FULL METAL JACKET: THE EFFECT OF COMBAT EXPOSURE ON EMOTION PROCESSING WITHIN WORKING MEMORY

by

Tabitha Alverio

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Approved by:

_____
Dr. Sara M. Levens

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Dr. Christine Elnitsky

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Dr. Richard McAnulty

ABSTRACT

TABITHA ALVERIO. Full metal jacket: The effect of combat exposure on emotion processing within working memory. (Under the direction of Dr. SARA M. LEVENS)

Posttraumatic stress disorder (PTSD) is experienced by approximately 10 to 20% of service members and veterans who have served in Iraq and Afghanistan. To mitigate the effects of trauma experience on service members and their families, it is important to understand the impact of combat trauma exposure as well as understand underlying cognitive differences between those who develop posttraumatic stress disorder (PTSD) and those who do not. One component that may lead to the development of PTSD may be attentional biases for emotional information in the environment. The objective of the current study was to investigate whether biases in emotion processing differ as a function of combat exposure in a population of veterans. Participants were grouped based on whether they had served in the military (Service group, N = 28), and those who had not served in the military (non-combat experience Control group, N = 45). Participants completed an emotion working memory task in which they viewed a series of emotional expressions (Happy, Sad, Angry, Neutral and Fearful) and indicated if the currently presented emotional expression was the same as or different than the emotional expression presented two trials earlier. Performance was compared across groups to isolate emotion-processing biases as a function of service experience (Service members with combat experience versus controls). Repeated measure ANOVA analyses replicated Emotion and Trial Type effects found in prior research, yet revealed no effects of Service. Future studies should increase recruitment of military members as well as examine components of attentional biases such as interference and avoidance to determine if these components play a role in the development or maintenance of PTSD.

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CHAPTER 1: INTRODUCTION

All over the world, many individuals are exposed to traumatic events such as a death of a loved one, being held at gunpoint, sexual assault, a bombing of an airport, or detonation of a roadside bomb during combat. While the intensity of the traumatic event matters a great deal, equally important is how one copes with the traumatic experience. Some individuals will cope adaptively following the trauma while others cope less adaptively. Given that traumatic events appear to be occurring more frequently and with higher visibility, it is increasingly important to examine the ways that trauma may impact an individual's psychological functioning. What causes some to develop posttraumatic stress disorder (PTSD) while others remain resilient? The current study attempted to examine the effect of combat-based trauma in military service members and veterans on cognitive and emotion processing.

Over 2 million people have served in the U.S. military (including active duty, National Guard, Air National Guard, and reserves; United States Census Bureau, 2011). Of those who have served since 2003, there have been over 6,000 military casualties and over 44,000 wounded (United States Census Bureau, 2011). According to Veterans Affairs (VA), more than 90% of Army personnel and Marines deployed to Iraq and Afghanistan reported being shot at and exposure to deceased bodies. Furthermore, more than 80% of those individuals also reported being attacked or ambushed, receiving rocket or mortar fire and knowing someone killed or seriously injured (United States Department of Veterans Affairs, 2015). It is currently estimated that 12 to 20% of military personnel who have served in Iraq and 6 to 11% of military personnel who served in Afghanistan have experienced PTSD (Nebraska Department of Veterans' Affairs, 2007), with some concern that these rates might underestimate the true prevalence of PTSD in this population. Of the veterans diagnosed with PTSD symptoms, approximately 92% have received outpatient services and 8% have been hospitalized in a treatment facility (United States

Department of Veterans Affairs, 2015). PTSD is defined by the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) as a mental disorder characterized by intrusive symptoms, such as recurrent memories of the event, continuous avoidance of stimuli associated with the event, adverse changes in cognition, and changes in reactivity and arousal to stimuli associated with the traumatic event (American Psychiatric Association, 2013).

PTSD not only affects an individual but can also have an impact on those around them. Living with someone who is having recurrent memories of traumatic experiences with corresponding changes in their reactivity and/or arousal to stimuli associated with the event can be difficult to handle. Past research on Vietnam veterans has shown that individuals with a PTSD diagnosis have high rates of marital problems and domestic violence (Chrysos et al., 2005; Glenn, et al., 2002: Taft, et al., 2005). Studies also revealed that individuals who have PTSD symptoms are more likely to have a heightened anger expression disposition (Taft, et al., 2007). Cumulatively, these studies suggest that emotional and cognitive changes following exposure to combat trauma often negatively affect interpersonal relationships.

Based on DSM-5 criteria, an individual must have experienced or witnessed a traumatic event to be diagnosed with PTSD. While experiences of trauma are becoming more ubiquitous, the risks of experiencing trauma are particularly high for individuals in the military due to repeated deployment. Multiple deployments have been found to increase the risk of mental health problems (U.S. Army Surgeon General, 2008) in active service members and veterans. Deployment times to combat areas can vary by the five armed service branches: Air Force, Army, Coast Guard, Marine Corps and Navy. For instance, the average deployment time for the Air Force is 180 days whereas in the Army it is typically 18 months. The prolonged exposure to witnessing and experiencing trauma may be especially likely to alter the way an individual processes emotional content, similar to how adverse events and trauma during development can impact later emotion processing in adulthood (Levens et al., 2016). For example, the experience

of trauma may lead individuals to search for threatening information in the external environment even when such information is at very low levels or absent. This threat vigilance may reduce cognitive resources for the processing of other relevant emotional information.

Emotion processing involves the appraisal and encoding of emotional stimuli from the environment. Emotional content is processed according to an individual's own experience and schemas, giving rise to more holistic emotional experiences (Rachman, 1980). How individuals attend and react to an external emotional stimulus may be affected by their trauma experience. Previous research has found that individuals who have PTSD attend more to trauma-related material and that these individuals also experience an increase in heart rate in comparison to controls when viewing emotional stimuli (Elsesser, Sartory & Tackenberg, 2005). Research has also found that individuals with PTSD report experiencing more negatively valenced emotions in response to negative photos that include both trauma and non-trauma related material (Wolf, Miller & McKinney, 2009), suggesting that their heightened negative reactions are generalizing to non-trauma related emotional content as well. The 'spreading' of trauma-specific reactions to non-trauma related content could reflect broader emotional vigilance or impairments in executive control following trauma that limits individuals' ability to control their attention.

