Impact of Conditioning Inhibitory Control Recruitment to Threat Processing in Trauma Exposed Adults

by

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Abstract

The underlying mechanisms contributing to the risk and maintenance of post-traumatic stress disorder (PTSD) are unclear. Deficits in inhibitory control (IC) have been associated with worse post-traumatic stress symptoms (PTSS) in PTSD. Therefore, training IC activation during threat processing may be therapeutic for trauma-exposed individuals.

Seventy-one trauma-exposed undergraduate students were recruited and were randomly assigned to either the IC+threat or IC+happy training conditions. In the IC+threat condition, high IC demand trials of a flanker task (e.g., <<><<) were associated with threatening emotional face stimuli, while in the IC+happy condition, high IC demand trials were associated with happy emotional face stimuli. We expected the IC+threat group to improve performance during high IC-demand trials with novel threatening emotional faces. Conversely, the IC+happy group was predicted to exhibit the opposite pattern.

Results suggest that IC-emotional processing association can be learned; however, the association does not transfer to novel stimuli.

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List of Abbreviations

ANOVA:	Analysis of Variance
CEI:	Congruency Effect Index
CI:	Confidence Interval
dACC:	Dorsal Anterior Cingulate Cortex
dlPFC:	Dorsolateral Prefrontal Cortex
DSM-5:	Diagnostic and Statistical Manual of Mental Disorders – Fifth Edition
EEG:	Electroencephalogram
ERPs:	Event-Related Potentials
ERQ:	Emotional Regulation Questionnaire
EOG:	Horizontal Electrooculogram
fMRI:	Functional Magnetic Resonance Imaging
ICH:	IC + Happy
IC:	Inhibitory Control
ICT:	Inhibitory Control over Threat
LEC-5:	Life Events Checklist for DSM-5
PTQ:	Perseverative Thinking Questionnaire
PTSD:	Post-Traumatic Stress Disorder
PTSS:	Post-Traumatic Stress Symptoms
rIFC:	Right Inferior Frontal Cortex
RT:	Reaction Time

Inhibitory Control Training in Trauma

Introduction

Approximately 50% of people will experience at least one traumatic event in their lifetime (Kessler et al., 1995). However, only a fraction of those who have a history of trauma develop PTSD (Aupperle et al., 2012). Moreover, a review of the PTSD literature reveals that not all PTSD patients respond to extant treatments (Schottenbauer et al., 2008). Together, these observations suggest that the mechanisms underlying risk for and maintenance of PTSD after trauma exposure are unclear. Accumulating evidence suggests that deficits in inhibitory control (IC) may be one such mechanism (Aupperle et al., 2012). Functional magnetic resonance imaging (fMRI) and neuropsychological studies employing inhibitory control tasks suggest that PTSD patients show reduced functional activity in brain areas during IC-demanding tasks (Cisler et al., 2011; Falconer et al., 2008; Fitzgerald et al., 2018; LaGarde et al., 2010). For example, Falconer et al. (2008) found that increased PTSD severity was associated with diminished recruitment of executive inhibitory control networks such as the dorsolateral prefrontal cortex (dlPFC), right inferior frontal cortex (rIFC), and dorsal anterior cingulate cortex (dACC) during a Go/No go task. Thus, alterations in IC may be relevant in understanding the etiology of PTSD.

Inhibitory control is an executive function defined by the capacity to disengage from irrelevant, salient stimuli and focus on goal-relevant stimuli (Egner et al., 2008; Miyake & Friedman, 2012). Several studies have utilized conflict-inducing tasks, such as the Flanker task (Eriksen and Eriksen, 1974), to study this mechanism (Braem et al., 2019; Clayson & Larson, 2011; Egner, 2007; Feldman & Freitas, 2019; Ligeza & Wyczesany, 2017). In conflict-inducing tasks, a conflict arises when a stimulus leads to two competing responses. For example, in the Flanker task, participants are required to identify the direction of the target stimulus (i.e., the center arrow) for congruent (<<<<< or >>>>) and incongruent (<<><< or >><>>) trials in a speeded response paradigm. In this task, a conflict is created by incongruent trials, where the target arrow is pointing in the opposite direction of the flanker arrows. In this task, reaction time slowing to incongruent relative to congruent trials (i.e., congruency effect index [CEI]; incongruent RT – congruent RT) is used as a behavioral index of IC ability. At the neurobiological unit of analysis, previous work suggests that the ACC is responsible for detecting conflicts (Egner & Hirsch, 2005), and works in concert with other IC-related regions of the brain (e.g., dlPFC) to resolve the conflict (Banich, 2009; Egner & Hirsch, 2005). Likewise, results from Event-Related-Potentials (ERPs) studies show that the N2 component is sensitive to conflict on IC tasks (e.g., Flanker; Clayson & Larson, 2011). Behavioral and neural indices of poor IC have been linked to PTSD symptom severity (Falconer et al., 2008), suggesting that impaired IC may be an important underlying mechanism of the disorder.

PTSD-linked IC deficits may be particularly evident in threatening contexts. PTSD is marked by hypervigilance and bias towards negative, often threat-related, stimuli (Bryant & Harvey, 1997; Buckley et al., 2000; Paunovic et al., 2002). Several studies have shown that PTSD is associated with elevated threat-related activation in the amygdala and other emotional processing regions (Bremner et al., 2004; Falconer et al., 2008; Shin et al., 2005). The attentional bias towards threat-related stimuli may impact the performance of executive functioning in such contexts. Indeed, accumulating evidence suggests that individuals with a history of PTSD perform worse on IC tasks when the task stimuli are presented in a trauma-related context compared to a neutral context (Bryant & Harvey, 1997; Mueller-Pfeiffer et al., 2010; Paunovic et al., 2002). This hypervigilance and bias towards negative stimuli may be due to the attentional interference caused by the stimuli, suggesting a potential underlying dysfunction in disengagement from the negative stimuli and inhibition (Pineles et al., 2007, 2009). Interestingly, recent studies have shown that improvement in PTSD symptoms (PTSS) through exposure therapy is correlated with enhanced disengagement from negative stimuli (El Khoury-Malhame et al., 2011).

Given that IC in the context of threat has been linked with PTSD, training IC activation during threat processing may be therapeutic with respect to its ability to improve conflict adaptation and enhance spontaneous disengagement from the emotional distractor. Although IC is typically conceptualized as a static ability, evidence suggests that it is dynamic and responsive to environmental demands (Clayson & Larson, 2011; Spielberg et al., 2015). For example, Clayson and Larson (2011) showed that the amplitude of the conflict-sensitive ERP (i.e., the N2) is maximal when a congruent trial is followed by an IC-demanding incongruent trial, whereas the N2 amplitude decreases when an incongruent trial follows another incongruent trial. The authors suggest that consecutive incongruent trials primes IC activation, which leads to a decrease in N2 amplitude and faster RT, also known as conflict adaptation (Clayson & Larson, 2011. Moreover, recent evidence suggests that trauma-exposed individuals and those diagnosed with PTSD show poorer conflict adaptation compared to healthy individuals (Marusak et al., 2015; Steudte-Schmiedgen et al., 2014). Taken together, these findings suggest that IC activation is modulated by context (e.g., recency of IC demand, concurrent threat processing), and PTSD is associated with impairment in IC recruitment, particularly in negative affective contexts, as well as IC adaptation.

