NEURAL CORRELATES OF EMOTION REGULATION IN A SAMPLE OF SYRIAN REFUGEE CHILDREN: AN ERP STUDY

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ABSTRACT

Introduction: The Syrian War led to millions of displaced families all around the world. A large portion of those refugees were children, who had to grow up abroad. The United States opened its doors to Syrian refugees, many of which resettled in Texas. As a result, many of these families, including the children, suffer challenges that may include depression and post-traumatic stress disorder. This study focuses on differences in regulation of emotions in these refugee children, whether they have symptoms of post-traumatic stress disorder (PTSD), and if they show resilience.

Methods: Using a multi-method approach, the study consisted of the Emotion Regulation Task that measures event-related potentials (ERP) from an electroencephalograph (EEG) reading, and two surveys. The Emotion Regulation Task consists of three trial conditions (while measuring the ERP): look-neutral, look-negative, and decrease-negative. One survey is the Children's Impact of Event Scale 13 measure (CRIES-13), which assesses the children for symptoms of PTSD, and the Child and Youth Resilience measure (CYRM-R) that measures resiliency.

Results: Age has a significant correlation with condition for area under the curve ($F(2,22) = 4.02$, $p = .03$). Repeated measures analysis of variance (ANOVA) with ERP trials conditions within subject factors and max value as the outcome approached significance ($F(2,24) = 2.80$, $p = .08$). No other variables were significant.

Discussion: The main significant effect was between age and condition, which indicated that the participants reacted differently, or had different abilities in regulating emotion when interacting with the various tasks due to age. Further research is to be conducted with a larger sample, language modifications, stricter age classifications among others.

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Introduction

Since the outbreak of the Syrian Civil War, roughly 13 million Syrians have been displaced around the world (United Nations High Commissioner for Refugees, 2022). Many of them fled to the United States (US) amid the worldwide Syrian Refugee crisis in 2014, where the US welcomed about 15,000 refugees (Kallick et al., 2016). As of 2021, there are a total of roughly 21,893 Syrian refugees who have resettled in the US (Darawsheh et al., 2021). Of those, a large portion of the refugees were young children at the time, who continued to grow up in the US, enrolling in public education and maneuvering through the American system. However, the traumatic stress that children and their parents have experienced—in addition to racism, Islamophobia, acculturative stress— developing resilience and grit, and enduring depression are among the myriad challenges faced even after resettlement.

The Syrian Civil War began early in 2011 when protests broke out in rebellion against President Bashar Al-Saad's regulations and government (Yigit & Tatch, 2017). These protests served as a catalyst for a series of rebellions of military groups, and ultimately led to the emergence of the Islamic State of Iraq and Al-Sham (Islamic State of Iraq and Syria), more commonly known as ISIS, in Syria (Yigit & Tatch, 2017). This group of militant terrorists would proceed to seize parts of Syria: taking over Raqqa and pronouncing it to be the capital of the ISIS emirate, followed by Mosul, Tikrit, Kobani, Palymra in 2015, and others (Yigit & Tatch, 2017). The residents of these cities were forced to flee to neighboring countries to seek refuge from the war. Refugees fled to the camps stationed at the Syrian-Jordan border, along with camps in Turkey, Egypt, Lebanon, and Iraq (Yigit & Tatch, 2017). Global responses included providing

funding and aid and opening borders to a limited number of Syrian refugees, giving them access to European states and the US (Yigit & Tatch, 2017). Their geographic placement in the US varied; California, Michigan, and Texas received the most refugees under the Obama Administration and up until 2016 (Jie Zong, 2021). In 2017, Texas had over 1,000 total resettled Syrian refugees, mainly in Dallas and Houston cities (Jie Zong, 2021). For this study, I am focusing on the Syrian children, under 18 years old, who resettled in the US with family after 2014. This includes children born in Syria and in refugee camps.

The chronic stressors previously mentioned are expected to challenge the normative development and general well-being of the Syrian refugee children. Along with the trauma and hardships experienced in their country of origin, they are significantly more at risk for long term mental and physical health problems. It is imperative that we gain understanding on factors that support resiliency in this vulnerable group of children and families, to ensure that resources and services catered to them to be effective. This thesis examines how variability in traumatic stress may influence children's abilities to regulate emotions. I utilize a multi-method approach to examine neurophysiological and behavioral measures of emotional regulation. I also explore protective factors that support resiliency despite traumatic stress exposure to identify potential intervention targets to support healthy development in this vulnerable sample of children and families.

Trauma and Mental Health Among Syrian Refugees

Numerous ongoing investigations have shed light on mental health risks among Syrian refugee children and families. For example, in their 2018 study, Gormez, Kılıç, and Orengul et al. analyzed the prevalence of psychopathology and its correlation with risk factors in a sample

population of Syrian refugees who resettled in Turkey. Their findings suggested that development of psychopathology in these children, aged 18 years and younger, resulted from the direct exposure to trauma and violence. Another study found that forced displacement among Syrian children in Turkey was associated with risk factors for developing psychological problems, namely "emotional and behavior problems, and psychological distress" (Gormez, 2017). Findings of emotional problems and anxiety were present in children who were "exposed to war-related trauma" (Gormez, 2017). One of the causes of depression and anxiety to the refugees expressed in this study was associated with the change in culture and was referred to as "acculturative stress". Another study, conducted by Alsayed and J. Wildes (2018), also focused on refugees who had resettled in Turkey. The researchers used the Strengths and Difficulties Questionnaire (SDQ) to examine the psychological status of Syrian refugee children being raised in Turkey. Responses were compared to those given by a group of Turkish students (similar in age range) who took part in the same self-report questionnaire. Results suggested that Syrian children showed "severe psychological difficulties" seemingly correlated to trauma-related stress and experiences of "war, migration and resettlement" (Alsayed & Wildes, 2018).