Executive Control (EC) comprises the processes involved in planning, attending and monitoring everyday tasks (Rubinstein, Meyer & Evans, 2001). Through executive control, we can adjust our performance on tasks. For example, while receiving criticism from a boss an *individual* may need to suppress *their* expression of anger and allocate cognitive resources to new/other tasks as needed, such as focusing on a task at work after the aforementioned negative interaction with a boss. Working Memory (WM) is part of the executive control system; within WM an individual encodes, updates, and manipulates information from the environment to enable task completion (Baddeley, 2003). To enable executive control, executive processes, such as updating, inhibitory control, and selection, organize content within WM storage buffers to enable

the goal-directed behavior. Research has revealed that trauma affects executive control processes as well. Trauma exposure can impair an individual's ability to inhibit actions or behaviors in response to irrelevant stimuli. For example, if an individual experienced a roadside bomb during deployment, he/she may feel compelled to drive in the middle of the street instead of the correct lane. Research conducted by Wu et al., (2010), showed that individuals with PTSD, in comparison to controls, had deficits in response inhibition in a Go-No-Go task. The Go-No-Go task involves stimuli being presented continuously and participants are instructed to make a motor response for some stimuli while other stimuli require participants to restrict the motor response (Wu et al., 2010). In addition, past research utilizing the emotional Stroop task has shown that individuals with PTSD take significantly longer when naming the color of trauma-related words compared to non-trauma words (McNally, 1990), suggesting increased attention capture to trauma-related content that may impair inhibitory control. As WM load increases the ability to selectively attend, monitor and manipulate information decreases (Gazzaley, 2011). If an individual is unable to inhibit irrelevant information in the environment, then the individual may be unable to fully focus his or her attention, resulting in decreased cognitive resources to the current task which could impair performance.

Given that WM is a limited capacity system which must simultaneously monitor and manipulate information from the environment, executive processes in WM may be particularly influenced by emotion (Baddley, 1992; Cowan, 2013). For an individual to effectively complete a task, relevant information must be kept active within WM while irrelevant information must be discarded so that it does not consume limited WM resources. Trauma-related emotional content is unique because it was originally highly relevant, and once these representations are activated from long-term memory, it may be difficult for the once-relevant information to be discarded from WM. In support of this, prior research has shown that compared to controls, individuals with PTSD have poorer performance on emotional word WM tasks. For example, Schweizer and

Dalgleish (2011) had participants recall words from a list while also completing a trauma sentence task. The goal was to illustrate how individuals with PTSD may experience intrusive thoughts while trying to complete a word recall task. Results revealed that individuals who had PTSD recalled significantly fewer words than controls (Schweizer & Dalgleish, 2011). In addition, research by Morey et al., (2009) showed that participants with PTSD, in comparison to trauma-exposed controls, had significantly different neural activity in response to task-irrelevant trauma distractors. The difference in neural activity was associated with maintaining focus during the task, therefore, those with PTSD were unable to maintain focus in the presence of task-irrelevant trauma distractors (Morey et al., 2009). Collectively this research suggests that trauma-related emotional stimuli interact with WM processing; it may be that this interaction creates an emotion processing bias within WM that makes it difficult to inhibit negative emotional content more generally, thereby contributing to PTSD symptomatology.

One WM process that may be especially crucial for maintaining task-relevant information over task-irrelevant information is updating. Updating is an executive process that allows an individual to change their focus on incoming information, currently held information and retrieving needed information in order to complete a task (Baddeley, 2003). Because WM is a limited capacity system, as new information enters WM from the environment, irrelevant information needs to be discarded. If the old information is not discarded from WM, then new task-relevant information is not processed, which could significantly impair performance. Updating is the primary executive process that is responsible for keeping relevant information active while discarding information that is no longer relevant. Going back to the previous example of a critical boss, after the meeting, updating would keep task-relevant content active in WM while letting now irrelevant content (criticism from the boss) go. In this way, relevant information would be maintained and irrelevant information would be released. Naturally, what is relevant will vary across situations, allowing an individual to react appropriately.

Attention biases toward trauma-related stimuli (Buckley et al., 2000) and a decrease in ability to disengage from trauma-related stimuli (Pineles, 2007) have been studied in individuals with PTSD. If there were biases in updating, such that trauma-related content was maintained as relevant (even when it is not relevant to the current task), then updating processes would be biased to maintain negative content at the expense of other potentially relevant content which could greatly affect task performance, memory, and, ultimately, interpersonal interactions. Currently, emotion updating has not been examined in the context of PTSD, although there has been research on emotion updating in major depressive disorder (MDD). Given that PTSD and MDD are often comorbid, studies examining updating processes in MDD populations may suggest how potential PTSD emotion updating patterns affect the processing of incoming information. In previous research, individuals with MDD, as well as those who have recently recovered from depression, had difficulty disengaging from sad content, yet they disengaged from happy content more rapidly than never-depressed individuals (Levens & Gotlib, 2010; 2015). If a similar pattern is found for individuals with PTSD, individuals with PTSD may have trouble disengaging from emotionally-charged negative content (like anger or fear), which would allow this negative content to remain in WM, thereby influencing subsequent encoding and interactions with stimuli from the environment. Relatedly, previous research has found that individuals with MDD had greater difficulties inhibiting stimuli that were irrelevant to task completion thus leading irrelevant information to affect participants' performance (Yoon, LeMoult & Joorman, 2014). Attending to irrelevant information could also be a response to the novelty of the information, giving rise to one of the characteristic symptoms of PTSD, hyperarousal. Kimble et al. (2000) examined hyperarousal in service members. They found that combat veterans with PTSD had a heightened response to novel stimuli in comparison to combat veterans without PTSD. These results could suggest that hyperarousal to novel information may cause an individual to attend to information that is irrelevant to completing the task. In this way, examining emotion biases in updating may shed light on how emotional content is sustained in

WM, even when it is no longer relevant, possibly elucidating how heightened negative reactions spread from trauma-related emotional content to non-trauma related emotional content.

The current study aimed to determine if emotion updating biases within WM develop as a function of combat exposure. The prolonged wars in both Iraq and Afghanistan have increased the number of veterans with PTSD. Because of the burden of PTSD on society, it is critical to determine if emotion processing biases in WM may contribute to the development and/or maintenance of PTSD. A previous study utilizing an emotional cognitive task known as the Emotional Stroop task showed that veterans with PTSD took longer color-naming trauma related words, but after attending an Attention Modification Training they no longer showed this effect (Khanna et al., 2015). This prior research suggests that cognitive tests can be developed to provide an alternate route for identifying and treating individuals who have PTSD symptoms. To identify emotion updating biases in WM, military service members and/or veterans who have been exposed to combat trauma and non-service controls completed the emotion n-back task. In the current study combat based trauma was defined as being deployed to an active combat area such as Afghanistan and Iraq. In the emotion n-back task, participants viewed a series of faces with Happy, Sad, Angry, Neutral and Fearful expressions and indicated whether the current emotional expression was the same as or different than the emotional expressions viewed two faces previously. This emotion updating task has been shown to differentiate individuals who have experienced recent versus distant adversity (Levens et al., 2016), currently depressed and never depressed controls (Levens & Gotlib, 2010) and remitted depressed individuals and never disordered controls (Levens and Gotlib, 2012). Based on this past research, we hypothesized that service members and veterans who have served in combat zones would engage with fearful and angry content faster, and disengage from fearful and angry content slower than their non-combat service members/veterans and controls. We also hypothesized that service members with combat

exposure would have a decreased maintenance of positive content compared to non-service member/veteran controls.