The previous research demonstrates that IC activation is responsive to the temporal context (i.e., recency of IC demand) and can be affected by concurrent threat processing. Accumulating research has shown that IC activation can also be conditioned to distinct stimuli categories, such that IC becomes more efficient in response to stimuli presented disproportionately in IC-demanding contexts (Chiu & Egner, 2019). For example, Crump and Milliken (2009) paired incongruent and congruent trials of the classic Stoop task with different spatial locations on the presenting computer screen. The authors showed that the spatial location that was paired mostly (i.e., 100% of the time) with incongruent trials in the training phase could serve as a bottom-up contextual cue to facilitate top-down control in the subsequent Stroop task with novel colors and even location proportions (Crump & Milliken, 2009). Interestingly, even subtle emotional information in images of facial expressions can be conditioned to IC recruitment. For example, in a non-clinical sample, Cañadas et al. (2016) superimposed emotional faces (e.g., angry or happy) on each trial of a flanker task. To condition IC activation to specific emotion categories, the authors manipulated the association between IC demand (i.e., the proportion of congruent vs. incongruent trials) and emotional face type. The results revealed that the congruency effect index (CEI; incongruent RT – congruent RT) was larger for emotional expressions associated with a high proportion of congruent trials relative to those associated with a low proportion of congruent trials. Crucially, this effect was also found for emotional face stimuli that were not associated with the same congruency bias as the other category exemplars, suggesting that generalization of the IC demand + emotion category association occurred (Cañadas et al., 2016). Taken together, these findings suggest that, as with other forms of Pavlovian learning, associations between IC demand and other categories (e.g., emotional faces and locations) can be learned. Moreover, this association is generalizable to novel unbiased stimuli, suggesting that effects are unlikely to be solely attributable to stimulus-response learning.

Although the reviewed research show that IC activation can be conditioned to stimulus categories, including emotional cues, and generalize to novel category exemplars, the clinical relevance of this form of learning is unclear. In one relevant study, Cohen et al. (2015) paired negatively charged emotional images repeatedly (i.e., 90% of the time) with either incongruent or congruent trials of a flanker task to create two conditions. Participants were randomly assigned to complete a training block consisted of 384 trials in one of the conditions. The authors found that participants randomized to the negative-stimuli+incongruent pairing condition reported lower state levels of rumination after a post-training sad mood induction compared to those randomized to the negative-stimuli+congruent pairing (Cohen et al., 2015). In a different study with the same paradigm, Cohen and Mor (2018) asked participants to utilize cognitive reappraisal after a sad mood induction. The authors showed that participants randomized to the negative stimuli+incongruent condition demonstrated increased efficacy of instructed reappraisal as well as elevated spontaneous use of reappraisal relative to participants randomized to the negative stimuli+congruent condition (Cohen & Mor, 2018). These results suggest that increasing IC recruitment before engaging in negative emotional processing may result in greater subsequent emotional regulation in a clinically-relevant context.

This sequence of studies, however, has two significant limitations. First, in Cohen and colleagues' studies (2015 & 2018), emotional stimuli are presented *after* the IC demand trials; therefore, it is difficult to suggest that a predictive association between emotional images and IC demand was formed. It is possible that the reported improvement in RT and emotion regulation could be explained by reduced residual negative emotional activation from the training task (i.e., due to IC activation reducing reactivity to the subsequent negative images) rather than the learned association between negative stimuli and IC activation. As reviewed above, Cañadas et al. (2016) successfully created a conditioning effect between IC demand and emotional stimuli; however, the authors did not address the far-transfer effects of IC-demand+emotion on any clinically relevant outcome. To our knowledge, no study has tested whether learned associations between IC demand and negative emotional cues can transfer to a clinically-relevant context.

Second, Cohen and colleagues (2015 & 2018) measured the effects of IC demand on emotional adaptation using behavioral (i.e., reaction time) data, which is limited by the influence of processes extraneous to conflict detection and IC activation (e.g., motor movement/decisionmaking processes). To address this issue, some researchers supplement these data with neurophysiological data, such as ERPs, which are theoretically closer to the IC process itself. One ERP component that is typically utilized to study conflict detection and adaptation is the N2 (Aupperle et al., 2012; Clayson & Larson, 2011). The N2 is a negative deflection in the ERP measured 250-350 ms after stimulus presentation in the frontocentral sites and has been reliably associated with response conflict in an inhibitory control context (Yeung et al., 2004). To our knowledge, however, no study has utilized neurophysiological data to study IC demand learning.

The present study addressed the aforementioned limitations. Our overall aim was to test the clinical utility of training IC activation during threat processing in a trauma-exposed sample reporting elevated PTSS. To meet this aim, we randomized participants to one of two training conditions. In the IC+threat condition, high IC demand disproportionately co-occurred with threatening compared to positively-valenced emotional face stimuli, whereas in the control condition, high IC demand disproportionately co-occurred with positively-valenced compared to threatening emotional face stimuli. We hypothesized that generalization of IC demand+emotion learning to novel emotional face stimuli would occur at the end of the training task (i.e., near-transfer effect). Specifically, we predicted that participants who received IC+threat training would perform better (i.e., faster RT and smaller N2 amplitude) during high IC-demand trials in the context of novel threatening compared to positively-valenced emotional face stimuli, whereas the opposite pattern would emerge in the control condition.

To test the clinical utility of IC+threat training (i.e., far transfer effect), we instructed participants to complete a trauma-writing exercise after completing the IC+emotion training. After the trauma writing exercise, state reappraisal and rumination was assessed (Cohen et al., 2015; Cohen & Mor, 2018). We hypothesized that participants who received the IC+threat training would have lower and higher levels of state rumination and reappraisal, respectively, after the trauma writing task compared to participants in the control group.

Lastly, we tested IC+emotion learning as a mechanism of the expected differential effect of training conditions on state emotion regulation. Specifically, we hypothesized that the effect of training conditions on state rumination/reappraisal would be mediated by the extent of the near- transfer effect. Specifically, we predicted that the extent to which IC+threat learning transfers to novel threat stimuli, indexed via RT and N2 amplitude, would mediate the impact of the IC+threat condition on post-trauma writing state rumination/reappraisal.

Methods

Participants

The sample (n = 71) included participants from the Auburn University (AU) undergraduate psychology pool (see Table 1). To be eligible for the study, participants had to be 18 years of age or older, fluent English speakers, report at least one traumatic event based on Criterion A of the Diagnostic and Statistical Manual of Mental Disorders (5^{th} ed.), and screen positive for PTSD based on the Primary Care PTSD Screen for DSM-5 (Prins et al., 2016).