Emotion Regulation and Event-Related Potentials (ERPs) studied through ERP analysis

Emotion Regulation in these youths is important in identifying how childhood trauma can help detect signs of psychological difficulties or illnesses (Alsayed & Wildes, 2018). Specific to the refugee population, the war- and threat-related adversities, as well as traumatic stressors experienced, can impact their ability to regulate emotions and creates challenges for their psychological status (Alsayed & Wildes, 2018).

Event-Related Potentials, or ERPs, can be used to study the neural response to a specific stimulus, thus its relevance in this study. Electroencephalography (EEG) and scalp-recorded event-related potentials (ERPs) have been studied to examine neural correspondence of emotion regulation. The ability to assess emotion through changes in ERPs was tested in a study by Dennis et al. (2009), where the participants (children ages five to nine) completed an attention task. ERPs indicated an effective method to "detect early risk for psychopathology." Through these methods, we can draw correlations between emotions, emotional facial processing, and, more relevant to this specific study, how ERPs obtained through scalp EEG can reflect ability to decrease emotional intensity—which may indicate vulnerability for psychopathology (Dennis et al. 2009).

ERP correlates of emotion regulation were previously studied by Moser et al. (2009), where they analyzed ERPs of showing unpleasant images. The study's participants consisted of female undergraduate students and showed how increasing or decreasing emotional responses was reflected on the ERP readings. The set of skills an individual develops to help them manage, i.e., increase or decrease the intensity of their emotions, is known as the process of cognitive reappraisal (Moser et al., 2009). Emotional regulation, then, can be defined as the "conscious process of cognitive reappraisal", which will enable a person to alter their interpretation of an emotional event (Moser et al., 2009). It has been theorized that psychopathology is characterized by insufficient cognitive reappraisal, which can explain the therapeutic approach for building positive reappraisals (Moser et al., 2009).

There must be a thorough understanding of cognitive reappraisal due to its strong linkage to psychopathology and psychotherapy. Moser et al. (2009) referred to Gross & Thompson's (2007) four strategies for generating emotion: 1) confronting the emotional event, 2) deployment

of attention to that event, 3) engaging in the appraisal processes by the event (cognitive reappraisal), and 4) engaging in the response towards the event. The first three steps occur before response tendencies, such as physiological reactions and emotional expressions, while step 4 would occur right at the response tendency stage. This is relevant to my research because in this study, I investigate and discuss how the ERPs appear at each of these stages, before and after the response tendencies are initiated.

Another study by Rodman et al. (2019) examined the neurobiological indicators of resilience in children with a history of childhood adversity, specifically in the form of threat. Study outcomes detected a strong correlation between resilience and depression and anxiety. The study consisted of 151 participants from ages eight to 17 in a longitudinal sample, all of whom presented a history of childhood adversity. The findings identified resilience as a long-term protective factor against mental health issues. This study also uncovered the presence of neurobiological markers that indicated resilience in children who had been exposed to threat-related adversity. The research also found that children with the ability to regulate their emotions by using "cognitive control strategies" are able to protect themselves from developing depressive disorders. This ability to display resilience stems from regulation of the amygdala and prefrontal cortex regions of the brain, as well as their use of cognitive reappraisal strategies. Neural circuits have also shown that having cognitive control over one's emotions reveal the child's resilience strategies (Buhle, et al., 2014). The fMRI task of emotion regulation found that, when comparing children who underwent childhood adversity to those who have not, resilience acts as a "buffer" to protect the child from developing severe psychological harm (Rodman et al., 2019).

Present study aims and hypotheses

Despite the insights gained from these studies, few scholars in this field have studied ERPs of emotion regulation in children from refugee backgrounds, who experience adversities different from those of US-born children with trauma history. This study addresses a gap in the research on the psychological effects of trauma in Syrian Refugee children. Specifically, studying ERPs of emotion regulation can help us detect neural correlates of psychological dysfunction in this underserved population. Therefore, the research questions for this study were:

Question 1:

1. How are symptoms of trauma associated with emotion regulation as measured by ERPs and subjective reports of arousal?

Question 2:

2. How is resilience associated with emotion regulation as measured by ERPs?

Given the research questions above, my corresponding hypotheses are:

H_1: Participants who score high on the CRIES-13 questionnaire to assess symptoms of trauma, will reflect the ability to regulate their emotions as measured by the ERPs and subjective reports of arousal.

H_2: Resilience will act as a buffer to large changes in arousal, which will indicate higher ability to regulate their emotions.

Materials and Methods

Study Participants and Recruitment

Participants in this study (N= 13) consisted of Syrian refugee children seven to 18 years of age and their primary caregivers from the local Houston area. These families were recruited through IMPACTs, a Houston organization that engages in the Middle Eastern and Asian refugee resettlement processes. All participants resettled in the US between 2014 and 2016. As this is a part of a larger ongoing study, the number of participants increased to a total of 21, but not in time to be included in the analyses for this thesis. Therefore, the number of participants was capped at 13. Dr. Johanna Bick—the study's PI—obtained written informed parental consent and verbal assent from children—a process through which the researcher reads the form to the child and explains the activities of the study, then signs to confirm. No participants reported having histories of severe psychiatric diagnoses that would hinder the study's results. Recruitment methods and experimental procedures were all approved by University of Houston's Institutional Review Board (IRB).

Inclusion/Exclusion

Participants all must have been born in Syria or born in refugee camps after displacement to the US. Children were excluded if they had a history of significant cognitive or developmental delay, serious head injury, pervasive developmental disorder, Tourette's syndrome, cerebral palsy, or seizures. These criteria ensured that the data was collected from the correct

representative population, and that there were no additional participant vulnerabilities of a cognitive nature.

Setting

Research visits and data collection occurred in Dr. Johanna Bick's lab, assistant professor in the psychology department, located in the Health and Biomedical Sciences Building 1 on the University of Houston-Main campus. This study has been approved by the University of Houston IRB. Funding for this study was provided by a GEAR grant for Dr. Samina Salim and Dr. Johanna Bick.

