causes are not ignored by broad labels. The regression of total CTQ-28 scores, as well as specific domains categorized by the researcher, allow for the identification of more impactful types of childhood trauma on emotional processing. This study positions itself as an introductory consideration of child maltreatment subtypes' impacts on emotional processing and finds evidence that this distinction, as well as general relationships between childhood adversity and emotional dysregulation, are worthy of further study.

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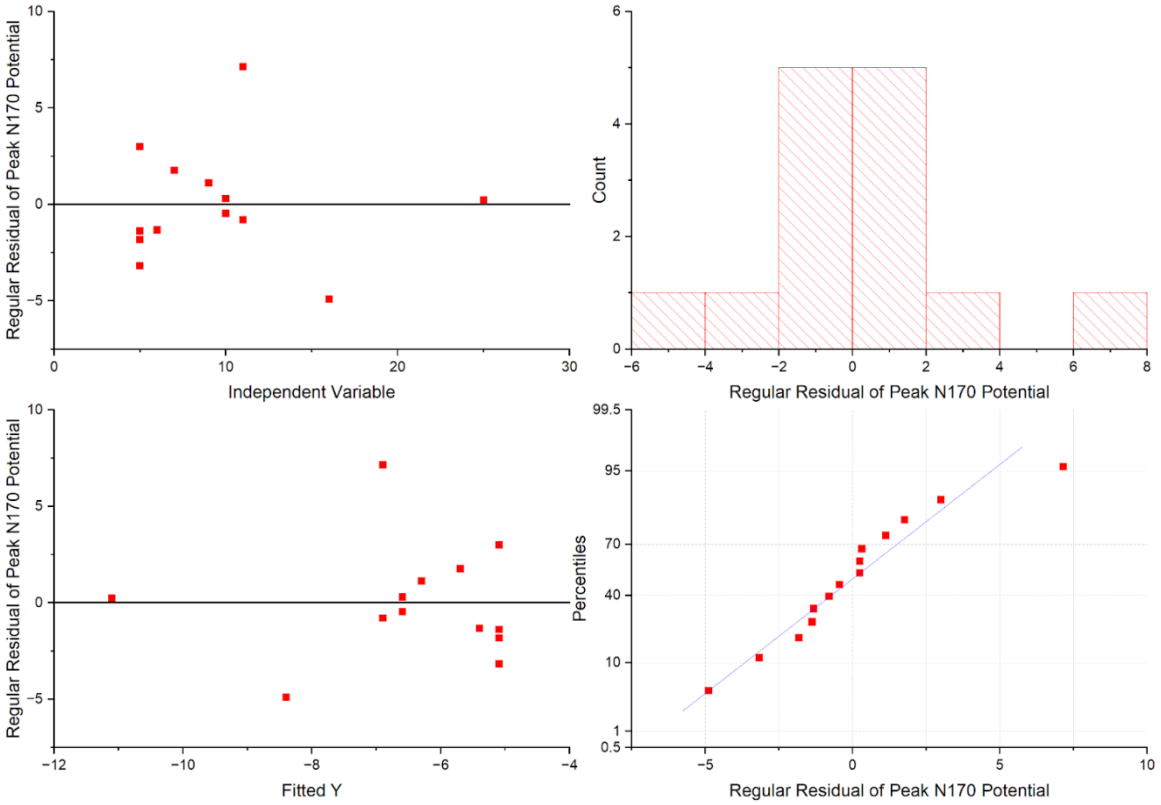
Appendix A