An online advertisement with a link to our online screener form was posted on the SONA system to reach out to potential participants. After completing an online version of the informed consent via the Qualtrics website, participants completed the Life Events Checklist for DSM-5 (LEC-5; Weathers et al., 2013). The LEC-5 is used to assess trauma exposure. In this survey, we asked participants to briefly describe their traumatic experiences and indicate the frequency of the event(s). Next, a graduate-level clinician determined participants' eligibility based on whether their reported worst event was a DSM-5 Criterion A trauma and whether they screened positive on the Primary Care PTSD Screen. Eligible participants were contacted by our staff team to schedule a three-hour lab visit.

Measures

Life events checklist for DSM-5 (LEC-5)

The LEC-5 (Weathers et al., 2013) is a 17-item checklist that is used to assess traumatic events. The checklist lists sixteen potentially traumatic events (e.g., natural disasters, sexual assault, sudden death) and one miscellaneous item, which allows participants to type in another stressful experience not included in the checklist. For each event, participants indicated how they experienced the index event (e.g., "happen directly to me"), and how frequently they have experienced it. At the end of the survey, participants indicated which event they considered the worst. The psychometric properties of this version of the LEC-5 have been demonstrated to be satisfactory (Blevins et al., 2015).

The Primary Care PTSD Screen for DSM-5

The Primary Care PTSD Screen for DSM-5 (Prins et al., 2016) is an abbreviated version of the PTSD Checklist designed to measure PTSD symptoms in primary care settings. This self-report measure consists of five statements related to PTSD symptoms (e.g., "Had nightmares about the event(s) or thought about the event(s) when you did not want to?"), indexed to their worst traumatic event. Respondents indicated if they experienced any symptoms mentioned in the measure within the past month by responding Yes or No to each statement. The psychometric properties of this version of the PCL have been demonstrated to be satisfactory (Prins et al., 2016). Regarding diagnostic sensitivity, the authors found that a score cut off of *three* would optimally minimize false negative screen results (Prins et al., 2016).

State Reappraisal and Rumination

In this study, state reappraisal and negative perseverative thinking after the trauma writing task was measured using a combined version of the Emotional Regulation Questionnaire (ERQ; Gross & John, 2003) and the Perseverative Thinking Questionnaire (PTQ; Ehring et al., 2011). The combined version consisted of 15 statements regarding cognitive reappraisal (e.g., “I am controlling my emotions by changing the way I’m thinking about the stressful event.”) and state rumination (e.g., “I can’t stop dwelling on my negative thoughts related to the stressful event.”) in response to the trauma writing task. Respondents were asked to rate the degree to which they agree with each statement using a 7-point Likert scale ranging from 0 (*strongly disagree*) to 7 (*strongly agree*). Both measures have been shown to have good psychometric properties (Cohen & Mor, 2018; Ehring et al., 2011).

Laboratory Measures

Once in the laboratory, participants were asked to review and sign a physical consent form similar to the electronic consent form completed prior to the initial online screener via Qualtrics. Following consent, the EEG recording was prepared.

The laboratory session consisted of administering self-report measures and several computerized tasks. Pertaining to the present study’s hypotheses, participants completed the Emotional Flanker Training task, followed by the trauma writing task and then the state emotion regulation measures. Stimuli were presented using a Dell OptiPlex 7050 computer on a 21″ LCD color monitor at a viewing distance of 100 cm, subtending a visual angle of 3.5°. All the tasks and instructions were presented using E-Prime 3.0 software.

Emotional Flanker Training and Near Transfer Task

This study used a modified version of the standard Flanker task (Eriksen & Eriksen, 1974). In each trial, participants saw five horizontally aligned arrowheads. For half of the trials, arrows were congruent (<<<<< or >>>>>) and for the other half arrows were incongruent (<<><< or >><>>). Participants were instructed to indicate the direction of the center arrow (left or right) as quickly and as accurately as possible by clicking the appropriate response key on a Serial Response Box. In our modified version of the task, the arrows were superimposed on images of emotional faces (e.g., fearful or happy). To make sure participants attend to the images before shifting their attention to the arrows, the target arrow (i.e., the center arrow) appeared 100ms after the emotional image was presented. Moreover, participants were specifically instructed to pay attention to the faces because they will be asked about them at the end of the experiment. All five arrows and the emotional face remained on the screen for another 100ms. The arrows and the face then disappeared, followed by a blank screen that remained on the screen for 600ms, during which participants were free to respond. Following the response window's termination, there is a staggered ITI of 800-1200ms before the next trial begins.

To allow participants to take short breaks during this task, we divided the total number of trials into seven equal blocks (i.e., 144 trials per block). The first six blocks were considered the training blocks, and the last block is designed to measure the generalization of IC demand+emotion learning to novel stimuli (i.e., the near-transfer effect). During the training blocks, participants completed a total of 864 trials (50% incongruent, 50% congruent, 50% fearful, 50% happy). However, unbeknownst to the participants, the emotional faces (i.e., fearful or happy) were disproportionately paired with incongruent vs. congruent flankers, depending on the training condition to which the participant was randomized. Precisely, in the Inhibitory Control over Threat (ICT) training condition, 85% of the incongruent trials were paired with fearful faces, whereas 85% of congruent trials were paired with happy faces. In contrast, in the

Inhibitory Control over Happy (ICH) task, 85% of the incongruent trials were paired with happy faces, whereas 85% of congruent trials were paired with fearful faces. In the final near-transfer block (i.e., the 7th block), 144 trials (50% incongruent, 50% congruent, 50% fearful, 50% happy) with *novel* fearful and happy faces were presented. In contrast to the six preceding training blocks, emotional faces were equally divided between congruent and incongruent trials (i.e., each emotion was paired with incongruent flankers 50% of the time). Participants were not informed about these changes. Before completing the task, participants completed a 12-trial practice run to make sure they had an adequate understanding of the task. Completing each block of the Emotional Flanker Training and near-transfer block took approximately 7 minutes (~49 minutes total).

Trauma Writing Task and State Emotion Regulation

To elicit a negative mood, we instructed participants to engage in a 15-minute trauma writing exercise. To maximize the impact of the trauma writing, we instructed participants to use the present tense (e.g., “I am driving…”) to describe the worse traumatic event that they have experienced.

To measure the far-transfer effect of the ICT on state reappraisal and perseverative thoughts, we asked participants to complete a 15-item self-report state reappraisal/perseverative thought measure after the writing task. This measure was presented 5 minutes after the writing task using a 1 to 7 Likert scale on the computer screen.

EEG Apparatus and Analysis

BrainVision Recorder software was used to record EEG data collected with the BrainVision actiCHamp amplifier (1000Hz sampling frequency) and a BrainVision actiCap 32-

channel cap with active electrodes. The midline electrode AFz was used as the ground, and FCz was used as an online reference electrode. Horizontal electrooculogram (EOG) activity was recorded from electrodes placed lateral to the outer canthus of each eye, while vertical EOG activity was recorded from electrodes placed above and below the left eye. Electrodes were filled using electrolyte gel. All impedance values were kept below 10 K ohms throughout the recording session.