COVID-19 Protocol

All participants were encouraged to wear a mask at all times during the duration of the visit. When applicable, a minimal distance of 6 ft was ensured between participant and experimenter. Participants and family members were also asked to sign a COVID waiver form to notify them of the COVID-related restrictions and policies. A contact tracing log was kept of the visit and dates of experiment and deleted every two weeks.

Emotion Regulation Task

In this task, children are shown age-appropriate pictures that are either negative or neutral in valence. Prior to viewing each picture, the child is instructed to either look at the pictures normally or use a cognitive reappraisal strategy to decrease their emotional response to the picture. After looking at the picture, the child is then asked to rate the emotional arousal of the

picture on a Likert scale of 1-to-5 (1 = no arousal, and 5 = extremely high arousal). Therefore, each trial consists of 1) an instruction to look or to decrease, 2) a picture of negative or neutral valence, and 3) arousal rating. The children view 10 look-neutral, 10 look-negative, and 10 decrease-negative pictures in three blocks of 30 pictures each. In total there are 90 pictures throughout this task.

Each trial begins with showing one second of a fixation cross, that is immediately replaced by instructions for two seconds (instructions being to just "look" or to "decrease" emotions). Then a blank white screen appears for 1000 ms, followed by the image for 1500 ms (the image would be negative or neutral depending on the trial). After the image, the child is shown a rating picture, which remains on the screen until the child decides how they feel on a scale of 1-to-5. The images in the trials are presented in randomized order.

The task is split into three separate blocks; each block consists of 30 trials. The first block consists of 10 neutral images with a "look" instruction. The second block has 10 negative images with the "look" instruction; lastly, the third block has 10 negative images with the "decrease" instruction. The trials in each block are in randomized order.

Child Post-Traumatic Stress Questionnaire

We assessed the severity of childhood post-traumatic stress using the Child Revised Impact of Events Scale-13 item version (CRIES-13; Horowitz et al., 1979), a self-report measure of PTSD. The CRIES-13 contains three subscales that measure intrusion, avoidance, and arousal symptoms, respectively. The total score for this measure ranges from zero to 65—zero being an indication of no or minimum trauma, and 65 being the score for increased or maximum trauma (See Table 4 and Table 5 for the CRIES-13 total scores across participants).

Child and Youth Resilience Measure

To assess the participants' resilience or ability to overcome childhood adversity, we use the Child and Youth Resilience Measure (CYRM; Jefferies et al., 2018). It is a self-report measure for children ages five to nine years, and youth ages ten to twenty-three years. This measure has two subscales: the first is personal resilience, and the second is caregiver resilience. There is a total of 17 questions, with 5-point measure for each question. The responses range from 1 to 5, 1 being "not at all" and 5 being "a lot". The minimum possible score is 17, and the maximum is 85 (See Table 4 and Table 6 for CYRM-R total scores across participants).

EEG Recording and ERP Analysis

The electroencephalogram (EEG) was recorded with a 64-electrode actiCap system (Brain Products GmbH) with reference at FCz. The signals were amplified using an actiCHamp with a sampling rate of 1000 Hz. Impedances were checked online prior to the beginning of the session and throughout the task and considered acceptable if lower than 20 KΩ. All the data included in the subsequent analysis met the impedance criteria, i.e., at least 50% of channels have an impedance lower than 20 KΩ. EEG data were processed offline using The Harvard Automated Processing Pipeline for Electroencephalography (HAPPE software for preprocessing and ERP analyses) (Lopez, Monachino, Morales, Leach, Bowers & Gabard-Durnam, 2021). The continuous signals were subsequently resampled to 250 Hz and band-pass filtered with 0.1–30 Hz. Wavelet-threshing was applied to remove artifact from the continuous data. The continuous

signal was then segmented into epochs centered on stimulus onset with a 200 ms baseline and comprising 1,500 ms of stimulus presentation and re-referenced to the algebraic mean of all the channels. To eliminate artifacts, individual channels were automatically rejected whenever the signal exceeded ± 175 μV on the segmented data. Individually excluded channels were replaced using spherical spline interpolation.

Across all participants, there was an average of 23.46 trials contributing to the average ERP and statistical analyses for each condition (See Table 3 for values). Inspection of the grand-averaged waveforms revealed a well-defined late positive potential (LPP) in the Pz waveform. In children, the LPP is used as a neural marker for their ability to regulate their emotions (Dennis, T. A., & Hajcak, G., 2009). As described by Moser et al., the LPP window corresponds with the level of arousal of images shown during the task (Cuthbert et al., 2000; Schupp et al., 2000, 2004). A study by Hajcak and Nieuwenhuis revealed that during the decrease-negative instruction when the magnitude of the LPP was reduced, there was a positive correlation in the self-report of emotional intensity (Hajcak & Nieuwenhuis, 2006). A time window of 4600-5200 ms was chosen based on previous studies of this component, and on visual examination of the component's peak for participants (Moser et al., 2009). Peak amplitude (μV) and area under the curve values were extracted and entered in the statistical analyses.

Data Analysis Plan:

The following analyses are to be conducted using RStudio (RStudio 2.2.0, 2020). Peak value and area under the curve were analyzed through a 3 x 2 repeated measures of Analysis of Variance (ANOVA) and an Analysis of Covariance (ANCOVA).

In order to check for any correlations between the variables, a correlation matrix was conducted, and included symptoms of trauma (CRIES-13), peak amplitude, and area under the curve along with the independent variables (Table 2). The correlations between the LPP for each condition as measured by max value and area under the curve are expected to be high. Through the correlation matrix, we can gain insight on whether there are significant correlations between age, CRIES-13 (trauma symptoms), and CYRM-R (resiliency) with the LPP.