Chapter 2: Materials and Methods

Participants

Participants were recruited through UNC-Charlotte's Veteran Student Services as well as the university's SONA system. Eighty-five participants completed the emotional n-back task and questionnaires. Participants completed the study in exchange for course research credit or a ten-dollar Target gift card. Participants' age ranged from 18-50 years old (M = 23.54, SD = 7.68) with 61.1% reporting as Caucasian, 23.5% reporting as African American, 10.5% reporting as Hispanic, and 14.1% as 'Other'. In the current study, 45 of the participants were male. Participants were grouped based on whether they had previously served in the military (Service Group) or not (Controls). The Service Group consisted of 31 participants, 28 males and with ages ranging from 19-50 (M = 30.83 SD = 8.60). Of these participants, 71% reporting as Caucasian, 19.4 % as African-American, 16.1% as Hispanic and 9.7% as 'Other,' out of the 31 participants, 3 had not deployed and had no combat experience. While we originally hoped to have more non-deployed service members as a military control group, we were not able to recruit enough individuals from this special population. Based on my overarching goal of trauma effects on emotion updating, we made the decision to focus our analyses on service members who had combat experience, and the 3 service members without combat experience were excluded from future analyses. An additional 9 participants were excluded from analyses due to accuracy rates on the emotional n-back task being below 50% (below chance levels) indicating that these participants may not have understood the task.

The final sample of 73 consisted of 41 males with ages ranging from 18-50 years old (M = 23.84, SD = 8.05). Of the 73 participants, 63% reporting as being Caucasian, 21.9% as African-American, 9.6% as Hispanic and 13.7% as 'Other'. Participants were grouped based on whether they had previously served in the military (Service Group) or not (Controls). The Service Group

consisted of 28 participants, 25 males and 3 females, with age ranging from 19-50 (*M* = 31.10, *SD* = 8.92). Of the Service Group participants, 67.9% reporting as being Caucasian, 21.4 % as African-American, 10.7% as Hispanic and 10.7% as 'Other.' The Control group consisted of 45 participants, 16 males and 29 females with an age range from 18-25 (*M* = 19.31, *SD* = 1.60). Of the Control participants 61.4% reporting as being Caucasian, 22.7% as African-American, 8.9% as Hispanic and 15.9% as 'Other.'

Measures

Demographics: Information included age, gender, ethnicity, marital status, level of education, military rank, number of deployments, length of deployment, deployment location, time since deployment, medical history and history of mental illness for self and family.

Trauma History: Trauma History Questionnaire (THQ; Hooper, et al., 2011) was used to assesses if participants had *ever* experienced trauma (Ever Experienced) and if they had experienced trauma in the *past 6 months* (6 Month Experienced). It is a 24-item self-report of the participant's experience of traumatic events such as physical assault, loss of a loved one, natural disaster in a yes/no format. Items were then summed with higher scores indicating more traumatic experiences. On average participants experienced 3.34, (*SD* = 2.76) traumatic events in their lifespan and .54, (*SD* = .85) traumatic events within the past 6 months.

Post-traumatic Stress symptoms: The PTSD Checklist-Military Version (PCL-M) was used to assess current levels of PTSD symptoms in response to stressful military experiences (Weathers et al., 1993). The PCL-M is a 17-item self-report measure that is commonly used to screen individuals for PTSD as well as aiding in diagnostic assessment and monitoring any change in PTSD symptoms. Each item is scored *not at all* (1) to *extremely* (5). Scores were then summed with a range of scores being 17-85, the range of scores predict acuity levels with 17-33

being low, 34-43 moderate and 44-85 as high symptoms of PTSD. The mean of the current sample was 25.42 (*SD* = 21.20) with adequate internal consistency reliability (α = .18).

Depression symptoms: Depression symptoms were assessed using the Center for Epidemiological Studies Depression Scale (CES-D; Randolf et al., 2012). The CES-D contains 20 items that ask individuals to rate how often they have felt certain symptoms for the past week with ratings ranging from *less than 1* day (0) *to 5-7 days* (3) on a four-point Likert scale. Most of the questions were of negative affect such as "I felt that everything I did was an effort," and two were positive, "I was happy," and "I felt hopeful about the future." Items were then summed with the two positive items being reversed scored, scores range from 0-60 with higher scores indicating the presence of depression symptoms. The mean of the current sample was 38.91 (*SD* = 7.14 with internal consistency reliability (α = .12)

Stress: The Perceived Stress Scale (PSS; Cohen, Kamarck & Mermelstein, 1983) was used to measure the extent that an individual recognizes certain life experiences as stressful. The PSS consists of items such as "In the last month, how often have you been upset because of something that happened unexpectedly." These items are rated on a five-point Likert scale with ranges from *never* (1) to *very often* (5). The PSS was summed with higher scores indicating more perceived stress. The mean of the current sample was 28.19 (*SD* = 7.21) with internal consistency reliability (α = .09).

Affect: The International Positive and Negative Affect Scale Short Form (I-PANAS-SF; Thompson, 2007) was used to measure positive and negative affect. Participants indicated to what extent they felt a certain way either at the moment or the extent they have felt over the past week. Participants' ratings were on a 5-point Likert scale with a range from v*ery slightly or not at all* (1) to e*xtremely* (5). Examples of the positive affect items are “Determined,” “Attentive,” and “Active,” for the negative affect items asked were “Upset,” “Ashamed,” and “Afraid.” Positive and Negative items were scored separately with higher scores indicating higher feelings of affect.

The mean for the positive affect of the current sample was 30.41 (*SD* = 8.94) and for the negative affect was 18.00 (*SD* = 6.65) with internal consistency reliability (α = .38).