Data Analytic Plan

Power Analysis

To determine the minimum sample size required for our near-transfer hypothesis, we examined the effect sizes reported by Cañadas et al. (2016). Similar to our study, Cañadas et al. (2016) looked at the generalizability of IC+emotion learning to novel stimuli. We used the mean reaction times (RT) reported by Cañadas et al. (2016) to estimate the expected effect size of our hypothesized Condition*Emotion*Congruency interaction (η^2 =.07). An online simulation program (Lakens & Caldwell, 2021) was then used to determine the required N to detect a significant ($p<.05$) Condition*Emotion*Congruency interaction of medium effect size (η^2 =.07) with .80 power. Our analysis yielded a recommended minimum sample size of N = 114, with 57 participants in the ICT group and 57 in the CT group. Since no other study, to our knowledge, has examined the N2 in a paradigm similar to our study, we were only able to use mean RT effects reported by Cañadas et al. (2016) to inform our power analysis. However, it is worth noting that determining the sample size based on the expected RT effect size is inherently conservative because, theoretically, RT is a downstream consequence of IC relative to the N2 and thus would be expected to be a noisier effect.

To determine the sample size for our far-transfer hypothesis, we looked at the group differences in state reappraisal/rumination reported by Cohen and More (2018) (d=0.49). We ran an a priori two-tailed power analysis using G*Power (Erdfelder et al., 1996) that set Type-I error probability and tatistical power to 0.05 and 0.80, respectively. With an effect size of d = 0.49 and an allocation ratio of 1, our analysis yielded a recommended minimum sample size of n = 134, with 67 participants in each group.

Lastly, to determine the required sample size for our mediation hypothesis, we utilized the results of a series of power simulations for mediation analyses conducted by Fritz and MacKinnon (2007). Given that we expect our independent variable (i.e., Group) to have a medium-sized effect on the mediator (i.e., N2/RT congruency effect on novel fear vs. happy faces [near-transfer hypothesis]) and the mediator, controlling for the effect of Group, to have a medium-sized effect on state reappraisal/rumination, N=148, with n=74 in each group, is required to detect a significant ($p<.05$) indirect effect of Group on state reappraisal/rumination via the N2/RT congruency effect on novel fear vs. happy faces with 0.80 power (bias-corrected bootstrap mediation test in PROCESS [Hayes, 2012]).

Because the required sample size for the mediation analysis was larger than that of the near-transfer or far-transfer hypotheses, the mediation hypothesis was our primary consideration in determining the sample size.

Data Pre-Processing

Recorded EEG data from the Emotional Flanker Training task was downsampled to 250Hz and re-referenced to the averaged mastoids. Following re-referencing, data was filtered using high- pass (.10Hz) and low-pass (30Hz) cut-offs. Near-transfer block data was then epoched for correct response trials from 300ms before to 1600ms after the presentation of the center arrow. Next, eye movement artifacts were corrected using the algorithm developed by

(Gratton et al., 1983). The epochs were then baseline-corrected using the -300 to -100ms window. Other artifacts (e.g., muscle movements) were rejected in two steps: (1) whole-epoch and channels- within-epochs were rejected using an automated statistical thresholding algorithm on voltage range, deviation from channel's mean voltage, and voltage variance (Nolan et al., 2010); (2) after automated rejection, remaining artifacts were rejected by visual inspection. Cleaned epochs were averaged separately for congruent and incongruent trials presented with fear vs. happy faces.

Mean amplitude (+/- 15ms) surrounding the local negative peak at FCz between 250-350ms for each of the four averaged waveforms (Fear+congruent, Fear+incongruent, Happy+congruent, Happy+incongruent) was computed for each participant. To test the near-transfer and mediation hypotheses, IC+emotion learning was quantified using a difference score [i.e., (Fear Incongruent N2 – Fear Congruent N2) – (Happy Incongruent N2 – Happy Congruent N2)] such that more positive values indicate greater learning of the IC+fear relative to IC+happy association. The same difference score approach was used with reaction time in place of N2 amplitude.

Hypothesis Testing

Near-transfer Effect

The near-transfer hypothesis posits that the generalization of IC demand+emotion learning to novel emotional face stimuli will occur in the near-transfer block of the training task. We will run a three-way (2x2x2) omnibus Analysis of Variance (ANOVA) to test for group differences (i.e., ICT vs. ICH) in the interaction between emotion (i.e., fearful vs. happy) and congruency (i.e., congruent vs. incongruent). Specifically, we anticipate that, for participants in the ICT training group, the congruency effect (i.e., incongruent – congruent) on N2 amplitude will be more positive in the context of fear compared to happy faces, and the congruency effect on mean RT will be lower in the context of fear compared to happy faces. Additionally, we anticipate the opposite pattern of effects in the control group (i.e., ICH training group). The ANOVA will examine the following null and alternative hypotheses: $H0$: The association between IC demand+emotion learning is not transferred to novel emotional face stimuli. That is, there is no difference between training groups in the congruency effect as a function of emotion on N2 amplitude or mean RT in the near-transfer block.

$H1$: The association between IC demand+emotion learning is transferred to novel emotional face stimuli. That is, there is a difference between training groups in the congruency effect as a function of emotion on N2 amplitude/mean RT in the near-transfer block.

Far Transfer Effect

The Far-transfer hypothesis suggest that relative to IC+happy training, IC+threat training will lead to lower and higher levels of state rumination and reappraisal, respectively. We will run a t-test to measure the average score differences on the self-report measures between the training conditions.

The t-test will examine the following null and alternative hypotheses:

$H0$: There are no score differences on the levels of state rumination and reappraisal between the training and the control group.

$H1$: There are significant score differences on the levels of state rumination and reappraisal between the training and the control group.

Mediation

To test IC+emotion learning as a mediator of the impact of training group on state emotion regulation, we will conduct a mediation analysis with PROCESS using asymmetric bootstrapping (5000 bootstrap resamples) to test indirect effects (Hayes, 2012). Specifically, Group (Threat Training vs. Control Training) will be entered as an IV, and IC+Emotion learning [Near-transfer block (Fear Incongruent – Fear Congruent) – (Happy Incongruent – Happy Congruent) RT/N2 amplitude] will be entered as the mediator. Post-writing task state rumination/reappraisal will be entered as the outcome. The mediation test will examine the following null and alternative hypotheses:

$H0$: Group effects on rumination/reappraisal are not mediated by the extent to which the IC+threat learning transfers to novel threat stimuli.

$H1$: Group effects on rumination/reappraisal are mediated by the extent to which the IC+threat learning transfers to novel threat stimuli.

Results

Similar to other studies (Cañadas et al., 2016), the practice and the first three blocks of training were considered learning trials; thus, their data were not included in the analysis. In addition, data from five participants were excluded from the analysis because they had excessive artifacts (N=1), experienced technical problems (N=3), or did not complete the emotional flanker task (N=1).