To test the main effects of task conditions on LPP and measure the LPP for each subject between the different conditions, two one-way repeated measures ANOVAs (analysis of variance) were conducted. The indicators are 1) area under the curve and 2) max value. For this statistical test, the purpose is to see if the different task conditions (look-neutral, look-negative, and decrease-negative) would elicit LPP differently. Covariates, such as age, were included in the models as needed.

To test my hypotheses regarding the effects of trauma (H1) and resilience (H2) on LPP, a repeated measures ANCOVA (analysis of covariance) was conducted. Two stages are run, where in both stages the ERP trial condition is the within subjects' factor. In the first stage, trauma symptoms total score was the covariate, and either max value or area under the curve as the outcome (both run separately). In the second stage, the resiliency total score replaced the trauma total score. These tests search for an interaction between symptoms of trauma as measured by the CRIES-13 questionnaire, the resiliency as measured by the CYRM-R questionnaire, and the two components of ERP: area under the curve and peak value. Therefore, it helps us look at one independent variable at a time, that being either trauma or resilience, and see what effect it has (without the influence of other variables) on the dependent variables.

Results

Preliminary Data Analysis

A correlation matrix was analyzed between age, PTSD symptoms (CRIES-13 total score), resilience (CYRM-R total score), max value and the area under the curve for each condition. Significant values, as determined by a $p < .05$ are indicated the asterisks. The result of the correlation matrix, as seen in Table 2, present significant values between max value and area under the curve across conditions, and between age and PTSD symptoms as measured through CRIES-13 total score (p = 0.72**). There was a positive significant correlation between max value for the look negative condition and 1) max value for the look neutral condition (p=0.89***), and 2) max value for the decrease negative condition (p= 0.94***).

There was a significant positive correlation between max value for the look neutral condition and the max value for the decrease negative condition (p = 0.91 ***). Area under the curve for the look negative position had a significant correlation between both the area under the curve for the look neutral condition (p = 0.80**) and area under the curve for the decrease negative condition (p = 0.90***).

A significant correlation was found between the max value for the look negative condition with area under the curve for look negative (p= 0.52*) area under the curve for look neutral (p= 0.82***) and area under the curve for decrease negative condition (p= 0.78**). Additionally, there was a correlation between max value for the look neutral condition with: area for look negative (p= 0.66*), area for look neutral (p= 0.95***), and area for decrease negative

(p= 0.81***). Lastly, max value for the decrease negative condition had significant values when correlated with area under the curve for look negative (p= 0.59*), area for look neutral p= 0.86***), and area under the curve for the decrease negative condition (p= 0.83***).

In summary, the two brain variables, area under the curve and max value are correlated across conditions (some more strongly than others). Additionally, age was the only covariate correlated with trauma symptoms. There were no correlations between trauma and resilience, resilience an age, or resilience and trauma with any of the ERP brain variables.

Associations between trauma history, resilience, and LPP

To look at potential interactive effects of trauma and resilience on LPP, we used two stages. In the first stage, we used a repeated measures ANCOVA with ERP trial condition as the within subjects' factor, total trauma symptoms as the covariate, and either max value or area under the curve as the outcome. In the second stage, we added total resilience score as a covariate.

Effects of task condition on Late Positive Potential (LPP):

Two repeated measures ANOVAs were run to test the effects of condition on late positive potential (LPP). The two indicators are area under the curve, and peak value (also referred to as max value or max amplitude). For all models, the task condition was entered as a within subjects' factor, and the LPP peak or area was entered as the dependent variable. Models were tested with and without age and gender as covariates. Given the sample size, we ran separate models for

each covariate. Covariates were entered as main effects and as interacting with the condition factor. Figure 1, a box plot, shows the results of the repeated measures ANOVA with LPP peak (max value) and the ERP trial conditions.

Results for LPP Area Under the Curve:

In the first model, the effect of condition on LPP area under the curve was not significant ($F(2,24) = 0.89$, $p=.42$). In the next model, there was a significant interaction between age and condition ($F(2,22) =4.02$, $p=.03$). Post hoc analyses were conducted to decompose the interaction. Older age was associated with increased area under the curve for the decrease-negative, and look-neutral conditions, and with decreased area under the curve for the look-negative condition (See Figure 2).

Results for LPP Peak:

The association between condition and LPP peak was not statistically significant, only approached significance ($F(2,24) = 2.80$, $p=.08$). There is no main effect of age on LPP peak.

Associations between trauma history, resilience, and LPP

To look at potential interactive effects of trauma and resilience on LPP, we used two stages. In the first stage, we used a repeated measures ANCOVA with ERP trial condition as the within subjects' factor, total trauma symptoms as the covariate, and either max value or area

under the curve as the outcome. In the second stage, we added total resilience score as a covariate.

Association between trauma, task condition and LPP:

LPP area: When area under the curve was the outcome, the ERP trial condition, CRIES-13 total score, and their interaction were non-significant (all p's >.10). Additionally, the interaction between CRIES-13 total score and ERP trial condition was not significant ($F(2,22) = 0.427$, $p=0.658$).

LPP peak: When max value was the outcome in the ANCOVA with ERP trial conditions as the covariate, CRIES-13 total score approached significance ($F(1,11) =3.38$, $p=.09$), as did ERP trial condition ($F(2,22) = 2.60$, $p=.097$). However, the interaction between CRIES-13 total score and ERP trial condition was not significant ($F(2,22) = 0.15$, $p=.87$).

Association between resilience, task condition and LPP

LPP area: When area under the curve was the outcome, the ERP trial condition, CYRM-R total score, and their interaction were non-significant. The interaction between CYRM-R total score and ERP trial condition was not significant ($F(2,22) = 0.575$, $p=0.572$).

LPP peak: When max value was the outcome, the main effects of CYRM-R total score when added as a covariate, no predictors were significant (all p's > .10) The interaction between CYRM-R total score and ERP trial condition was not significant ($F(2,22) = 1.504$, $p=0.246$).