Attention and Working Memory Tasks

Emotion 2-Back Task: This task measures the reaction times and responses of participants as they encode and updating emotional content in WM. Participants viewed a series of emotional facial expressions one at a time and were asked to determine whether the current emotional expression they currently viewed was the same as or different than the emotional expression they viewed two trials previously. Participants were instructed to press a key labeled "SAME" if the facial expression was the same as that presented two faces previously or the key labeled "DIFF" if the facial expression was different than that presented two faces earlier. Participants were instructed that for the first two faces in a block trials, they should view the stimuli and then from the third face onward they should respond to each facial stimulus. The faces conveyed happy, sad, neutral, angry and fearful emotional expressions. During the task, participants viewed each face for 2 seconds with 2.5-second inter-trial-interval between each facial expression. The task consisted of 330 trials which were separated into 6 blocks of 55 trials each as well as an additional 10 trails that were unscored practice trials.

Trial Types:

Match-set trials are when the current emotional expression being viewed was the same as the emotional expression viewed two faces earlier. In this trial type participants must form an association between two similar stimuli that engages an overarching emotional concept. Specifically, this trial type requires the individual to conceptually link the current emotional expression to the emotional expression that they viewed two trials earlier.

Break-set trials follow the match-set trials. WM is a system that has a limited capacity so it must discard information that is no longer necessary. During break-set trials the individual must

break sets of previously matched emotional content to respond to the current facial expression. Break-set trials assess how quickly and accurately an individual can disengage from previously relevant, yet now irrelevant data.

No-set trials are trials that elicited a "DIFF" response but these trials do not follow match-set trials. On no-set trials, participants are not required to break a previously-paired representation to respond; instead, they only needed to determine that no set exists and integrate the new stimuli. This trial type assesses a participant's ability to evaluate a given emotional stimuli's relatedness to other stimuli that are present in WM.

Study Procedure

To begin the study research assistants went over informed consent with the participants and administered the study measures in person. Participants provided informed consent before completing the emotional n-back task. Once participants completed the task, they were instructed to complete a battery of questionnaires that included the CES, THQ, PCL-M, CES-D, PSS, STAI, PANAS and the BIS/BAS. After completing the questionnaires, they were debriefed about the study. All questionnaire data was collected using online Qualtrics survey software.

Chapter 3: Results

The results are presented in two sections. In the first section, the entire final sample was included (N = 73), and the Service group (*N* = 28) was compared to the Non-Service Control group (*N*=45). Given that recruitment of military service members and veterans was lower than originally proposed, we conducted an additional post hoc analysis that modified how participants were matched across the service and control groups. Specifically, to reduce age and gender differences between the Service and Control groups in the final sample, the groups were re-matched (as best as possible within the sample) on age and gender to create a Non-Service Control subgroup (*N*=28) of older male participants. In the second set of analyses the Non-Service Control subgroup was compared to the Service member group. First, final sample descriptive, accuracy and reaction time analyses are presented. Next, post hoc balanced sample descriptive, accuracy and reaction time analyses are presented.

Final Sample

Descriptive and Correlation Analyses: Service Group participants reported lower levels of mean Negative Affect (*M* =16.85, *SD* = 5.17) than Positive Affect (*M* = 34.78, *SD* = 8.06). Participants' Depression symptoms (*M* = 18.17, *SD* = 1.09) were not indicative of meeting criteria for depression, but their Perceived Stress (*M* = 26.53, *SD* = 7.70) did indicate moderate levels of perceived stress. Service group participants endorsed an average of 4.50 (*SD* = 2.51) traumatic experiences from the THQ across their lifespan, and an average of .64 (*SD* = .95) traumatic experiences from the THQ in the past 6 months. Service Group participants' PCL-M averages of 25.42 (*SD* = 21.20) scores indicated low acuity levels of PTSD. Of the Controls, participants reported lower levels of Negative Affect (*M*= 18.71, *SD* = 7.39), Positive Affect (*M* = 27.68, *SD* = 8.43), Depression symptoms (*M* = 19.37, *SD* = 7.18) were not indicative of meeting criteria for depression, and Perceived Stress Symptoms (*M* = 29.22, *SD* = 6.78) indicating high

levels of perceived stress. Controls endorsed an average of 2.62 (*SD* = 2.69) traumatic experiences from the THQ across the lifespan and an average of .48 (*SD* = .78) traumatic experiences from the THQ within the past 6 months.

Across both groups bivariate correlation analyses revealed significant positive correlations between Negative Affect and Depression symptoms, $r(1,73) = .519$, $p<.01$, Negative Affect and Perceived Stress, $r(1,73) = .453$, $p<.01$, and Depression symptoms and Perceived Stress, $r(1,73) = .545$, $p<.01$. Correlation analyses also revealed significant negative correlations between Positive Affect and Depression symptoms, $r(1, 73) = -.358$, $p<.01$, Positive Affect and Perceived Stress, $r(1, 73) = -.395$, $p<.01$, and traumatic experiences across the lifespan and traumatic experiences within the past 6 months, $r(1, 73) = -.294$, $p<.05$ (see Table I for Entire Sample correlations).To examine group differences, Independent t-tests revealed that the Service group had significantly higher levels of reported positive affect, $t(71) = -.354$, $p<.01$, and a higher number of lifetime traumatic incidents, $t(71) = -2.97$, $p<.01$ than controls.

Accuracy Analysis

Accuracy rates are presented in table II. A three-way Trial Type by Emotion by Group ANOVA on Emotion n-back accuracy rates yielded significant main effects of Trial Type, $F(2,142) = 27.59$, $p< .01$, Emotion, $F(4,284) = 25.67$, $p< .01$, and an Emotion x Trial Type interaction, $F(8,568) = 16.41$, $p< .01$. No other main effects or interactions were significant. Follow up paired t-test revealed that Match-set accuracy levels were significantly different from Break-set, $t(72) = -6.43$, $p<.01$ and No-set trials, $t(72) = -5.59$, $p<.01$. Break-set (*M* = .81, *SD* = .09) trials had the highest level of accuracy followed by No-set (*M* = .81, *SD* = .11), and Match-set (*M* = .74, *SD* = .12) trials the lowest level of accuracy. To test the main effect of Emotion, paired t-tests revealed that Angry was significantly different from Happy, $t(72) = 6.125$, $p<.01$, Neutral, $t(72) = -4.66$, $p<.01$, and Sad, $t(72) = 3.36$, $p<.01$; Happy was significantly different

from Fear, $t(72) = 4.59$, $p<.01$, and Sad, $t(72) = 8.91$, $p<.01$; Neutral was significantly different from Sad, $t(72) = 7.73$, $p<.01$, and lastly Fear was significantly different from Sad, $t(72) = 5.25$, $p<.01$. Happy ($M = .76$, $SD = .19$) trials had the highest level of accuracy followed by Neutral ($M = .74$, $SD = .21$), Fearful ($M = .72$, $SD = .21$), Angry ($M = .71$, $SD = .20$), and least accurate was Sad ($M = .69$, $SD = .19$), all ps$<.05$. Follow-up analyses revealed that the significant Emotion x Trial type interaction was due to changes in emotion accuracy across trial type. Accuracy levels for Happy stimuli were highest in the Match-set ($M = .84$, $SD = .14$) and No-set ($M = .83$, $SD = .14$) trials but lower in the Break-set trial condition ($M = .80$, $SD = .11$).