Near-transfer Effect

Analysis of the mean reaction time (RT) revealed a congruency effect, $F(1, 67) = 391.04$, $p<.000$; $\eta2=.85$. As expected, participants showed a longer RT on incongruent (M = 428.75 ms, SE = 4.32 95% CI [420.13, 437.38]) than on congruent (M = 390.28 ms, SE = 4.72; 95% CI [380.86, 399.71]) trials. Further analysis revealed a similar congruency effect for the N2. As expected, incongruent trials showed a more negative N2 (M = -1.13 µV, SE = .72; 95% CI [-2.76, .09]) compared to congruent trials (M = -.21 µV, SE = .62; 95% CI [-1.44, 1.03]). In contrast to predictions, the condition*emotion*congruency interaction was non-significant for both the N2 $F(1,64) = .37$, $p = .55$ (see Figure 1) and reaction time $F(1,67) = 1.71$, $p = .195$, indices. These findings suggest that the N2 amplitude and response latency indices of inhibitory control did not vary across emotion categories as a function of the IC training task.

Since the near-transfer effect was non-significant, we ran an additional analysis to test whether the expected IC demand+emotion learning effect occurs during training. Specifically, we ran a similar condition*emotion*congruency omnibus ANOVA to test for group differences in the interaction between emotion and congruency in the second half of the training blocks. Results revealed that the condition*emotion*congruency interaction was non-significant for the reaction time $F(1,67) = .81$, $p = .37$, but was significant for the N2 $F(1.65) = 4.71$, $p = .034$. Further analysis of the N2 interaction (see Figure 2) revealed that in the ICT group, the average ΔN2 amplitude for fearful faces (M = -1.33 µV, SE = .39; 95% CI [-2.11, -.55]) was more positive than the average ΔN2 amplitude for happy faces (M = -2.55 µV, SE = .65; 95% CI [-3.85, -1.26]). Conversely, in the ICH group, the average ΔN2 amplitude for happy faces (M = -.18 µV, SE = .69; 95% CI [-1.53, 1.17]) was more positive than the average ΔN2 amplitude for fearful faces (M = -1.07 µV, SE = .41; 95% CI [-1.89, -.26]).

Far-Transfer Effect

In contrast to our hypothesis, the far-transfer effect was non-significant. Specifically, the ICT group (M = 38.25, SD = 13.84) did not differ from the ICH group (M = 40.27, SD = 13.24), $t(67) = .62$, $p = .54$, on state rumination after the trauma writing task. Moreover, there was not a significant difference between the ICT group (M = 26.06, SD = 6.92) and ICH group (M =

25.36, SD = 6.58), t(67) = .-43, p = .67, on state reappraisal after the trauma writing task.

Mediation

The mediation hypothesis was initially included to test whether IC+emotion learning mediated the training group's impact on state emotion regulation after the trauma writing task. Since the IC+emotion learning generalization effect (i.e., near-transfer) and the impact of IC+emotion learning on clinical measures (i.e., far-transfer) were non-significant, we did not run this analysis.

Discussion

The purpose of this study was to test whether training trauma-exposed individuals to recruit inhibitory control (IC) in a threat-related context 1) would generalize to a new but similar context and 2) would improve emotion regulation after a trauma-writing exercise compared to participants who received IC training in a happy-related context. Overall, neither of these hypotheses were supported. Specifically, there were no significant differences between the IC+Happy (ICH) and IC+Threat (ICT) training groups on N2 or reaction time modulation by emotional category in the novel emotional face block. Further, there were no group differences on state rumination or reappraisal after the trauma writing task.

Although the near-transfer and far-transfer hypotheses were not supported, the significant group*emotion*congruency interaction for the ΔN2 in the second half of the training task showed that IC+emotion associations were learned as expected during training. This finding is in line with Cañadas et al. (2016), who showed that emotional expressions that are repeatedly paired with incongruent trials could serve as contextual cues and elicit faster reaction times on subsequent incongruent trials. One possible explanation for why we did not find a near-transfer effect could be the rapid adaptability of IC to the requirements of the task. In one study utilizing a flanker task with disproportionate congruency rates (e.g., 75% incongruent trials), Grützmann et al. (2021) showed that by manipulating the levels of IC demand in their design, an initial adaptation to incongruent trials (e.g., faster reaction time) could be formed. However, their results show that this adaptation does not sustain when task requirements are no longer present (i.e., 50% incongruent trials). Indeed, in studies where only the context stimuli (e.g., emotional pictures) and not the congruency proportion of trials were manipulated, the near-transfer effect was detected (Cañadas et al., 2016).

In contrast to neurophysiological findings (i.e., ΔN2) and contrary to our predictions, the condition*emotion*congruency interaction for the training phase's reaction time was non-significant. This finding suggests that behavioral indices did not detect the learning effect captured by the ΔN2. One explanation for this discrepancy is that the behavioral data could be contaminated with extraneous noise (e.g., minor delays between pressing the response key and generating the digital code) and are less sensitive to IC alterations than neurophysiological markers. Another possible explanation is the presence of emotional faces. Previous studies suggest that the presence of emotional faces, especially threat-related stimuli, during an inhibitory control task could slow response time (Reinhard et al., 2017). Since each participant might react differently to fearful faces, a wide variety of reaction times is expected, especially during the training phase, where the IC demanding trials (i.e., incongruent trials) are disproportionality paired with either fearful or happy faces.

The far-transfer hypothesis was also nonsignificant. Since the far-transfer effect hinges on participants' ability to generalize the learned association between fearful stimuli and activating IC to contexts beyond the training phase, this non-significant effect was unsurprising given the absence of a near-transfer effect.

There are some limitations of the present study. First, although we tried to keep our clinical sample homogenous in terms of post-traumatic stress symptoms (PTSS), we could not verify if any of our participants met the DSM-5 diagnosis for PTSD. Considering that individuals diagnosed with PTSD might process emotional faces, especially fearful faces, differently from the trauma-exposed individual without a PTSD diagnosis (Morey et al., 2009), this limitation might have increased variability in our data. Future studies should utilize a sample with trauma-exposed participants with and without PTSD diagnosis and a symptom-free control group. Second, the present study was slightly underpowered. Our *a priori* power analysis yielded a recommended minimum sample size of N = 114 for our near-transfer and a minimum sample of N = 134 for our far-transfer hypothesis. However, due to recruitment restrictions imposed by Auburn University for in-person studies after the COVID-19 pandemic, our final sample size was 71. It is expected that this small sample size impacted our effect sizes across our hypotheses and could explain why some of our findings were in the expected direction but did not reach significance. Future studies should consider utilizing a larger sample to detect near- and far-transfer effects. Lastly, this study did not control for any psychiatric medication participants used before the study. Since some psychiatric medications, such as antidepressants, could impact some of this study's dependent variables (e.g., state rumination), controlling for them in future studies would reduce the confounding effects of these medications.

Conclusion

In sum, the current study suggests that repeated IC+emotion training can produce a Pavlovian conditioning learning effect such that more inhibitory control recruitment is associated with emotional faces paired with the IC-demanding trials. However, this learning effect does not transfer to novel emotional face stimuli, nor does it impact any clinical measures after the training phase. One possible explanation for these null findings in our study could be the cognitive load of the IC-demanding trials after the change in the congruency paring rate. Specifically, we changed our flanker/emotional faces congruency paring rate from 85% in the training blocks to 50% in the near-transfer block. As suggested by Grützmann et al. (2021), changes in the congruency paring rate may lead to a rapid IC adaptation, which could overwhelm the learning effect and diminish the near-transfer effect. Indeed, studies such as Cañadas et al., (2016) that did not change the congruency paring rate reported a near-transfer effect. Further studies should investigate whether a larger and more homogenous sample could yield a more robust learning generalization effect. Moreover, a longer training phase might be required for generalization.