Discussion

Through the findings from previous studies, we can draw conclusions and compare differences in outcomes. The Moser paper, used as guidance for a large part of this study, is one where I draw the most comparisons from. Firstly, Moser's study included the instruction to increase arousal, in addition to this study's instructions to look and decrease. Working with adults, their ERP task also presented with negative images of much higher valence for arousal, which was suitable for adults but inappropriate for children (gore, pornography, etc.). Therefore, in this study, the ERP task consisted of images with much lower arousal and appropriate for children. I hypothesized that participants with higher trauma symptoms will reflect a greater ability to regulate their emotions, and that resilience will act as a buffer to experiencing strong negative emotions. The results did not support the hypotheses.

This study utilized ERPs to analyze the effects of trauma, resilience, and demographic factors, on emotion regulation. Emotion regulation was measured through an ERP task, by the LPP area under the curve and peak amplitude (or max value) in response to images of negative and neutral arousal. This emotion regulation ERP task was replicated from the Moser paper, with some changes suitable for our child participants. As previously mentioned, one major change was the arousal of the negative valence images (greatly decreased arousal).

Application of Results

For the decrease instruction, where the child was to use a cognitive reappraisal strategy to decrease their feelings, older age was associated with increased area under the curve. Due to the increased area, this implies a higher level of arousal in response to the image, and a rather unsuccessful attempt to use a cognitive reappraisal tool to decrease their feelings or emotional response. One explanation can be that because of their relatively older age, these children generally may have experienced more trauma or related traumatic experience and had more time to see how that affects plays out into their everyday lives. The younger children on the other hand, may have been more capable of decreasing their feelings because of having spent less time after the traumatic experience living through consequences of the trauma. The trauma measure used (for PTSD symptoms) is shown to be positively correlated with age; meaning older children express higher symptoms of trauma, by scoring higher on the CRIES-13 questionnaire. Younger age can be interpreted as a protective factor due to the amount of trauma experienced and the amount of time, they have been navigating the changes and struggle to adapt.

Comparatively, the conditions with the look instructions resulted in inconsistent results. For the look neutral condition, older age was associated with increased area under the curve. Alternatively for the look negative condition, older age was associated with decreased area under the curve. In this part of the task, no cognitive reappraisal strategy is *instructed* to be used. For the look-negative condition, a reason behind these results could be that the older kids automatically decrease their feelings or emotional response to an image regardless (possibly as a trauma response), whereas younger kids do not display use of that strategy.

Although age was the most significant aspect of the study, it also introduced some challenges that are specific to children and do not apply to adults (participants in Moser's study). For one, there is some ambiguity with the child questionnaires such as the CRIES-13 for trauma symptoms and the CYRM-R for resilience. This can be due to the language barrier, and code-switching that may occur with bilingual children (Arabic and English for this study). For each participant, their level of English language comprehension and communication greatly varied, but mostly showed to be corresponding with age. In future studies, age groups can be utilized. Due to the sensitivity of the experienced trauma at that age, this study can be repeated with isolated age brackets and given modified suitable questionnaires and tests. Narrowing down the age groups will enable the researchers to control for any changes between school education as well.

Parent intervention during questionnaires is thus questionable. It aids the child in getting through the questionnaire, understand each question, and ask about their tendencies and habits if they are unsure. However, it can also be hindering, and may lead to inaccurate representations of the child's feelings given a parental audience. The most effective way to deliver these questionnaires to bilingual children, where the child's personal feelings and thoughts are measured accurately is unclear. In our study, parent intervention was kept minimal. Instead, the experimenter in most cases would be able to help the child through the questionnaires, having to translate some words or phrases such as "do you feel that you *fit in* with other children?" or "are you treated *fairly*?" (CYRM-R for ages 5-9) and use other methods to simplify the definition. Instead, two questionnaires can be used in the future for a similar study: one for the parent's perspective for questions that ask about children's traits, such as sharing, and the other from the

child's perspective, in simpler English. Therefore, any externally observable behavior the children display can also be accounted for through the parent perspective.

The importance of this study comes in two forms: the first is its contribution to the field of mental health, and the second is the preventative aspect in terms of health, life expectancy and quality. In contribution to mental health, we must first acknowledge the importance of using electroencephalography (EEG) and event-related potentials (ERPs) to gain information on emotional regulation. The EEG and ERPs provide real time information on neuronal patterns, and neural oscillations that underpin neurocognitive processes—such as emotion regulation. While the measure of behavior using questionnaires is a method, the impact of using EEG enables us to better identify these neuronal and cognitive patterns before they are displayed in behavior. It provides a deeper understanding of risk factors and thus more insight on how to regulate those factors better, especially for children. Therefore, finding a biomarker for trauma, resilience, emotional regulation, is also a preventative measure. As many previous studies have proven, trauma has biological effects on the human body, and, more specifically, traumatic stress in children can cause developmental and long-term health problems. Through EEG studies, researchers and medical providers can identify these neural patterns, and find ways to shape the trajectory of the child's life before it becomes debilitating.

Study Limitations

The majority of my results were non-significant or approaching significance with exception to age and condition ($F(2,22) = 4.02$, $p = .03$). This could be due to a variety of factors. Firstly, our small sample size of 13 could have attributed to weaker correlations (those that approached significance). Also, our study was limited by geographic location by only recruiting

Syrian refugees in Houston. Therefore, any results obtained cannot be generalized to include Syrian refugees across the US.

The small sample size (N=13) decreases the statistical significance of the results, and therefore there is not enough statistical power to reject the null hypotheses. Thus, the results cannot be generalized at this stage. While including the larger sample of 21 participants would increase statistical power, the study would still likely require a much larger sample size. Additionally, the study did not utilize a control group to draw comparison between the neural processes of children who have experienced war-related trauma, and other children.