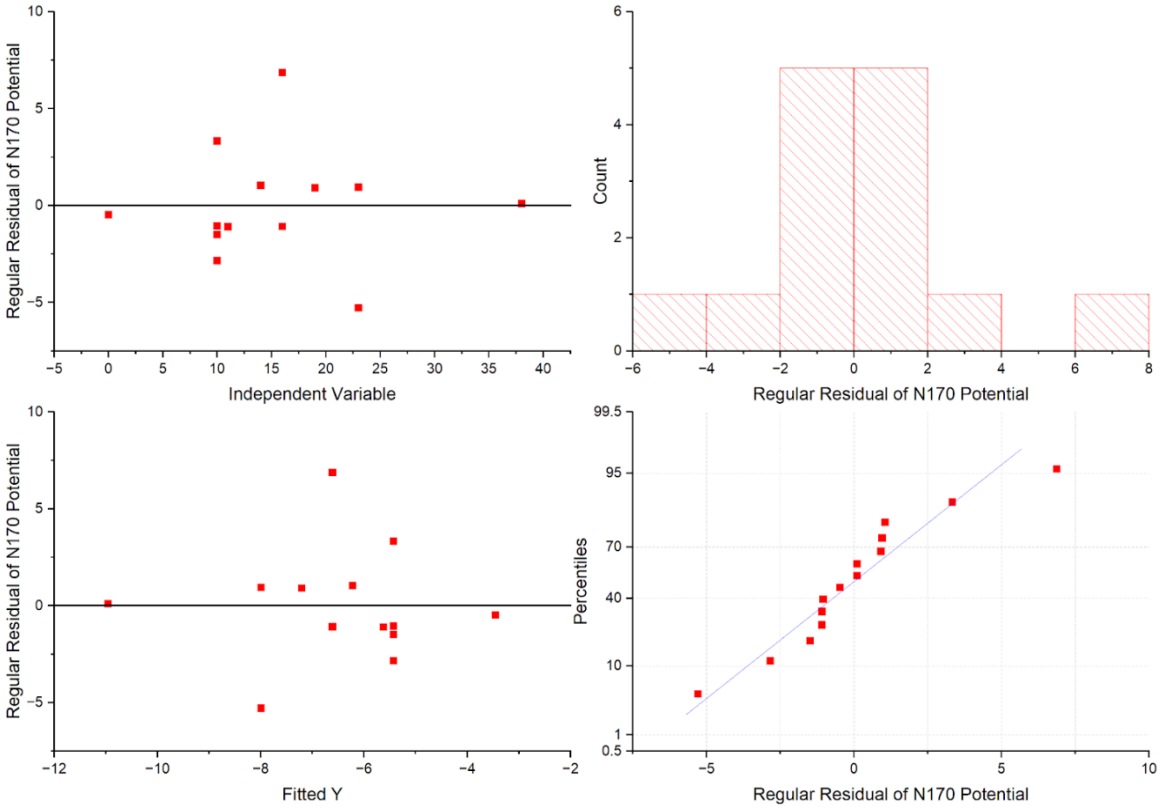
Residual Plots of Figure 1



Appendix A. This is a series of residual graphs to demonstrate the statistical significance of the linear regression done in Figure 1.

Appendix B

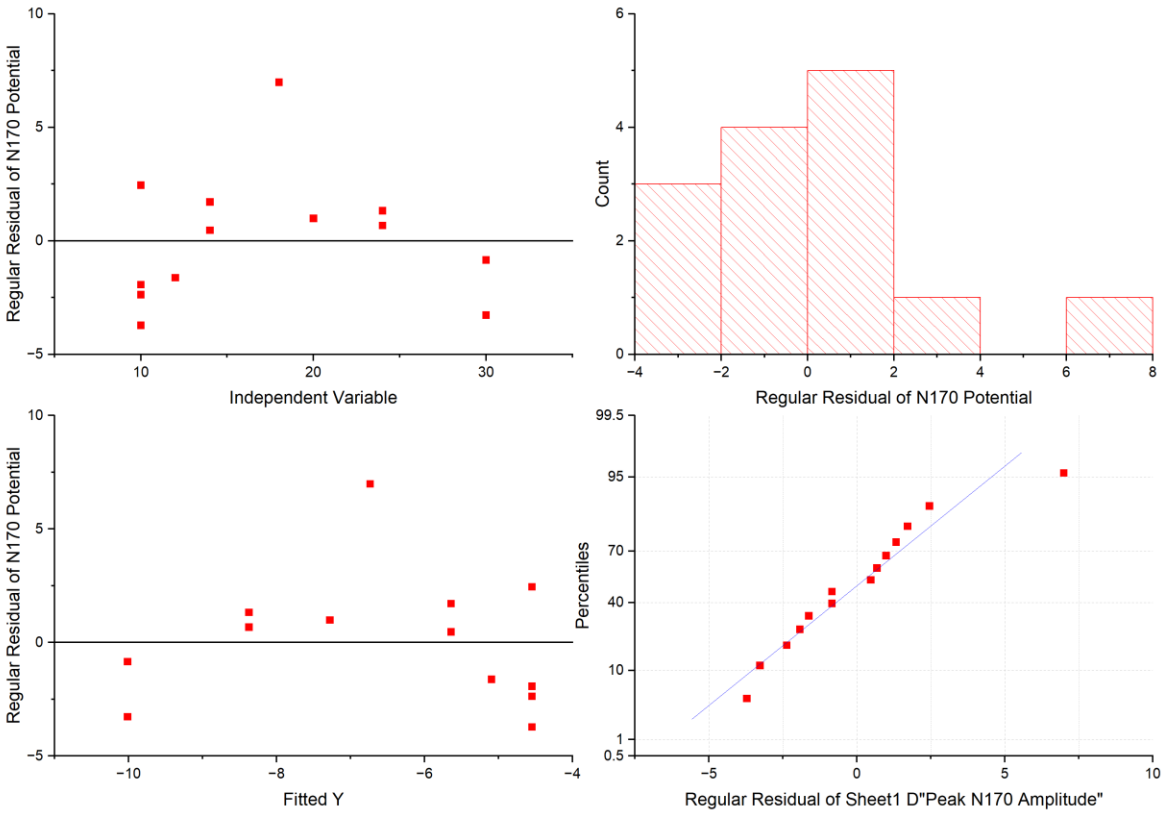
Residual Plots of Figure 3



Appendix B. This is a series of residual graphs to demonstrate the statistical significance of the linear regression done in Figure 3.

Appendix C

Residual Plots of Figure 5



Appendix C. This is a series of residual graphs to demonstrate the statistical significance of the linear regression done in Figure 5.