References

Aupperle, R. L., Melrose, A. J., Stein, M. B., & Paulus, M. P. (2012). Executive function and PTSD: Disengaging from trauma. *Neuropharmacology*, *62*(2), 686–694. https://doi.org/10.1016/j.neuropharm.2011.02.008

Banich, M. T. (2009). Executive Function: The Search for an Integrated Account. *Current Directions in Psychological Science*, *18*(2), 89–94. https://doi.org/10.1111/j.1467-8721.2009.01615.x

Blevins, C. A., Weathers, F. W., Davis, M. T., Witte, T. K., & Domino, J. L. (2015). The Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5): Development and Initial Psychometric Evaluation. *Journal of Traumatic Stress*, *28*(6), 489–498. https://doi.org/10.1002/jts.22059

Braem, S., Bugg, J. M., Schmidt, J. R., Crump, M. J. C., Weissman, D. H., Notebaert, W., & Egner, T. (2019). Measuring Adaptive Control in Conflict Tasks. *Trends in Cognitive Sciences*, *23*(9), 769–783. https://doi.org/10.1016/j.tics.2019.07.002

Bremner, J. D., Vermetten, E., Vythilingam, M., Afzal, N., Schmahl, C., Elzinga, B., & Charney, D. S. (2004). Neural correlates of the classic color and emotional stroop in women with abuse-related posttraumatic stress disorder. *Biological Psychiatry*, *55*(6), 612–620. https://doi.org/10.1016/j.biopsych.2003.10.001

Bryant, R. A., & Harvey, A. G. (1997). Attentional Bias in Posttraumatic Stress Disorder. *Journal of Traumatic Stress*, *10*(4), 635–644. https://doi.org/10.1023/A:1024849920494

Buckley, T. C., Blanchard, E. B., & Neill, W. T. (2000). Information processing and ptsd: A review of the empirical literature. *Clinical Psychology Review*, *20*(8), 1041–1065. https://doi.org/10.1016/S0272-7358(99)00030-6

Cañadas, E., Lupiáñez, J., Kawakami, K., Niedenthal, P. M., & Rodríguez-Bailón, R. (2016). Perceiving emotions: Cueing social categorization processes and attentional control through facial expressions. *Cognition and Emotion*, *30*(6), 1149–1163. https://doi.org/10.1080/02699931.2015.1052781

Chiu, Y.-C., & Egner, T. (2019). Cortical and subcortical contributions to context-control learning. *Neuroscience & Biobehavioral Reviews*, *99*, 33–41. https://doi.org/10.1016/j.neubiorev.2019.01.019

Cisler, J. M., Wolitzky-Taylor, K. B., Adams, T. G., Babson, K. A., Badour, C. L., & Willems, J.L. (2011). The emotional Stroop task and posttraumatic stress disorder: A meta-analysis.

Clinical Psychology Review, *31*(5), 817–828. https://doi.org/10.1016/j.cpr.2011.03.007

Clayson, P. E., & Larson, M. J. (2011). Effects of repetition priming on electrophysiological and behavioral indices of conflict adaptation and cognitive control. *Psychophysiology*, *48*(12), 1621–1630. https://doi.org/10.1111/j.1469-8986.2011.01265.x

Cohen, N., & Mor, N. (2018). Enhancing Reappraisal by Linking Cognitive Control and Emotion. *Clinical Psychological Science*, *6*(1), 155–163. https://doi.org/10.1177/2167702617731379

Cohen, N., Mor, N., & Henik, A. (2015). Linking Executive Control and Emotional Response: A Training Procedure to Reduce Rumination. *Clinical Psychological Science*, *3*(1), 15–25. https://doi.org/10.1177/2167702614530114

Crump, M. J. C., & Milliken, B. (2009). Short article: The flexibility of context-specific control: Evidence for context-driven generalization of item-specific control settings. *Quarterly Journal of Experimental Psychology*, *62*(8), 1523–1532. https://doi.org/10.1080/17470210902752096

Egner, T. (2007). Congruency sequence effects and cognitive control. *Cognitive, Affective, & Behavioral Neuroscience*, *7*(4), 380–390. https://doi.org/10.3758/CABN.7.4.380

Egner, T., Etkin, A., Gale, S., & Hirsch, J. (2008). Dissociable Neural Systems Resolve Conflict from Emotional versus Nonemotional Distracters. *Cerebral Cortex*, *18*(6), 1475–1484. https://doi.org/10.1093/cercor/bhm179

Egner, T., & Hirsch, J. (2005). Cognitive control mechanisms resolve conflict through cortical amplification of task-relevant information. *Nature Neuroscience*, *8*(12), 1784–1790. https://doi.org/10.1038/nn1594

Ehring, T., Zetsche, U., Weidacker, K., Wahl, K., Schönfeld, S., & Ehlers, A. (2011). The Perseverative Thinking Questionnaire (PTQ): Validation of a content-independent measure of repetitive negative thinking. *Journal of Behavior Therapy and Experimental Psychiatry*, *42*(2), 225–232. https://doi.org/10.1016/j.jbtep.2010.12.003

El Khoury-Malhame, M., Lanteaume, L., Beetz, E. M., Roques, J., Reynaud, E., Samuelian, J.-C., Blin, O., Garcia, R., & Khalfa, S. (2011). Attentional bias in post-traumatic stress disorder diminishes after symptom amelioration. *Behaviour Research and Therapy*, *49*(11), 796–801. https://doi.org/10.1016/j.brat.2011.08.006

Erdfelder, E., Faul, F., & Buchner, A. (1996). GPOWER: A general power analysis program. *Behavior Research Methods, Instruments, & Computers*, *28*(1), 1–11. https://doi.org/10.3758/BF03203630

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics*, *16*(1), 143–149. https://doi.org/10.3758/BF03203267

Falconer, E., Bryant, R., Felmingham, K. L., Kemp, A. H., Gordon, E., Peduto, A., Olivieri, G., & Williams, L. M. (2008). The neural networks of inhibitory control in posttraumatic stress disorder. *Journal of Psychiatry & Neuroscience : JPN*, *33*(5), 413–422.

Feldman, J. L., & Freitas, A. L. (2019). An analysis of N2 event-related-potential correlates of sequential and response-facilitation effects in cognitive control. *Journal of Psychophysiology*, *33*(2), 85–95. https://doi.org/10.1027/0269-8803/a000212

First, M.B., Williams, J.B.W., Karg, R.S., & Spitzer, R.L. (2015). *Structured Clinical Interview for DSM-5—Research Version (SCID-5 for DSM-5, Research Version; SCID-5-RV)*. Arlington, VA. American Psychiatric Association.