Future Directions and Next Steps

The next step in this study is to include all 21 participants to increase the sample size with the newly available data and include gender as a covariate in addition to age. In the future, the study can be repeated with a much larger sample size, across geographic locations—nationally and globally. The importance and role of gender changes in different cultures across the world, there is especially a difference living in the western culture versus others. Control groups also must be included in the future studies, to ensure that their traumatic experiences explain differences in neural processes and responses. More specifically, the control group can consist of other minority groups—Muslim populations who resettled in the US by choice (possibly in search of opportunity, not by force). Also, the results obtained from this study may not be applicable to refugees around the world or nationally across the United States due to different cultures. For example, there is a much larger Muslim population in Michigan, one of the other states where many Syrian refugees resettled. This may change the process and attitudes towards resettlement. Compared to the conservative Texas state, where attitudes around mental

health and minority groups differ, Michigan may be more tolerant and have more resources for the minority groups (where Muslims, and refugees fall under). Beyond the national level, global differences would change refugees' ability to resettle. Refugees in Jordan or Turkey will present with different experiences due to the similarities in heritage and ability to assimilate much faster than in the US, among other factors.

Syrian refugee children's emotional regulation calls for more extensive studies to be done in the future, considering the areas of improvement mentioned above. As my results imply, we do not know enough about the effects of trauma on these children and how their ability to decrease or neutralize their feelings is affected. With a larger sample, age brackets, ensured language comprehension, and others, more information about this vulnerable but large population can be explored. Thus, we can know how to provide the correct preventative mental health resources to these young refugees.

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TABLE 1.

Participant Demographics for all Syrian refugee children at the time of study

	n	%	M	SD
TOTAL	13	100		
GENDER				
Female	5	38.5		
Male	8	61.5		
AGE				
Youngest	7.97		12.9	2.85
Oldest	17.81			

TABLE 2.

Correlation Matrix showing max value (peak amplitude of LPP) for each condition, along with age, PTSD total score (CRIES-13), and resilience total score (CYRM-R)

	Age	CRIES-13	CYRM-R	Max_Look_Neg	Max_Look_Neu	Max_Dec_Neg	Area_Look_Neg	Area_Look_Neu	Area_Dec_Neg
Age	**1.00**								
CRIES-13	0.72**	**1.00**							
CYRM-R	-0.072	-0.43	**1.00**						
Max_Look Neg	0.38	0.50	-0.49	**1.00**					
Max_Look_ Neu	0.36	0.50	-0.48	0.89***	**1.00**				
Max_Dec_ Neg	0.37	0.40	-0.54	0.94***	0.91***	**1.00**			
Area_Look Neg	-0.084	0.20	-0.46	0.52*	0.66*	0.59*	**1.00**		
Area_Look_ Neu	0.26	0.43	-0.40	0.82***	0.95***	0.86***	0.80**	**1.00**	
Area_Dec_ Neg	0.20	0.32	-0.47	0.78**	0.81***	0.83***	0.90***	0.91***	**1.00**

*Note: *p < .05, **p < .01, ***p <.001*

TABLE 3.

Quality Check Results: After pre-processing, cleaning data

Subject ID	% Of Good Channels Selected	Segments post segment rejection (out of 90)	Trials Passed for each condition	
1. SRS_002	79.69 %	40	Look-neutral	16
			Look-negative	12
			Decrease-negative	12
2. SRS_003	79.69 %	39	Look-neutral	10
			Look-negative	12
			Decrease-negative	17
3. SRS_004	85.94 %	87	Look-neutral	29
			Look-negative	28
			Decrease-negative	30
4. SRS_006	76.56	71	Look-neutral	24
			Look-negative	23
			Decrease-negative	30
5. SRS_007	78.75	90	Look-neutral	30
			Look-negative	30
			Decrease-negative	30
6. SRS_009	76.56	47	Look-neutral	19
			Look-negative	11
			Decrease-negative	17
7. SRS_012	84.94	68	Look-neutral	23*
			Look-negative	22*
			Decrease-negative	23*
8. SRS_014	76.56	79	Look-neutral	25
			Look-negative	24
			Decrease-negative	30
9. SRS_015	82.81	82	Look-neutral	28
			Look-negative	25
			Decrease-negative	29
10. SRS_020	68.75	90	Look-neutral	30
			Look-negative	30
			Decrease-negative	30
11. SRS_022	71.88	67	Look-neutral	22
			Look-negative	22
			Decrease-negative	23
12. SRS_024	84.38	87	Look-neutral	30
			Look-negative	28
			Decrease-negative	29
13. SRS_025	78.13	69	Look-neutral	24
			Look-negative	20

	Decrease-negative	25

**Indicates total number of trials was less than 30*

TABLE 4.

The descriptives for the trauma measure Children's Impact of Event Scale-13 (CRIES-13), and the Child and Youth Resilience Measure (CYRM-R)

	Descriptives			
Measure	MIN	MAX	M	SD
CRIES-13 (PTSD)	5	43	24	14.03
CYRM-R (Resilience)	43	85	65.58	14.15

Note. CRIES-13 scores range from 0 to 65, CYRM-R scores range from 17 to 85

TABLE 5.

Children's Impact of Event Scale-12 (CRIES-13) total scores for each participant

Subject ID	CRIES-13 Score
SRS_002	30
SRS_003	8
SRS_004	11
SRS_006	43
SRS_007	26
SRS_009	15
SRS_012	5
SRS_014	20
SRS_015	51
SRS_020	31
SRS_022	29
SRS_024	33
SRS_025	10

Note: CRIES-13 scores range from 0 to 65

TABLE 6.

Child and Youth Resilience Measure (CYRM-R) total scores for each participant

Subject ID	CYRM-R Score
SRS_002	46
SRS_003	61
SRS_004	85
SRS_006	*
SRS_007	67
SRS_009	43
SRS_012	75
SRS_014	81
SRS_015	50
SRS_020	56
SRS_022	73
SRS_024	72
SRS_025	78

*Note: * Indicates an incomplete survey, excluded from analyses,CYRM-R scores range from 17 to 85*

FIGURE 1.