Reaction Time Analysis

Reaction times are presented in table II. A three-way Trial Type by Emotion by Group ANOVA yielded significant main effects of Trial Type, $F(2,142) = 57.26$, $p<.01$, Emotion, $F(4,284) = 47.61$, $p<.01$, Trial Type X Emotion interaction, $F(8,568) = 29.80$, $p<.01$. There was no effect of Service. To test the main effect of Trial Type, paired t-test were conducted between each trial type. Results reveal that each trial type was significantly different from the others with RTs being the fastest to Match-set ($M = 1202$, $SD = 171$), followed by Break-set ($M = 1278$, $SD = 174$) and No-set trials ($M = 1330$, $SD = 197$). To test the main effect of emotion, paired t-tests were conducted between each emotion: Angry RTs were significantly different from Happy, $t(72) = 7.16$, $p<.01$, Fear, $t(72) = -5.02$, $p<.01$, and Sad, $t(72) = -3.94$, $p<.01$; Happy RTs were significantly different from Neutral, $t(72) = -6.84$, $p<.01$, Fear, $t(72) = -12.63$, $p<.01$, and Sad, $t(72) = -10.88$, $p<.01$; Neutral RTs were significantly different from Sad, $t(72) = -5.44$, $p<.01$ and Fear, $t(72) = -5.86$, $p<.01$. Happy trials produced the fastest reaction times ($M = 1198$, $SD = 182$), followed in turn by Neutral ($M = 1263$, $SD = 169$), Angry ($M = 1270$, $SD = 193$), Sad ($M = 1307$, $SD = 172$) and Fearful ($M = 1312$, $SD = 177$), all ps$<.05$. Follow-up analyses revealed that the significant Emotion by Trial type interaction was due to changes in emotion reaction time across trial type. Reaction times to Sad faces were longer than the other expressions during

Match-set (*M* = 1308, *SD* = 173) trials, yet shorted compared to other expressions during Break-set (*M* = 1268, *SD* = 192) and No-set (*M* = 1345, *SD* = 216) trials.

Final Sample Summary

Results revealed that participants responded fastest when matching emotional stimuli, yet at a cost, as this condition had the lowest accuracy. Regarding emotion, happy stimuli were responded to the fastest and with the highest accuracy—reaction time and accuracy decreased for negative facial expressions. We found no effects of service on performance. One potential reason is that the samples were not well balanced regarding age, gender and trauma experience. For example, the Control participants age ranged from 18 to 25 and mostly comprised of females (29 out of the 45 participants). Whereas the Service group age ranged from 19-50 and was only males. The large range in age could give rise to more time passing since the combat-related trauma experience. Also, trauma experience in the general course of life, outside of their service experience, differed between the groups. The Service group reported the experience of 4.5 THQ events over the lifespan while the younger Control group endorsed 2.62 THQ events over the lifespan. These differences may have increased sample variability and made the group comparison difficult. To better control for trauma history, recent trauma, gender and age differences between the Service Group and Controls, we tried to align the control group with the service group as best as possible. This gave rise to a Non-Service Control subgroup that we then compared to the Service member group (see Matched Sample analyses below).

Matched Sample Analyses

Descriptive and Correlation Analyses: To create more balanced groups, participants from the control group were selected to create a Control subgroup who best aligned with participants from the Service on age, gender and trauma experience. The original control group was predominantly female, younger, and had a higher range of traumatic experiences which may have

clouded potential combat exposure effects. The matched Control subgroup was selected to exclude young females and include more males who were older and had fewer traumatic experiences to function as matched controls—the Control subgroup was named the No Trauma Control group (NT Controls). The current analysis examined the range of reported trauma experience between the two groups. The Service Group reported a range of 0-11 (M = 4.5, SD = 2.51) traumatic experiences from the THQ across the lifespan, while the NT Control group reported 0-3 (M = 1.46, SD = 1.13) traumatic experiences from the THQ across the lifespan. Recent Trauma was reported in the Service Group as a range between 0-3 (M = .64, SD = .95) events in the last 6 months while recent traumatic events in the NT Control group ranged from 0-2 (M = .39, SD = .62) events in the last 6 months. The NT Controls reported lower levels of Negative Affect (M = 18.67 SD = 7.65), and higher levels of Positive Affect (M = 28.17, SD = 8.34). Their Depression symptoms (M = 18.10, SD = 6.63) were below threshold criteria for Depression, and their Perceived Stress Symptoms (M = 27.82, SD = 7.28) indicated high levels of perceived stress according to the PSS scale scoring guidelines.

Correlation analyses revealed significant positive correlations between reported Negative Affect and Depression symptoms, $r(1,56) = .498$, $p<.01$, between Negative Affect and Perceived Stress, $r(1,56) = .517$, $p<.01$, and between Depression symptoms and Perceived Stress, $r(1,56) = .578$, $p<.01$. Correlational analyses also revealed significant negative correlations between Positive Affect and Depression symptoms, $r(1,56) = -.416$, $p<.01$, and between Positive Affect and Perceived Stress, $r(1,56) = -.365$, $p<.01$ (see Table III for Matched Sample correlations).To examine group differences, Independent t-tests revealed that the service group reported significantly higher positive affect, $t(54) = -3.01$, $p<.01$, and traumatic experiences across the lifespan, $t(54) = -5.81$, $p<.01$ than NT controls.

Accuracy Analyses

Accuracy rates are presented in table IV. A three-way Trial Type by Emotion by Group ANOVA on the Emotion n-back accuracy rates produced significant main effects of Trial Type, $F(2,108) = 24.18$, $p < .01$, Emotion, $F(4,216) = 17.41$, $p < .01$, and an Emotion x Trial Type interaction, $F(8,432) = 14.70$, $p < .01$. No other main effects or interactions were significant. Follow up paired t-tests revealed that Match set accuracy levels were significantly different from Break-set, $t(55) = -5.42$, $p<.01$ and No-set trials, $t(55) = -5.18$, $p<.01$. Break-set ($M = .81$, $SD = .09$) trails had the highest level of accuracy followed by No-set ($M = .81$, $SD = .11$) and Match-set ($M = .74$, $SD = .13$). To test the main effect of Emotion follow up t-tests revealed significant differences between Happy and Angry, $t(55) = 4.75$, $p<.05$, Fear, $t(55) = 3.66$, $p<.01$, and Sad, $t(55) = 6.97$, $p<.01$, significant difference between Angry and Neutral, $t(55) = -3.11$, $p<.01$, and Sad, $t(55) = 3.01$, $p<.01$, significant differences between Neutral and Fear, $t(55) = 2.22$, $p<.01$, Sad, $t(55) = 5.91$, $p<.01$ and lastly significant differences between Fear and Sad, $t(55) = 4.48$, $p<.01$. Accuracy rates for Happy ($M = .82$, $SD = .11$) faces were the highest followed by Neutral ($M = .81$, $SD = .10$), Fearful ($M = .79$, $SD = .12$), Angry ($M = .78$, $SD = .11$) and Sad ($M = .75$, $SD = .11$) expressions. Follow-up analyses reveal that the significant Emotion by Trial type interaction was due to changes in emotion accuracy across trial type. Accuracy rates for Sad expressions were lowest in the Match-set ($M = .65$, $SD = .16$) trials, but in Break-set ($M = .78$, $SD = .12$) and No-set ($M = .81$, $SD = .12$) trials, accuracy rates to Sad stimuli were higher.

Reaction Time Analysis

Reaction times are presented in table IV. A three-way Trial Type by Emotion by Group ANOVA yielded significant main effects of Trial Type, $F(2,108) = 36.77$, $p < .01$, Emotion, $F(4,216) = 42.05$, $p < .01$, and an Emotion x Trial Type interaction, $F(8,432) = 24.56$, $p < .01$, there were no significant interactions of Service. To test the main effect of Trial Type paired t-test

revealed that RTs for each trial type was significantly different from each other with Match-set (*M* = 1209, *SD* = 176) trials being the fastest followed by Break-set (*M* = 1276, *SD* = 173) and No-set (*M* = 1325, *SD* = 201). To test the main effect of Emotion, follow up t-tests revealed significant differences between Angry and Happy, $t(55) = 7.04$, $p<.01$, Fear, $t(55) = -5.06$, $p<.01$, and Sad, $t(55) = -3.22$, $p<.01$, significant difference between Happy and Neutral, $t(55) = -5.56$, $p<.01$ Fear, $t(55) = -12.22$, $p<.01$, Sad, $t(55) = -9.72$, $p<.01$ and significant differences between Neutral and Fear, $t(55) = -6.03$, $p<.01$, Sad, $t(55) = -5.04$, $p <.01$. RTs to Happy expressions (*M* = 1197, *SD* = 181) were the fastest followed by Neutral (*M* = 1258, *SD* = 174), Angry (*M* = 1270, *SD* = 196), Sad (*M* = 1306, *SD* = 173) and Fear (*M* = 1318, *SD* = 179) expression. Follow-up analyses revealed that the significant Emotion by Trial type interaction was due to changes in emotion reaction time across trial type. Reaction times to Happy expressions were the fastest during Match-set (*M* = 1014, *SD* = 202), but in Break-set trials Angry expressions were the fastest (*M* = 1256, *SD* = 208) and in No-set trials Fearful expressions were the fastest (*M* = 1374, *SD* = 215).

Matched Sample Summary

Results revealed that participants responded fastest when matching emotional stimuli, yet at a cost, as this condition had the lowest accuracy. Regarding emotion, happy stimuli were responded to the fastest and with the highest accuracy—reaction time and accuracy decreased for negative facial expressions. We found no effects of service on performance. Despite better alignment between the Service and NT Control groups, there were no significant effects of Service on task performance. Again, differences between groups were found. For example, Service members endorsed higher averages of positive affect (34.78), lower averages of negative affect (16.85) and perceived stress (26.53). Controls endorsed higher averages of negative affect (18.67) and perceived stress (27.82), but had lower averages for positive affect (28.17). These mood differences, in addition to the previously discussed trauma experience, age, and combat

variability experiences may explain why no effects of service were found. For example, Service members reported higher positive affect, therefore, this could indicate more resiliency (or simply an absence of PTSD) in this group in comparison to Controls. Researchers may want to consider these variables in future studies.

Chapter 4: Discussion

The goal of the current study was to examine whether emotion updating biases within WM develop as a function of military experience and combat exposure. While the current study found main effects of trial type and emotion expression, the study did not find significant differences between groups of emotional biases as a function of military experience and/or combat exposure. Previous research examining attentional biases in individuals with PTSD have been inconsistent. For example, Naim et al., (2014) found that individuals with attentional biases towards threatening stimuli had higher risk of experiencing PTSD in the future. On the other hand, studies have found that attentional biases away from threatening stimuli were also predictive of PTSD symptomatology (Sipos et al., 2013). These conflicting findings suggest that PTSD may be associated with different types of attentional biases within the domain of emotion processing. If there are different types of attentional biases for different executive processes, these variations in attentional biases may give rise to an array of various symptoms within a PTSD diagnosis. Given that service members exhibited low levels of PTSD, the current sample may not have experienced high intensity trauma during their deployment to create updating biases.

Classic characteristics of PTSD such as re-experiencing, avoidance and hyperarousal may lead to or cause differences in attending emotional information from the environment. It may be important therefore to conduct a series of experiments with groups of individuals with PTSD who are placed into separate groups based on their symptom profiles so that avoidance tendencies in some individuals don't necessarily ‘cancel out' hyperarousal tendencies within the same sample. While disordered populations are usually studied, future studies may want to examine specific symptomatology within a disorder. If certain symptoms such as hyperarousal are more apparent in an individual, it may be the heightened sensitivity to stimuli that leads individuals to develop and/or maintain PTSD. On the other hand, it could be a predisposition to be sensitive to certain

types of stimuli, intrusively ruminate, avoidance of emotion processing or a combination of ‘symptoms,' prior to a traumatic event that increases the likelihood of developing and/or maintaining the disorder after the experience of trauma. A more specific and controlled approach to examine different mechanisms of attentional biases may be needed to elucidate the attentional biases to predict who develops PTSD and who is more resilient following the experience of trauma. Also, examining individuals who are experiencing clinical levels of PTSD may elucidate trauma related difficulties in emotion processing within WM. The current study had participants who experienced low levels of PTSD therefore, these individuals may not have experienced enough trauma to develop attentional biases.

As mentioned above there are multiple executive processes that could process trauma related content in unique ways; the current study focused on one such executive process—updating. One possible reason that we found no differences between the service group and controls is that updating may not be as sensitive to trauma-related content. Instead, components of attention biases such as facilitation and interference may play a larger role in the development and maintenance of PTSD. Attentional interference is difficulty resolving interference between competing task relevant and task irrelevant information in the environment. As such attentional interference is usually associated with irrelevant stimuli interfering with target task performance (Pineles et al., 2007). For example, Pineles et al., (2007) found that individuals with high levels of PTSD showed greater attentional interference to threat-related stimuli in comparison to those with low levels of PTSD. Previous research has shown that individuals with PTSD have greater attentional interference to trauma-related stimuli resulting in poorer performance of task completion (Fani et al., 2012). Accordingly, attentional interference may play a role in the re-experiencing symptoms that are encountered by individuals who have PTSD.

While attending to intrusive trauma-related information may be problematic in task completion, attentional facilitation of traumatic stimuli may be just as important in developing

and/or maintaining hyperarousal symptomology in PTSD. Attentional facilitation is the focus on current stimuli due to past experiences of similar stimuli (Cohen, 2011). Research examining facilitation has been mixed. For example, in a study examining attentional biases, facilitation to threatening stimuli occurred in children with abuse history (Pollack & Tolley-Schell, 2003). However, in the previous study conducted by Pineles et al., (2007) they found no evidence for attentional facilitation to threatening stimuli in participants with either high or low PTSD. Military members often see hypervigilance as advantageous especially on the battlefield but off the field can create problematic behaviors such as intense emotional reactions, anxiety and impulsive behavior. In the current study, the emotion n-back task and stimuli may not have invoked symptoms of hyperarousal or re-experiencing. Had participants, for example, done a mental imagery re-experience exercise to simulate what may occur during a re-experience episode then task performance may have captured updating differences inherent in that acute emotional state.

There are several limitations of this study that could have also contributed to the absence of group differences. Combat exposure can be very different across individuals and these differences of experience could have impacted the current study. For example, the range of trauma experiences from the THQ in the Service Group in the present sample was 0-11. This is a wide range of traumatic experiences outside of their service deployment which could have affected results. It is also possible that some of the service members may have had multiple deployments as well as different military occupational specialties (MOS). Individuals who are in the service may have all been deployed to areas of active combat but based on their MOS they may not have experienced a traumatic event. For example, an individual who is Special Forces may be more likely to be involved in events where death is imminent while an individual who is an air traffic controller may be less likely to be involved in such events. This may be why some

individuals scored lower on the trauma history questionnaire even though they had been deployed to an active combat zone.

Previous research has also shown that service members with high combat stress are more reactive to stressful situations and/or experiences than those who had experienced low combat stress (Smid et al., 2013). Criterion A for a PTSD diagnoses is that the individual is either directly exposed, witnessed, was indirectly exposed via close relative or close friend or that the individual experienced repeated indirect exposure of a traumatic event (DSM 5, 2013). If an individual was deployed and did not experience "trauma," during their deployment then that individual may not be experiencing adverse effects of combat exposure. Service members who would meet Criterion A for a PTSD diagnoses but were resilient during and after this experience may not show attentional biases due to adaptively resolving their traumatic experience.

Another potential element that could have impacted findings is time since their deployment or traumatic experience. In a related study that utilized the same emotion n-back task Levens et al., (2016) examined the effect of adversity experience on updating emotional content within WM. In this study participants were grouped based into three groups based on their trauma experience: one, a distant adversity group, a recent adversity group, and no experience of adversity group. Results revealed that individuals who had experienced distant adversity were faster and more accurate at updating emotional content than those who had no adversity (Levens et al., 2016). In addition, findings also revealed that those who experienced recent adversity exhibited lower emotion updating accuracy compared to those with distant adversity and no history of adversity. These findings suggest that time can play a role in how individuals cognitively move past a negative experience. As time goes on, individuals might resolve their experience and no longer attend to irrelevant information in the environment, however, being assessed immediately following a traumatic experience may show attentional biases to negative stimuli. In the current study, there could have been a wide range of time since deployment and

trauma experience that could have contributed to findings. The Service group age ranged from 18-50 years old meaning that some individuals may have been deployed to OEF and OIF several years ago therefore given time to resolve their traumatic experiences during deployment. The current study did not take time since deployment into account which could suggest why no differences were found in the current study if combat exposure was not recent. For example, some of the older service members and/or veterans may have deployed to OEF and/or OIF several years ago whereas the younger service members would have deployed more recently.

Another limitation of this study is that sample size and differences between groups may have impacted our ability to fully examine attentional biases. The current study aimed to recruit 150 participants in total with 50 participants in three separate groups. Unfortunately, we were unable to recruit this sample size resulting in low statistical power. While we attempted to address this limitation by matching the samples using a subgroup of the original control group, age, gender and trauma experiences differences were still present. Non-service Group participants tended to be younger than the Service Group. This again could account for differences and time between trauma exposures. Younger participants may have experienced recent trauma whereas older participants' trauma experience may be more distant. Both groups consisted of college students, therefore, the sample may be limited in its generalizability. The Service Group also reported higher levels of positive affect, therefore it is possible that this sample of individuals may be more resilient in the face of trauma. Also, the Non-Service group was overwhelmingly female in comparison to the Service group. Previous research has shown that females tend to be better at recognizing and categorizing facial expressions in comparison to males (Mandal & Palchoudhury, 1985; Nowicki & Hartigan, 1988; Wild et al., 2001). Future studies may want to examine gender differences between service members' experience and how these differences relate to emotion processing. Examining these differences may shed light regarding how those differences may lead to the development of disorders after the experience of trauma.

In sum, future studies are needed to further investigate how trauma experience impacts emotion processing to lead to potential PTSD attentional biases. These future studies should aim to address some of the limitations of the current study by recruiting larger samples of service members and/or veterans with specific symptom profiles and trauma experience thereby allowing a better examination of individual differences. Also, given that women only account for 15 percent of Active Duty members (DOD, 2014), recruiting male controls may be important in future studies given gender differences in emotion processing (Mandal & Palchoudhury, 1985; Nowicki & Hartigan, 1988; Wild et al., 2001). If researchers are able to recruit larger populations of veterans and control for gender differences, these studies may be able to examine how differences in emotion processing within working memory may predict PTSD. Given previous research regarding time and adversity experience on emotion processing, future studies should also examine how time since deployments impacts emotion processing within WM. If studies can elucidate the timeframe of resolution or exacerbation following a deployment, then clinicians may be able to identify individuals who are at risk for developing PTSD and develop more tailored interventions. While the present study did not find emotion updating differences as a function of service experience, prior research suggests that emotion executive processing biases exist as a function of combat trauma experience. Therefore, well-controlled and powered emotion executive control studies that investigate a range of executive processes and symptom profiles are needed to further elucidate the effects of trauma on executive control.

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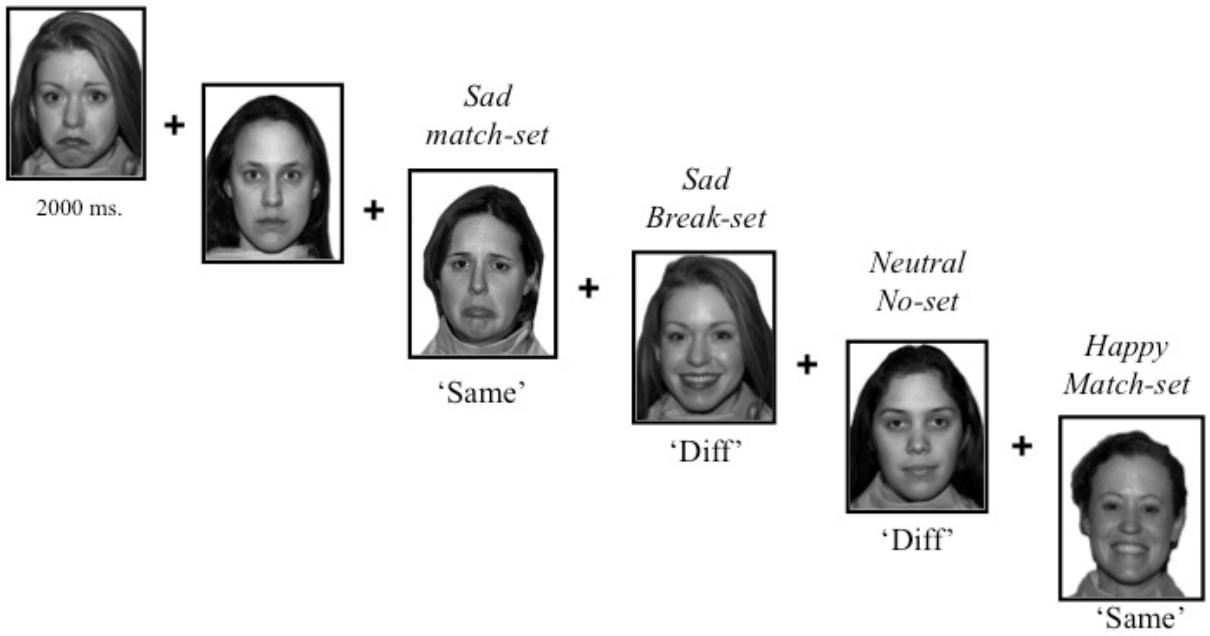

Figure 1

Caption:

Participants viewed each emotional face one at a time for 2000 ms. with an inter-stimulus-interval of 2500 ms. between each expression. For the first two trials participants press nothing and encode the faces; from the third face onward participants indicate whether the current facial expression is the same as/ or different than the facial expression viewed two expressions earlier. Two initial trials followed by 4 experimental trials with their correct response and trial types are displayed.

Table I Final Sample

Descriptive and zero-order correlations

	Variable	M	SD	1	2	3	4	5	6
1	Neg Affect	18.00	6.65		-.19	.52	.45	.05	.10
2	Pos Affect	30.41	8.94			-.36	-.40	.02	.10
3	CESD	38.92	7.14				.55	.00	.12
4	PSS	28.91	7.22					.18	-.02
5	THQ_Ever	3.34	2.77						-.29
6	THQ_6mos	0.55	0.85						

Note. N = 73. Neg Affect = Negative Affect Score. Pos Affect = Positive Affect Score. CESD = Center for Epidemiological Sudies Depression Scale. THQ_Ever = Trauma History Question-Ever Experienced. THQ_6mos = Trauma History Questionnaire-Experienced in the past 6 months.

Table II

2-back Trial Final Sample (N = 73) Mean Reaction Times, and Accuracy Rates

	RT	Acc
Match-set		
Happy	1011 (203)	84%(14%)
Neutral	1201 (170)	80%(12%)
Sad	1308 (173)	65%(15%)
Angry	1207 (229)	70%(15%)
Fearful	1282 (205)	73%(17%)
Break-set		
Happy	1305 (190)	80%(11%)
Neutral	1280 (190)	85%(10%)
Sad	1268 (192)	78%(12%)
Angry	1256 (203)	82%(10%)
Fearful	1282 (182)	82%(11%)
No-set		
Happy	1277 (218)	83%(14%)
Neutral	1307 (223)	80%(14%)
Sad	1345 (216)	81%(12%)
Angry	1348 (219)	81%(14%)
Fearful	1371 (211)	80%(13%)

Note: Standard deviations are shown in parenthesis; RT = reaction time; Acc = Accuracy

Table III Matched Sample

Descriptive and zero-order correlations

	Variable	M	SD	1	2	3	4	5	6
1	Neg Affect	17.77	6.54		-.23	.50	.52	.03	.23
2	Pos Affect	31.48	8.79			-.42	-.37	.09	.14
3	CESD	38.14	6.43				.58	.05	.08
4	PSS	27.18	7.46					.16	-.02
5	THQ_Ever	2.98	2.47						-.24
6	THQ_6mos	0.52	0.81						

Note. N = 56. Neg Affect = Negative Affect Score. Pos Affect = Positive Affect Score. CESD = Center for Epidemiological Sudies Depression Scale. THQ_Ever = Trauma History Question-Ever Experienced. THQ_6mos = Trauma History Questionnaire-Experienced in the past 6 months.

Table IV

2-back Trial Matched Sample (N = 56) Mean Reaction Times, and Accuracy Rates

	RT	Acc
Match-set		
Happy	1014 (202)	84%(15%)
Neutral	1206 (170)	79%(13%)
Sad	1318 (176)	65%(16%)
Angry	1211 (239)	70%(16%)
Fearful	1295 (214)	73%(19%)
Break-set		
Happy	1303 (181)	80%(11%)
Neutral	1274 (193)	84%(10%)
Sad	1259 (191)	78%(12%)
Angry	1256 (208)	83%(11%)
Fearful	1285 (177)	83%(12%)
No-set		
Happy	1273 (229)	83%(13%)
Neutral	1295 (225)	80%(14%)
Sad	1340 (215)	81%(12%)
Angry	1343 (222)	81%(13%)
Fearful	1374 (215)	81%(13%)

Note: Standard deviations are shown in parenthesis; RT = reaction time; Acc = Accuracy