Fitzgerald, J. M., DiGangi, J. A., & Phan, K. L. (2018). Functional Neuroanatomy of Emotion and Its Regulation in PTSD. *Harvard Review of Psychiatry*, *26*(3), 116–128. https://doi.org/10.1097/HRP.0000000000000185

Fritz, M. S., & MacKinnon, D. P. (2007). Required Sample Size to Detect the Mediated Effect.*Psychological Science*, *18*(3), 233–239. https://doi.org/10.1111/j.1467-9280.2007.01882.x

Gratton, G., Coles, M. G. H., & Donchin, E. (1983). A new method for off-line removal of ocular artifact. *Electroencephalography and Clinical Neurophysiology*, *55*(4), 468–484. https://doi.org/10.1016/0013-4694(83)90135-9

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, *85*(2), 348–362. https://doi.org/10.1037/0022-3514.85.2.348

Grützmann, R., Kathmann, N., & Heinzel, S. (2022). Cognitive control is quickly adapted to actual task requirements despite misleading context cues—Evidence from the N2, CRN, and ERN. *Psychophysiology*, *59*(2), e13961. https://doi.org/10.1111/psyp.13961

Hayes, A. F. (2012). *PROCESS: A versatile computational tool for observed variable mediation, moderation, and conditional process modeling.*

Iacoviello, B. M., Wu, G., Alvarez, E., Huryk, K., Collins, K. A., Murrough, J. W., Iosifescu, D. V., & Charney, D. S. (2014). Cognitive-Emotional Training as an Intervention for Major Depressive Disorder. *Depression and Anxiety*, *31*(8), 699–706. https://doi.org/10.1002/da.22266

Kessler, R. C., Sonnega, A., Bromet, E., Hughes, M., & Nelson, C. B. (1995). Posttraumatic Stress Disorder in the National Comorbidity Survey. *Archives of General Psychiatry*, *52*(12), 1048–1060. https://doi.org/10.1001/archpsyc.1995.03950240066012

LaGarde, G., Doyon, J., & Brunet, A. (2010). Memory and executive dysfunctions associated with acute posttraumatic stress disorder. *Psychiatry Research*, *177*(1), 144–149. https://doi.org/10.1016/j.psychres.2009.02.002

Lakens, D., & Caldwell, A. R. (2021). Simulation-Based Power Analysis for Factorial Analysis of Variance Designs. *Advances in Methods and Practices in Psychological Science*, *4*(1), 2515245920951503. https://doi.org/10.1177/2515245920951503

Ligeza, T. S., & Wyczesany, M. (2017). Cognitive conflict increases processing of negative, task-irrelevant stimuli. *International Journal of Psychophysiology*, *120*, 126–135. https://doi.org/10.1016/j.ijpsycho.2017.07.013

Marusak, H. A., Martin, K. R., Etkin, A., & Thomason, M. E. (2015). Childhood trauma exposure disrupts the automatic regulation of emotional processing. *Neuropsychopharmacology: Official Publication of the American College of Neuropsychopharmacology*, *40*(5), 1250–1258. https://doi.org/10.1038/npp.2014.311

Miyake, A., & Friedman, N. P. (2012). The Nature and Organization of Individual Differences in Executive Functions: Four General Conclusions. *Current Directions in Psychological Science*, *21*(1), 8–14. https://doi.org/10.1177/0963721411429458

Morey, R. A., Dolcos, F., Petty, C. M., Cooper, D. A., Hayes, J. P., LaBar, K. S., & McCarthy, G. (2009). The role of trauma-related distractors on neural systems for working memory and emotion processing in posttraumatic stress disorder. *Journal of Psychiatric Research*, *43*(8), 809–817. https://doi.org/10.1016/j.jpsychires.2008.10.014

Mueller-Pfeiffer, C., Martin-Soelch, C., Blair, J. R., Carnier, A., Kaiser, N., Rufer, M., Schnyder, U., & Hasler, G. (2010). Impact of emotion on cognition in trauma survivors: What is the role of posttraumatic stress disorder? *Journal of Affective Disorders*, *126*(1), 287–292. https://doi.org/10.1016/j.jad.2010.03.006

Nolan, H., Whelan, R., & Reilly, R. B. (2010). FASTER: Fully Automated Statistical Thresholding for EEG artifact Rejection. *Journal of Neuroscience Methods*, *192*(1), 152–162. https://doi.org/10.1016/j.jneumeth.2010.07.015

Paunovic, N., Lundh, L.-G., & Öst, L.-G. (2002). Attentional and memory bias for emotional information in crime victims with acute posttraumatic stress disorder (PTSD). *Journal of Anxiety Disorders*, *16*(6), 675–692. https://doi.org/10.1016/S0887-6185(02)00136-6

Pineles, S. L., Shipherd, J. C., Mostoufi, S. M., Abramovitz, S. M., & Yovel, I. (2009). Attentional biases in PTSD: More evidence for interference. *Behaviour Research and Therapy*, *47*(12), 1050–1057. https://doi.org/10.1016/j.brat.2009.08.001

Pineles, S. L., Shipherd, J. C., Welch, L. P., & Yovel, I. (2007). The role of attentional biases in PTSD: Is it interference or facilitation? *Behaviour Research and Therapy*, *45*(8), 1903–1913. https://doi.org/10.1016/j.brat.2006.08.021

Prins, A., Bovin, M. J., Smolenski, D. J., Marx, B. P., Kimerling, R., Jenkins-Guarnieri, M. A., Kaloupek, D. G., Schnurr, P. P., Kaiser, A. P., Leyva, Y. E., & Tiet, Q. Q. (2016). The Primary Care PTSD Screen for DSM-5 (PC-PTSD-5): Development and Evaluation Within a Veteran Primary Care Sample. *Journal of General Internal Medicine*, *31*(10), 1206–1211. https://doi.org/10.1007/s11606-016-3703-5

Reinhard, M., Allen, N., Wong, L. M., & Schwartz, B. L. (2017). Neuropsychological measurement of inhibitory control in posttraumatic stress disorder: An exploratory antisaccade paradigm. *Journal of Clinical and Experimental Neuropsychology*, *39*(10), 1002–1012. https://doi.org/10.1080/13803395.2017.1301389

Schottenbauer, M. A., Glass, C. R., Arnkoff, D. B., Tendick, V., & Gray, S. H. (2008). Nonresponse and Dropout Rates in Outcome Studies on PTSD: Review and Methodological Considerations. *Psychiatry: Interpersonal and Biological Processes*, *71*(2), 134–168. https://doi.org/10.1521/psyc.2008.71.2.134

Shin, L. M., Wright, C. I., Cannistraro, P. A., Wedig, M. M., McMullin, K., Martis, B., Macklin, M. L., Lasko, N. B., Cavanagh, S. R., Krangel, T. S., Orr, S. P., Pitman, R. K., Whalen, P. J., & Rauch, S. L. (2005). A Functional Magnetic Resonance Imaging Study of Amygdala and Medial Prefrontal Cortex Responses to Overtly Presented Fearful Faces in Posttraumatic Stress Disorder. *Archives of General Psychiatry*, *62*(3), 273–281. https://doi.org/10.1001/archpsyc.62.3.273

Spielberg, J. M., Miller, G. A., Heller, W., & Banich, M. T. (2015). Flexible brain network reconfiguration supporting inhibitory control. *Proceedings of the National Academy of Sciences*, *112*(32), 10020–10025. https://doi.org/10.1073/pnas.1500048112

Steudte-Schmiedgen, S., Stalder, T., Kirschbaum, C., Weber, F., Hoyer, J., & Plessow, F. (2014). Trauma exposure is associated with increased context-dependent adjustments of cognitive control in patients with posttraumatic stress disorder and healthy controls. *Cognitive, Affective, & Behavioral Neuroscience*, *14*(4), 1310–1319. https://doi.org/10.3758/s13415-014-0299-2

Weathers, F. W., Blake, D. D., Schnurr, P. P., Kaloupek, D. G., Marx, B. P., & Keane, T. M. (2013). The life events checklist for DSM-5 (LEC-5).