Boxplot with max value (peak amplitude) for each ERP trial condition

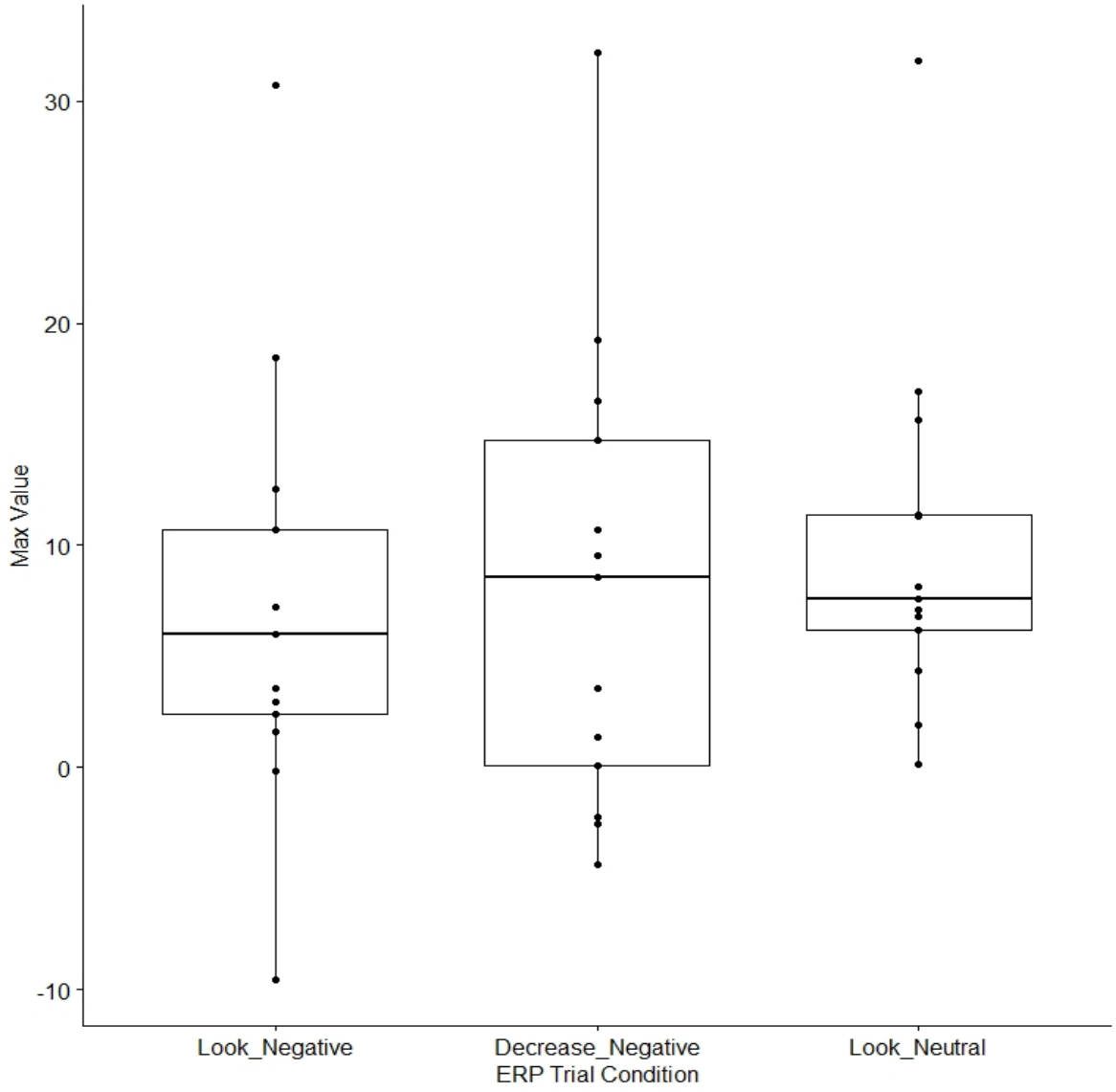

FIGURE 2.