Yeung, N., Botvinick, M. M., & Cohen, J. D. (2004). The Neural Basis of Error Detection: Conflict Monitoring and the Error-Related Negativity. *Psychological Review*, *111*(4), 931–959. https://doi.org/10.1037/0033-295X.111.4.931

Table 1. ICT and ICH group descriptive

	ICT (N=37) M(SD) or %	ICH (N=34) M(SD) or %	F or Chi-square	*P* Value
Demographics				
Age	19.66 (2.14)	19.82 (2.41)	.243	.62
Sex			2.28	.131
Female	89.2	79.4		
Male	8.1	20.6		
Sexual orientation			.73	.694
Heterosexual	81.1	94.1		
Homosexual	5.4	2.9		
Bisexual	5.4	2.9		
Other	0			
Ethnicity			1.33	7.22
Black	8.1	14.7		
White	86.5	76.5		
Hispanic	2.7	5.9		
Asian or Pacific Islander	2.7	2.9		
American Indian or Alaskan Native	0	0		
Other	0	0		
Marital State			.44	.51
Married	2.7	5.9		
Single/Never married	97.3	94.1		
Divorced	0	0		
Separate	0	0		
Widow/Widower	0	0		
Education			2.4	.30
Less than high school	0	0		
High school graduate	21.6	38.2		
Some college	75.7	58.8		
Bachelor's degree	2.7	2.9		
Non-professional graduate degree	0	0		
Professional degree and doctoral degree	0	0		
DSM-5 criterion A for trauma			8.79	.55
Natural disaster	0	2.9		
Fire or explosion	0	0		
Transportation	13.5	17.6		
Serious accident at work, home, or during recreational activity	2.7	2.9		
Exposure to toxic substance	0	0		
Physical assault	5.4	5.9		
Assault with a weapon	0	0		
Sexual assault	56.8	38.2		
Other unwanted or uncomfortable sexual experience	0	0		
Combat or exposure to a war-zone	2.7	2.9		
Captivity	2.7	0		

Life-threatening illness or injury	0	2.9		
Severe human suffering	0	0		
Sudden, violent death	10.8	26.5		
Sudden accidental death	0	0		
Serious injury, harm, or death	0	0		
Any other very stressful event or experience	2.7	0		
Average PCL	2.08 (1)	1.99	.160	.69

Figure 1. Topographic headmaps and waveforms for the Near-transfer task. Difference waveforms are calculated by subtracting congruent trials from incongruent trials.

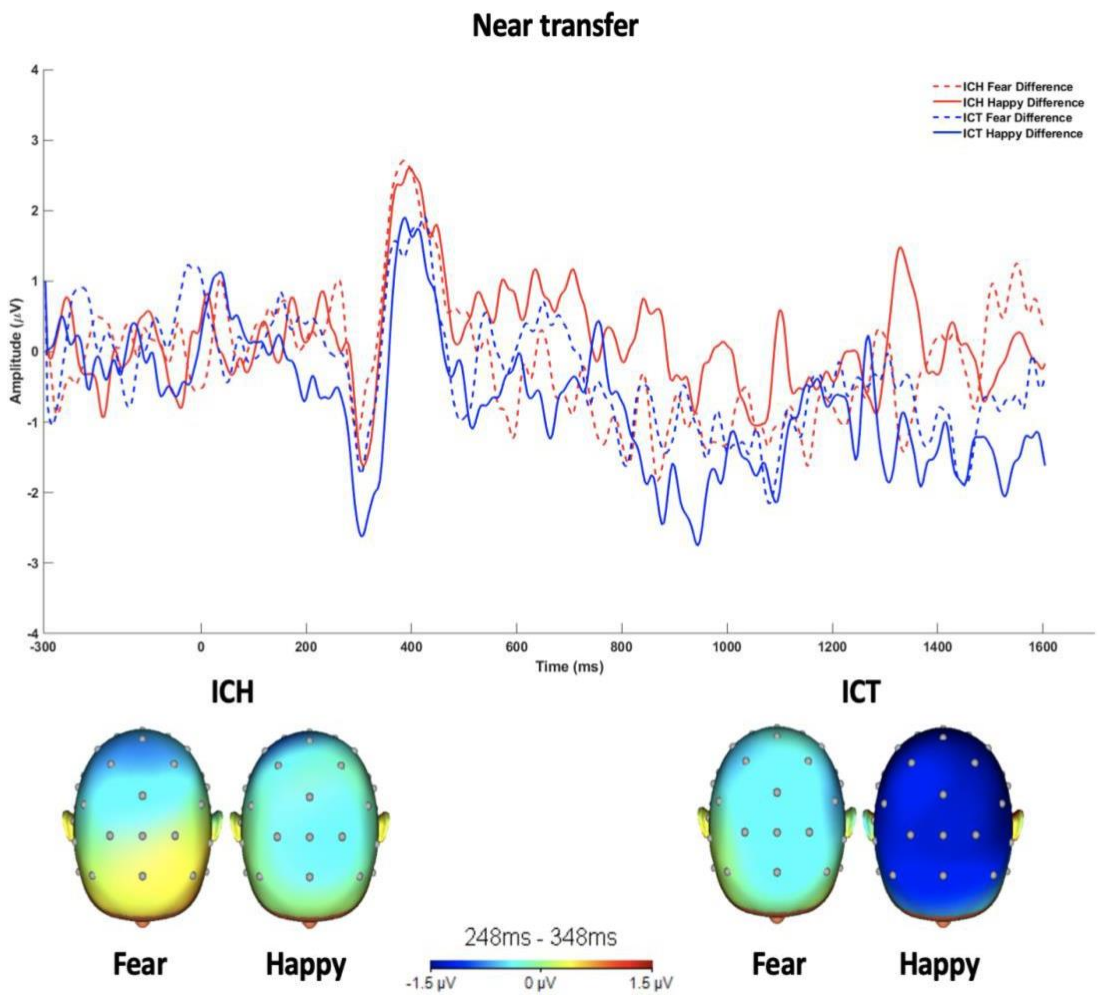

Figure 2. Topographic headmaps and waveforms for the second half of the training blocks. Difference waveforms are calculated by subtracting congruent trials from incongruent trials.