Scatterplot with age and area under the curve for each ERP trial condition

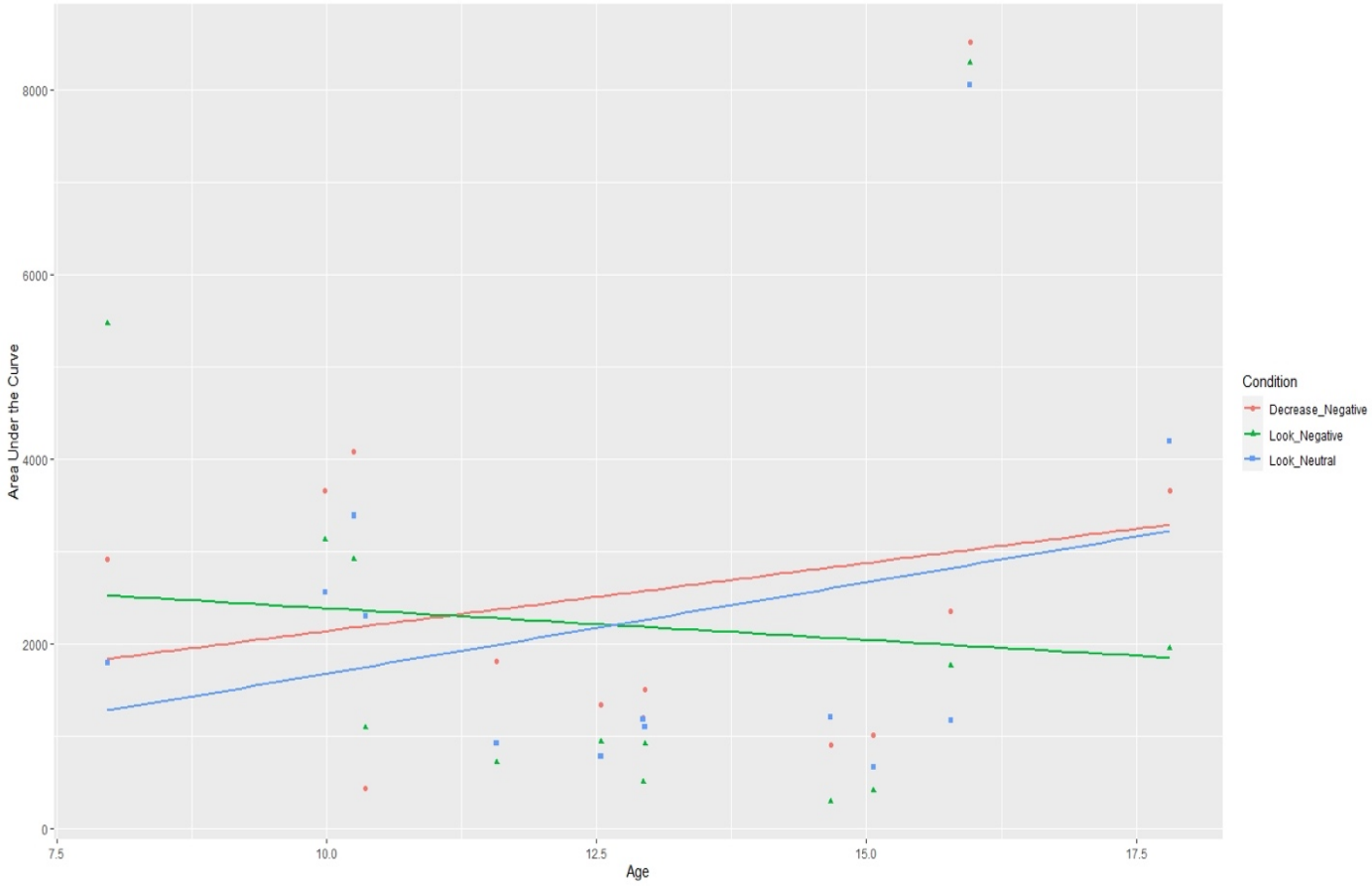

FIGURE 3.

EEG Cap with 64 electrode placements

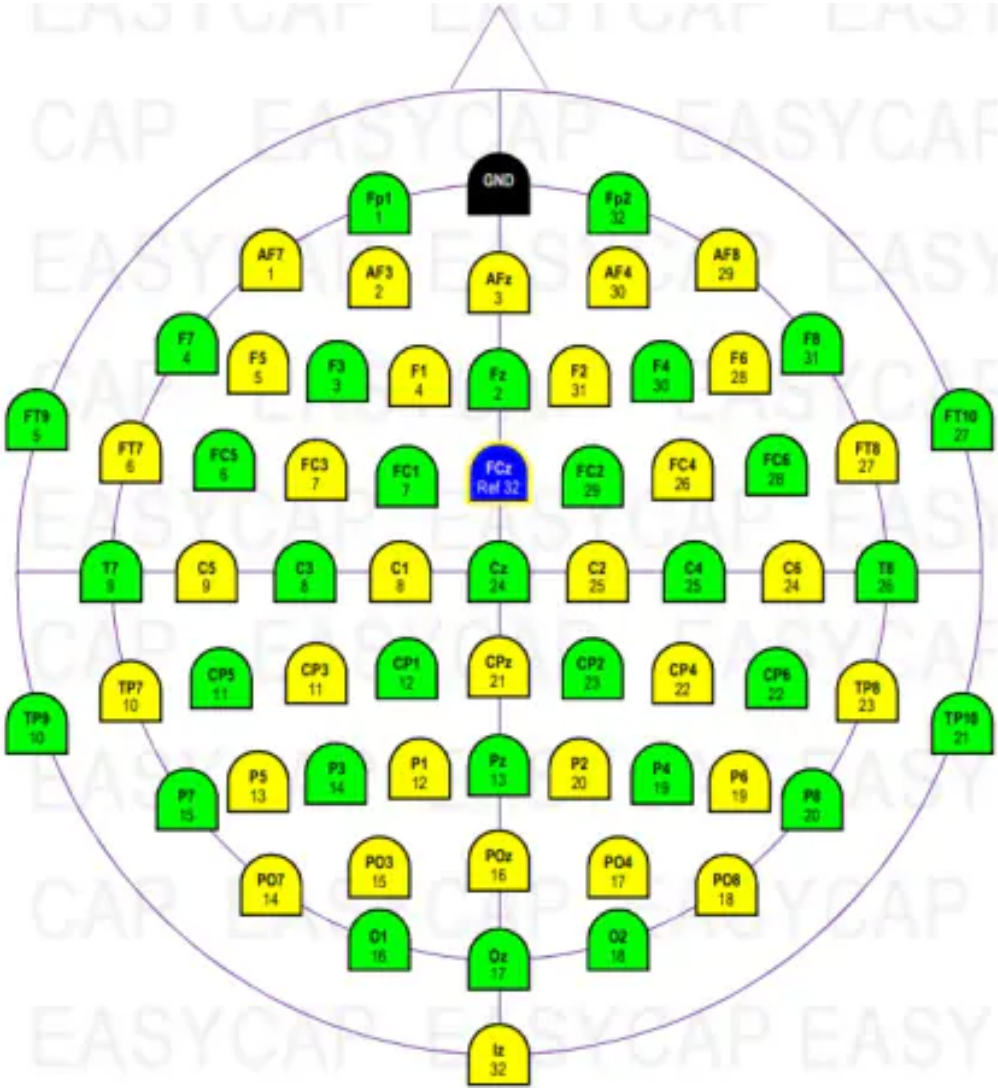

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FIGURE 4.

Emotion regulation task: Steps for one out of the three blocks: (These four steps are repeated

1. Instruction:	LOOK 		DECREASE 
2. Valence (arousal type):	Neutral	Negative	Negative
3. Image: (example given from task):			
4. Arousal Rating: