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The Interaction Between Behavioral Inhibition and Response Inhibition in Patients with Post-Traumatic Stress Disorder

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Abstract

Not all individuals exposed to traumatic events develop post-traumatic stress disorder (PTSD). Variations in susceptibility to PTSD diagnosis may be related to individual differences in personality and dysfunctional response inhibition. The present study examined the relationship between the Behavioral Inhibition System (BIS), a relevant personality trait, and response inhibition, a form of cognitive control necessary for trauma recovery, in relation to PTSD severity. Participants included a sample of seven adult veterans (2 female, 5 male) previously diagnosed with PTSD. Participants were rated on their BIS levels through questionnaires and performed a common response inhibition task, the Go/No-Go (GNG). As expected, BIS levels increased with PTSD severity and BIS scores were more predictive of PTSD score than GNG performance. In addition, arousal and re-experiencing symptoms were positively related to BIS scores where both arousal and re-experiencing symptoms were predictive of BIS. Performance on GNG was not significantly related to BIS or PTSD. Results suggest that trait BIS may be a vulnerability factor for PTSD diagnosis if exposed to traumatic events.

Keywords: post-traumatic stress disorder, PTSD, behavioral inhibition system, BIS, BIS/BAS, cognitive control, response inhibition

The Interaction Between Behavioral Inhibition and Response Inhibition in Patients with Post-Traumatic Stress Disorder

Not all individuals exposed to traumatic events develop post-traumatic stress disorder (PTSD; Bonanno, 2005; Maack, Tull & Gratz, 2011). Variations in susceptibility to PTSD diagnosis may be related to individual differences in personality and response inhibition (American Psychiatric Association, 2013; Amodio, Master, Yee, & Taylor, 2008; Aupperle, Melrose, Stein, & Paulus, 2012; Corr, 2008; Contractor, Elhai, Ractliffe, & Forbes, 2013; DeGutis, Esterman, McCulloch, Rosenblatt, Milberg, & McGlinchey, 2015; Gable, Reis, & Elliot, 2000; Gray,1982; Maack et al., 2011; McNaughton & Corr, 2004; Myers, VanMeenen, & Servatius, 2011; Pickett, Bardeen, & Orcutt, 2011; Quay, 1988; Swick, Honzel, Larsen, Ashley, & Justus, 2012; Swick, Honzel, Larsen, & Ashley, 2013; Vasterling et al., 2010). One relevant personality trait, the Behavioral Inhibition System (BIS), may be a logical contributing factor that puts individuals at risk for developing PTSD. The BIS differentiates personalities based on variations in motivational drives and there are many similarities between BIS characteristics and the symptoms of PTSD such as cognitive and physiological reactions (American Psychiatric Association, 2013; Amodio et al., 2008; Aupperle et al., 2012; Corr, 2008; DeGuitis et al., 2015; Gray,1982; McNaughton & Corr, 2004; Quay, 1988; Swick et al., 2012; Swick et al., 2013; Vasterling et al., 2010). Evidence suggests that differences in BIS levels could explain how mere exposure to traumatic events may be extremely stressful to some individuals and not others (Gable et al., 2000). Response inhibition, a form of cognitive control necessary for trauma recovery, may also contribute to PTSD susceptibility if impaired (Aupperle et al., 2012; Vasterling & Verfaellie, 2009). In fact, dysfunctional response inhibition may be common deficit observed in those with PTSD and BIS (American Psychiatric Association, 2013; Amodio et al., 2008; Aupperle et al., 2012; Corr, 2008; DeGuitis et al., 2015; Eriksson, Jansson, Lisspers, & Sundin, 2016; Gray,1982; McNaughton & Corr, 2004; Quay, 1988; Swick et al., 2012; Swick et al., 2013; Vasterling et al., 2010). To our knowledge no other study has specifically examined PTSD and response inhibition with respect to trait BIS. Further elucidation into how BIS and response inhibition may be related to PSTD severity may aid in untangling possible susceptibility factors for PTSD diagnosis, treatment alternatives, and preventative measures.

Behavioral Inhibition System (BIS)

The Behavioral Inhibition System (BIS) is an individual difference factor originally theorized in Jeffery Gray's Reinforcement Sensitivity Theory (RST; Gray,1982). The RST describes two basic personality types based on how individuals differ in their motivation towards rewards and punishments (Gray,1982). First, the Behavioral Activation System (BAS) is a personality type motivated by approaching rewards (Corr, 2008; Gray,1982). Second, the Behavioral Inhibition System (BIS) is a personality type motivated by avoiding punishment (Corr, 2008; Gray,1982). Previous research reported that individuals with high trait BIS typically displayed characteristics such as: increased arousal, avoidance, enhanced attention to threat, increased vigilance, and anxiety (Amodio, et al., 2008; Gray,1982; Quay, 1988). In fact, high trait BIS individuals were reported as highly sensitive to any cues of threat such as possible punishments, unexpected events, anything foreign or unfamiliar to them, and the lack of an anticipated reward (Amodio et al., 2008; Corr, 2008; Gray,1982). Due to the highly anxious, vigilant, and threat oriented characteristics associated with high trait BIS, the individuals were often described as possessing a “look out for danger” type of personality (Corr, 2008). For example, an individual with high trait BIS may become defensive if caught off guard as unexpected events would be interpreted as dangerous or threatening. As a result, threatening cues disrupt the individual’s ongoing behavior so that they may decide on a response to the threat (Amodio et al., 2008; Corr, 2008; Gray,1982; McNaughton & Corr, 2004).

Since Gray's initial 1982 theory, BIS has been extensively studied in relationship to abnormal behavior (Corr, 2008; Johnson, Turner, & Iwata, 2003; Zinbarg & Yoon, 2008). Gray's theory postulated that individuals with high BIS were at an increased risk for anxiety disorders as an elevated perception of threat was the common vulnerability factor for both BIS and anxiety (Zinbarg & Yoon, 2008). Contemporary research has narrowed the focus from general anxiety to more specific disorders such as PTSD (Vasterling et al., 2010). For example, recent work discovered that veterans from Operation Iraqi Freedom with high perceptions of threat were more predictive of PSTD severity than combat exposure (Vasterling et al., 2010). It may be that individuals with a disposition for high BIS are at greater risk for PTSD than anxiety. The highly sensitive nature of individuals with BIS to any cues of threat may exacerbate post-trauma symptom severity possibly increasing susceptibility for PTSD diagnosis.

Posttraumatic Stress Disorder (PTSD)

Posttraumatic stress disorder develops in certain individuals as a result of exposure to an event that is traumatic or stressful (American Psychiatric Association, 2013). An individual directly or indirectly exposed to violence would qualify as a traumatic or stressful event (American Psychiatric Association, 2013). For a diagnosis of PTSD, an individual must meet the symptom criteria established in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013). The criteria for diagnoses are broken down by cluster categories. First, the individual must have been exposed to a stressful or traumatic event. Also, the individual must have displayed a month or more of significantly distressful symptoms. Symptoms include: intrusion, which manifests as distressing dreams or memories such as re-experiencing the traumatic event, avoidance of objects or events that serve as traumatic reminders, negative mood or cognition, and changes in arousal associated with the traumatic event (American Psychiatric Association, 2013).

Extensive overlap exists between the symptoms associated with the diagnosis of PTSD and the typical mannerisms observed in those with trait BIS. For example, behaviors associated with both BIS and PTSD include avoidance, enhanced attention to threat, increased vigilance, and hyperarousal (American Psychiatric Association, 2013; Corr, 2008; Vasterling et al., 2010; Zinbarg & Yoon, 2008). Physiological reactions to unexpected events manifest as exaggerated jumpiness in both BIS and PTSD (American Psychiatric Association, 2013; Amodio et al., 2008; Corr, 2008; McNaughton & Corr, 2004). Literature also indicates that both display a perpetual disposition to remain on guard for signs of threat (American Psychiatric Association Corr, 2008; Vasterling et al., 2010). The overlap noted between trait BIS and PTSD suggests that individuals with BIS personalities may be at an increased risk for the development of PTSD diagnosis.

In fact, correlational studies indicate that BIS levels were similar and associated with the degree of symptoms found in those diagnosed with PTSD (Contractor et al., 2013; Maack et al., 2011; Myers et al., 2011; Pickett et al., 2011). Maack et al. (2011) discovered a positive correlation between BIS levels and PTSD status among undergraduate students who were exposed to trauma at some time in their life. The results indicated that those individuals who scored highest on trait BIS were more likely to display severe symptoms of PTSD (Maack et al., 2011). Myers et al. (2011) discovered that increases in veterans' behavioral inhibition was positively associated with their PTSD severity, especially avoidance symptoms (Myers et al., 2011). Similarly, Pickett et al. (2011) found that BIS scores were positively related to PTSD symptoms where avoidance symptoms were dependent on the relationship. Findings suggest that the behavioral traits present in those with high BIS were similar and associated with the degree of symptoms found in those diagnosed with PTSD (Contractor et al., 2013; Maack et al., 2011; Myers et al., 2011; Pickett et al., 2011). More recent work suggests that individuals with high trait BIS as well as individuals diagnosed with PTSD present signs of dysfunctional cognitive control especially, faulty response inhibition (American Psychiatric Association, 2013; Aupperle et al., 2012; Boksem, Tops, Wester, Meijman, & Lorist, 2006; Swick et al., 2012; Swick et al., 2013).

Response Inhibition

Response inhibition, a component of cognitive control (Smith & Kosslyn, 2006), has been considered a critical skill necessary for successful daily functioning and trauma recovery (Aupperle et al., 2012; Hofmann, Schmeichel, & Baddeley, 2012; Vasterling & Verfaellie, 2009). Cognitive control or executive functioning, includes response inhibition, mental flexibility, and working memory all essential components for more complex processes such as problem-solving and reasoning (Diamond, 2013). According to Hofmann et al. (2012), response inhibition may be an essential aspect of self-control and self-regulation, both qualities fundamentally required to obtain future goals needed for daily functioning. The ability to successfully regulate or inhibit unwanted behavior is not only crucial for daily life but also imperative to trauma recovery (Hofmann et al., 2012; Vasterling & Verfaellie, 2009). Vasterling and Verfaellie (2009) noted that dysfunctions in cognitive control had the potential to negatively impact one's ability to deal with intrusive memories, manage PTSD symptomology, and emotionally recover from trauma. In addition, dysfunctional response inhibition may also be implicated in PTSD symptoms such as re-experiencing and hyperarousal (Aupperle et al., 2012; Vasterling &Verfaellie, 2009). Of particular importance, response inhibition may be enhanced through meditation (Sahdra et al., 2011) and training (Eriksson et al., 2016). For this reason, further investigation into how response inhibition, PTSD, and BIS are related may help to guide future research in treatment alternatives, and preventative measures for those who experience trauma.

Response inhibition specifically refers to an individual's ability to suppress an automatic response (Smith & Kosslyn, 2006). For example, in a common response inhibition task, termed the GNG task, subjects are presented with a series of letters and instructed to respond by pressing a key for each letter (Go) except the letter "X" (No-Go; Smith & Kosslyn, 2006; Swick et al., 2012). The process of responding becomes very automatic until the letter "X" is presented, at which time the subject must inhibit their response (Smith & Kosslyn, 2006; Swick et al., 2012). The ability to correctly respond during Go trials and inhibit a response during the No-Go trials are evaluated and results indicate the individual's level of cognitive control (Smith & Kosslyn, 2006).

Research suggests that individuals diagnosed with PTSD show signs of dysfunctional cognitive control especially response inhibition (American Psychiatric Association, 2013; Aupperle et al., 2012; Swick et al., 2012; Swick et al., 2013). A literature review conducted by Aupperle et al. (2012) found that individuals with PTSD were not effective at inhibiting automatic responses. Additionally, Swick et al. (2012) showed symptom severity was significantly related to errors in performance on response inhibition GNG tasks when compared to controls. That is, individuals with more severe PTSD symptoms made the most mistakes (Swick et al., 2012). The presence of higher re-experiencing symptoms were even shown to be predictive of reduced performance levels (Swick et al., 2012). Swick et al. (2013) discovered that combat veterans with PTSD displayed greater variability in reaction times compared to veteran controls during a response inhibition task, the GNG. Those with PTSD were more inconsistent with regards to the time between when the stimulus was presented, the letter "O", and when they actually responded. Greater variations in reaction times were associated with an increase in errors in No-Go trials as the subjects responded to the letter "X" rather than inhibiting their response (Swick et al., 2013).

In a more recent study, dysfunctional response inhibition was more exclusively related to PTSD symptoms than overall cognitive control disruptions (DeGuitis et al., 2015). Individuals with moderate PTSD symptoms were given an array of tests that assessed general cognitive control. Inhibition tasks (GNG) were the most significant predictors of the variance in PTSD symptoms compared to general cognitive control tasks (DeGuitis et al., 2015). Therefore, there may be something exclusive about PTSD diagnosis and poor response inhibition (American Psychiatric Association, 2013; Aupperle et al., 2012; DeGuitis et al., 2015; Swick et al., 2012; Swick et al., 2013).

In addition, it has been proposed that high trait BIS individuals also display disruptions in cognitive control through reduced response inhibition (Amodio et al., 2008; Bokesem et al., 2006; Eriksson et al., 2016). Multiple studies suggest that increased BIS scores were associated with greater conflict in cognition (Amodio, et al., 2008; Bokesem et al., 2006). For example, Amodio et al. (2008) showed that undergraduate students with high BIS displayed increased electrophysiologyical activity in the anterior cingulate cortex, an area of the brain important in monitoring the conflict between thoughts and behaviors, during a GNG task (Amodio et al., 2008). Findings suggest that elevated cognitive conflict occurs in individuals with high trait BIS during particular response inhibition tasks. Similar research revealed that when conflict in cognition occurred, performance was significantly reduced during response inhibition tasks (Storbeck, Davidson, Dahl, Blass, & Yung, 2015). Meaning that those with high BIS exhibited a decreased ability to inhibit automatic responses due to cognitive conflict (Storbeck et al., 2015). In fact, recent work by Ericksson et al. (2016) proposed that individuals with high trait BIS may be at an increased risk for dysfunctional inhibitory control. Subjects with increased BIS scores displayed significant reductions in both reaction times and accuracy during a common response inhibition task, the stop signal task (Ericksson et al., 2016). The research presented indicates that there may be a relationship between BIS levels and negative changes in cognition with respect to response inhibition tasks (Amodio et al., 2008; Bokesem et al., 2006; Storbeck et al., 2015). Specifically, individuals with high BIS may be more likely to exhibit cognitive conflict during response inhibition tasks, which in turn may cause reduced performance. Since response inhibition may be enhanced via training and therapy (Ericksson et al., 2016; Sahdra et al., 2011), further investigation into how BIS and response inhibition may be related to PSTD severity could help untangle possible susceptibility factors for PTSD diagnosis, treatment alternatives, and preventative measures for those who experience trauma.

Overview and Hypotheses

The present research compared scores for BIS, PTSD, and response inhibition (quantified by total false alarm errors on the GNG task) in individuals with a previous diagnosis of PTSD. PTSD scores were evaluated utilizing the civilian version PTSD checklist (PCL-C; Weathers, Litz, Herman, Huska, & Keane, 1993). BIS scores were obtained through the use of Carver and White's (1994) BIS/BAS scales. Consistent with previous findings, we expected to find a positive correlation between BIS and PTSD levels (Contractor et al., 2013; Maack et al., 2011; Myers et al., 2011; Pickett et al., 2011). We first hypothesized that as BIS levels increased PTSD scores would also increase. Second, we hypothesized that higher BIS scores would correspond to reduced response inhibition such that high BIS scores would be positively correlated to the number of errors to No-Go stimuli (false alarms) during the GNG task. Third, we hypothesized higher PTSD scores would correspond to reduced response inhibition, specifically that individuals with higher PTSD scores would produce more errors to No-Go stimuli (false alarms) during the GNG task.

Methods

Participants

Eleven (2 females, 9 males) military veterans with a previous diagnosis of PTSD participated in the study. Two participants did not meet the inclusionary criteria and were excluded prior to data analyses: one participant was excluded due to previous traumatic brain injury (loss of consciousness extended 30 minutes) and the other for having a current diagnosis of schizoaffective disorder. After data was collected, two more participants were excluded from data analysis: one for extending the upper ($514.68\ ms$) and one for extending the lower ($348.47\ ms$) bounds of the GNG reaction time interquartile range ($IQR = 47.49ms$). The upper and lower bounds were calculated with a common outlier test used to determine if GNG reaction times were more than 1.5 IQR above the third quartile ($Q_3 + (1.5xIQR)$) or below the first quartile ($Q_1 - (1.5xIQR)$; Diez, Barr, & Cetinkaya-Rundel, 2014). The final sample included ($n = 7$) 5 males and 2 females ranging from 28 to 53 years old ($M = 42.29, SD = 8.12$). Among the participants, 6 reported having been engaged in active combat.

Participants were recruited through advertisements made available within the Helena area. Advertisements sought individuals between the ages of 19 and 55 with a current PTSD diagnosis. Prospective participants contacted the research team via phone to express their interest. During initial phone contact, subjects were scheduled to participate in the research. Upon arrival, each subject underwent an interview to determine eligibility. Interview questionnaires included information about previous military experience, work history, substance use, current medications, and traumatic brain injury. Participants were excluded if they were currently diagnosed with severe medical conditions, or diagnosed with psychiatric disorders other than PTSD (with and without depression/generalized anxiety). Exclusionary psychiatric disorders included bipolar and related disorders, dissociative disorders, substance-related and addictive disorders, as well as schizophrenia spectrum disorders (American Psychiatric Association, 2013). In addition, individuals were excluded from the study for suicidal ideation, previous traumatic brain injuries, neurodegenerative diseases, and the use of antipsychotic or anti-seizure medications.

All participants were compensated $20 per hour for their time. In addition, all participants signed written informed consent. Demographic and medical history was obtained during the interview for exclusionary criteria. The research was approved by the Carroll College Institutional Review Board.

Measures

PTSD measures. The civilian version of the PSTD checklist (PCL-C) was utilized to assess symptom severity and the stressful events associated with PTSD (Weathers et al., 1993). The PCL-C is a self-report assessment scale comprised of 17 questions designed to rate overall PTSD status and symptom severity based on the DSM-IV's diagnostic criteria for PTSD (e.g., "repeated, disturbing memories, thoughts, or images of a stressful experience"). Participants responded to each question with the 5-point Likert scale ($1 = "not\ at\ all"\ to\ 5 = "extremely"$) according to how often each symptom was problematic within the past 30 days (Weathers et al., 1993). The PCL-C remains a valid diagnostic tool for PTSD due to high test-retest reliability, internal consistency, convergent validity, and diagnostic utility (Weathers et al., 1993).

BIS/BAS measures. The BIS scores were obtained through the Carver and White's (1994) BIS/BAS scales. The scales were administered in a self-report questionnaire composed of 24 questions. Participants responded to each statement with the 4-point Likert scale $(1 = \text{"}very\ true\ for\ me\text{"}\ to\ 4 = \text{"}very\ false\ for\ me\text{"})$ according to the extent they agreed. The statements were designed to assess sensitivity levels to separate dimensions of personality by identifying differences in responses to rewards, fun seeking behavior, drive, and anxiety provoking behavior (Carver & White, 1994). The personality dimension of focus for the current study was BIS which included seven of the twenty-four questions, originally theorized by Gray Jeffery (1982). Higher scores on the seven questions corresponded with higher levels of trait BIS. The BIS/BAS scales are widely used and showed high validity and reliability (Carver & White, 1994).

Go/No-Go measures. The GNG task was administered to participants using Neurobehavioral Systems' Presentation software version 18.1 (Neurobehavioral Systems, Inc., https://www.neurobs.com) presented on a standard PC laptop in the same manner as appropriated in Swick et al. (2012). Stimuli consisted of uppercase black letters serially presented in the center of a white computer screen. Letters appeared on the computer for 200 ms at an inter-stimulus interval of 1500 ms. Participants were instructed to respond as quickly as possible to every letter, except for the letter "X" by pressing the number "1" on the number pad on the right-hand side of the keyboard. All responses were made with the subject's dominant index finger. The proportion of "Go" to "No-Go" trials alternated between easy (50/50) and difficult (90/10). In the easy trials, the "X" was presented 50 percent of the time whereas "X" was only presented 10 percent of the time in the difficult trials. The task included a short practice trial and four blocks of 140 letters each. Performance was quantified by scoring the number of errors for both Go and No-Go trials. Incorrect responses for No-Go stimuli were termed false alarms if the subjected erroneously responded to the letter "X". Incorrect responses to the Go stimuli were termed misses if the subject failed to respond to non-X letters. Higher numbers of errors indicated reduced response inhibition.

Procedure

After the initial screening interview, participants completed the GNG task and then the PTSD and BIS measures. Testing was administered in a quiet office where each participant provided informed consent and was given oral instruction from research personnel for the GNG task procedures. Once the participants were ready, they began the task and followed screen prompts through completion. There was one practice block and two blocks for each the easy (50/50) and difficult (90/10) conditions of the GNG task. The order was fixed and each participant completed the blocks in order of practice, easy, hard, easy, hard. After completing the computerized task, subjects were instructed to fill out questionnaires. Both questionnaires (PCL-C and BIS/BAS scales) were administered in a single packet to the subject. Individual testing sessions lasted no longer than one hour per subject. After questionnaires were completed, subjects were debriefed and compensated for their time.

Data Analysis

A within-subject correlational design was utilized to determine the relationship between BIS, PTSD, and GNG performance. Only the BIS scores were utilized from Carver and White's (1994) BIS/BAS scales. Raw PCL data produced four different scores which included the overall score (total PCL) and three separate symptom cluster scores (avoidance, arousal, and re-experiencing). The GNG error data consisted of the total number of incorrect responses for No-Go stimuli (false alarms) in both the easy (50/50) and difficult (90/10) conditions across the four blocks.

SPSS statistical software version 24 was used to analyze participant data including demographics, questionnaires (PCL-C, BIS/BAS), and performance scores (GNG false alarm errors). Analysis included bivariate linear correlation tests ($Pearson's\ r$) with two-tailed hypothesis testing ($t - tests$) at alpha level 0.05, and scatter plots with regression lines. Multiple linear regressions were used to determine how effective BIS scores were at predicting PTSD severity as well as GNG performance. In addition, the three PTSD symptom clusters were used to predict BIS score. Power and effect size were determined using XLSTAT 2016 software version 18.06 (Addinsoft, https://www.xlstat.com).

Results

Participant age was tested as a covariate to ensure age did not significantly correlate or predict PCL score, BIS, or GNG errors. Multiple linear regression with two-tailed t-test showed age was not significantly correlated with PCL score ($r = 0.165, p = 0.724$), BIS score ($r = -0.094, p = 0.842$) or total errors ($r = 0.680, p = 0.093$). PCL score ranged from 38 to 63 ($M = 52, SD = 9.33$), BIS scores ranged from 19 to 25 ($M = 23.14, SD = 2.04$), and total GNG errors ranged from 9 to 43 ($M = 24.29, SD = 13.33$).

As predicted, a significant positive correlation emerged between BIS scores and PCL scores ($r = 0.895, n = 7, R^2 = 0.802, p = 0.006$). Figure 1 shows the linear relationship where

R-squared is large enough to meet assumptions of normality. Additional positive correlations between re-experiencing and BIS scores (See Figure 2; $r = 0.788, n = 7, R^2 = 0.622, p = 0.035$), and arousal and BIS scores (See Figure 3; $r = 0.776, n =$

$7, R^2 = 0.622, p = 0.040$) were significant. However, inconsistent with predictions, results showed a non-significant correlation between BIS and total errors to No-Go stimuli (false alarms) during the GNG task ($r = 0.054, n = 7, R^2 = 0.003, p = 0.909$). Finally, inconsistent with predictions, PTSD scores did not significantly correlate total errors to No-Go stimuli (false alarms) during the GNG task ($r = 0.264, n = 7, R^2 = 0.070, p = 0.567$).

Total errors and BIS scores were entered simultaneously as independent variables into a multiple regression to test for how predictive they were to PCL scores. The model produced was significant ($F(2,4) = 11.219, p = 0.023$) explaining 77.3 % of the variance in PCL score ($adjusted\ R^2 =\ 0.773$). Model results indicated BIS scores were significantly predictive of PCL scores ($p =\ 0\ .011$) whereas total errors were not significantly predictive ($p =\ 0.328$). Information regarding the regression coefficients for BIS and total errors are shown in Table 1. Figure 4 shows the model normal probability plot for the standardized residuals where the R-squared ($adjusted\ R^2 =\ 0.773$) is close enough to one to meet assumptions of normality.

To expand further on the positive correlation between BIS and PCL scores, we created a second regression model. The model was created to determine which PTSD symptom cluster (avoidance, arousal, or re-experiencing) was the most predictive of BIS score. The model produced was significant ($F\ (3,3) = 22.669, p = 0.015$) accounting for 91.6 % of the variance in BIS score ($adjusted\ R^2 =\ 0.916$). Model results indicated arousal scores were the most significant predictor of BIS scores ($p =\ 0\ .025$) compared to re-experiencing which was moderately predictive ($p =\ 0\ .056$) and avoidance ($p =$

0.144) which was non-significant. Information regarding the regression coefficients for avoidance, arousal, and re-experiencing are shown in table 2. Figure 5 shows the model normal probability plot for the standardized residuals where the R-squared ($adjusted\ R^2 = 0.916$) is close enough to one to meet assumptions of normality.

Discussion

One goal of the present study was to uncover possible explanations for increased PTSD susceptibility due to individual differences in personalities. Since mere exposure to traumatic events do not adequately explain how PTSD develops (Maack et al., 2011), the study sought to identify risk factors for the development of PTSD. In support of the first hypothesis and previous research, we replicated the positive correlation between BIS and PTSD (Contractor et al., 2013; Maack et al., 2011; Myers et al., 2011; Pickett et al., 2011). Higher levels of trait BIS were associated with higher PSTD levels. Likewise, multiple regression showed BIS scores were highly predictive of the subjects' PTSD scores. The predictive nature of BIS to PTSD severity and the positive correlation between BIS and PTSD suggests individuals sensitive to BIS personality traits display a heightened sensitivity in their responses to traumatic experiences (Myers, et al., 2011; Pickett, et al., 2011). Our results strengthen existing literature supporting BIS as a possible vulnerability factor for PTSD helping to explain how two individuals exposed to the same traumatic event do not both develop PTSD (Gable et al., 2000).

The current study also demonstrated a significant positive relationship between two symptoms of PTSD, arousal and re-experiencing, and trait BIS scores. Where arousal and re-experiencing were more predictive of BIS than avoidance. Results for the positive association of arousal and re-experiencing to BIS, support existing literature (Gudino, 2013; Myers, et al., 2011). The predictive nature of arousal and re-experiencing to BIS score is a novel finding. These findings are of particular importance as re-experiencing has been identified as a symptom exclusive to PTSD (Swick et al. 2012). Exaggerated arousal responses are common diagnostic features of many anxiety disorders (American Psychiatric Association, 2013; Zinbarg & Yoon, 2008). Yet, the combination of arousal and re-experiencing symptoms post-trauma support the diagnosis of PTSD (American Psychiatric Association, 2013; Swick et al. 2012). In line with Jeffery Gray's Reinforcement Sensitivity Theory (RST; Gray,1982), it may be that the highly sensitive nature of individuals with high BIS to any cues of threat may amplify arousal levels and exacerbate the memories associated with the trauma (Zinbarg & Yoon, 2008), resulting in an increased number of traumatic memories in individuals with BIS dispositions ultimately contributing to increased arousal and re-experiencing symptoms.

However, the relationship between arousal and re-experiencing to BIS should be interpreted with caution as our results contrast some previous research. Some of the literature examining trait BIS and PTSD found avoidance was more associated to BIS than re-experiencing or arousal (Maack et al., 2011; Pickett et al., 2011). Yet, Contractor et al. (2013) did find that re-experiencing was more related to the BIS than BAS. Gudino (2013) discovered that baseline BIS scores were associated with avoidance and arousal six months after exposure to violence. Mixed results may be due to variations in subject populations between studies. For example, Pickett et al. (2011) utilized female college students as subjects, Gudino (2013) examined adolescent minorities, and Maack et al. (2011) studied undergraduates rather than the cohort of veterans examined in the present study. Despite the inconsistencies between studies, our results suggest that trait

BIS individuals may be at an increased the risk for PTSD diagnosis if exposed to traumatic events.

The current study was unable to support our two remaining hypotheses. The second hypothesis, high BIS scores would be positively correlated to the number of errors to No-Go stimuli (false alarms) during the GNG task, did not reach significance. In addition, we did not find sufficient evidence to support our third hypothesis, higher PTSD scores would produce more errors to No-Go stimuli (false alarms) during the GNG task. Therefore, we failed to support the possible relationship between response inhibition and PTSD and response inhibition and trait BIS. The inability to support our last two predictions may be due to due to a number of limiting factors. The main factor being an insufficient sample size. Based on the power analysis, the necessary sample size needed to reach $80\ \%$ effect size for an alpha of 0.05 was 26. The current sample $(n = 7)$ was substantially lower, producing an effect size of $23.8\ \%$ with an alpha of 0.05 and a beta of 0.762. Another limiting factor was the sample itself. Prior to participation, all subjects had a previous diagnosis of post-traumatic stress disorder (PTSD). However, three out of seven subjects did not meet the threshold PTSD score of 50 typically associated with PTSD diagnosis (Forbes, Creamer, & Biddle, 2001). Therefore, $43\ \%$ of our sample did not currently endorse PTSD symptoms at the time of the study. Indeed, our average PCL score was lower $(M = 52, SD = 9.33)$ compared to similar studies $(M = 57, SD = 9.33$; see Swick et al., 2012). Lastly, the lack of support for the possible relationship between response inhibition and the BIS may have been due to the type of response inhibition tasked used. Eriksson et al. (2016) was able to successfully demonstrate that high trait BIS individuals produced prolonged response times and reduced accuracy in a stop signal task. It may be that the stop signal task is a better measure of response inhibition than the Go/No-Go task utilized in the present study.

Despite the support for the first hypothesis, our study had limitations that should be addressed in future research. The present study showed six out of seven subjects were exposed to active combat. Yet, our study did not address the types of combat stressors subjects were exposed to. Schell and Marshall (2008) reported that the prevalence of PTSD was related to the severity of combat exposure. For example, witnessing a friend being severely wounded or killed was weighted as more severe combat exposure than witnessing brutality against a detainee or prisoner (Schell & Marshall, 2008). To ensure the type of combat exposures was not a confounding variable, future studies should address the possibility by specifically recording exposure types in contrast to PTSD severity when studying BIS susceptibility in relationship to response inhibition.

In addition, the current study did not rule out intelligence as a possible confounding variable. Mackline et al. (1998) found that lower levels of intelligence prior to exposure to trauma increased the risk of PTSD diagnosis. However, no other study has examined the relationship between BIS levels and intelligence. Due to the lack of information about intelligence and BIS levels, we could not predict how they may interact or confound our study. Therefore, future research should examine the relationship between intelligence, BIS, response inhibition, and PTSD, in order to gain insight on the possible limitation.

Despite the limitations, the present study was a success and future research could benefit from expanding the sample size and modifying the response inhibition task. Our study was limited by an insufficient sample size which made it difficult to obtain a PTSD cohort with severe enough symptoms to significantly show an effect between PTSD and GNG performance and BIS and GNG performance. In future research, it may be beneficial to expand the sample size to at least 26 and utilize the same response inhibition task as appropriated in Eriksson et al. (2016). In addition, a larger sample size would also be able to investigate low versus high levels of BIS on PTSD severity. It would be important to investigate whether individuals with higher levels of BIS show the most severe PTSD symptoms.

Out study suggests a link with BIS and PTSD. Future research will be better able to elucidate into how BIS and response inhibition may be related to PSTD severity. Untangling possible susceptibility factors for PTSD will enhance our understanding in diagnoses, treatment alternatives, and preventative measures. Our results strengthen existing literature supporting BIS as a possible vulnerability factor for PTSD helping to explain how two individuals exposed to the same traumatic event do not both develop PTSD (Gable et al., 2000).

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Appendix A

Table 1. Model-Linear regression coefficients (unstandardized and standardized) of variables entered into model. PCL score as dependent variable.

Independent Variable	**B**	**SE B**	**β**	***p***
BIS	4.050	0.893	0.884	0.011
Total Errors (Response Inhibition)	0.152	0.136	0.217	0.328

Table 2. Model -linear regression coefficients (unstandardized and standardized) of variables entered into model (avoidance, arousal, and re-experiencing).

Independent Variable	**B**	**SE B**	**β**	***p***
Avoidance	.086	.044	.283	.144
Arousal	.422	.102	.532	.025
Re-experiencing	.406	.134	.444	.056

Appendix B

Figure 1. Scatterplot illustrating the positive correlation between BIS score and PCL score in military veterans $n = 7, y = 0.1954x + 12.982, r = 0.895, R^2 = 0.80182, p = 0.006$.

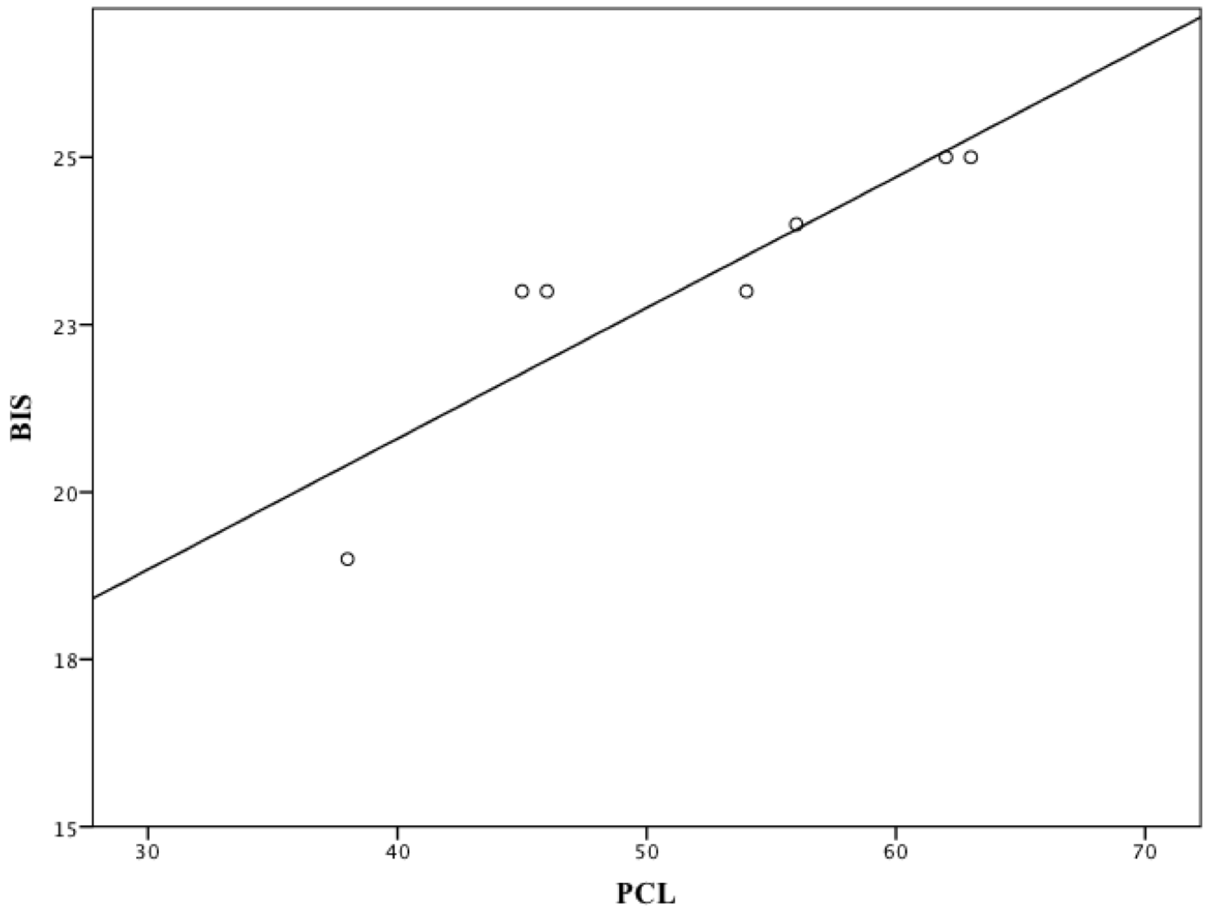

Figure 2. Scatterplot illustrating the positive correlation between BIS Score and re-experiencing in military veterans $n = 7, y = 0.7212x + 12.635, r = 0.788, R^2 = 0.622, p < 0.035$.

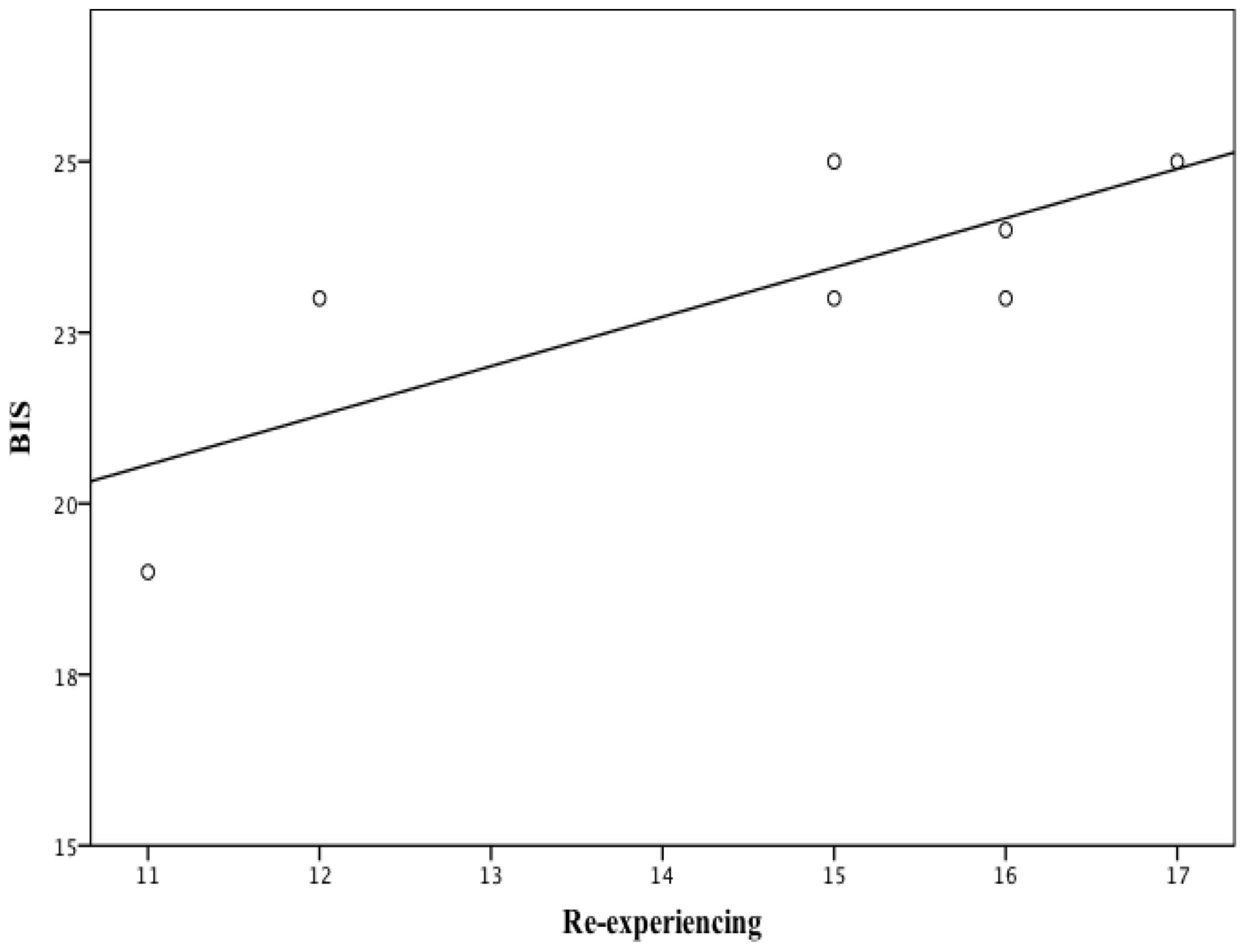

Figure 3. Scatterplot illustrating the positive correlation between BIS Score and arousal in military veterans $n = 7, y = 0.6159x + 12.848, r = 0.776, R^2 = 0.602, p < 0.040$.

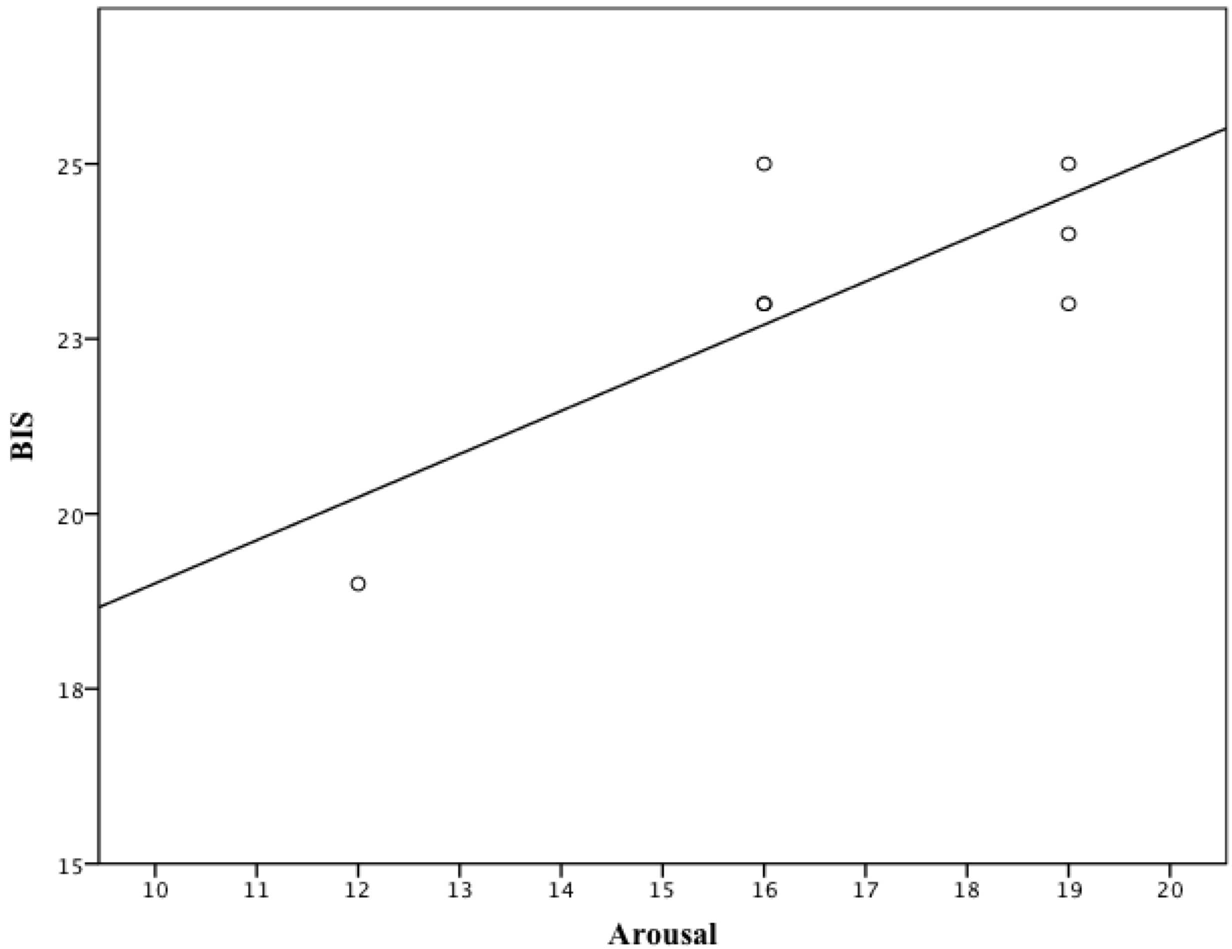

Figure 4. Model-Normal probability plot, P-Plot of regression standardized residuals. Dependent variable: PCL score, Independent variables: BIS, Total Errors.

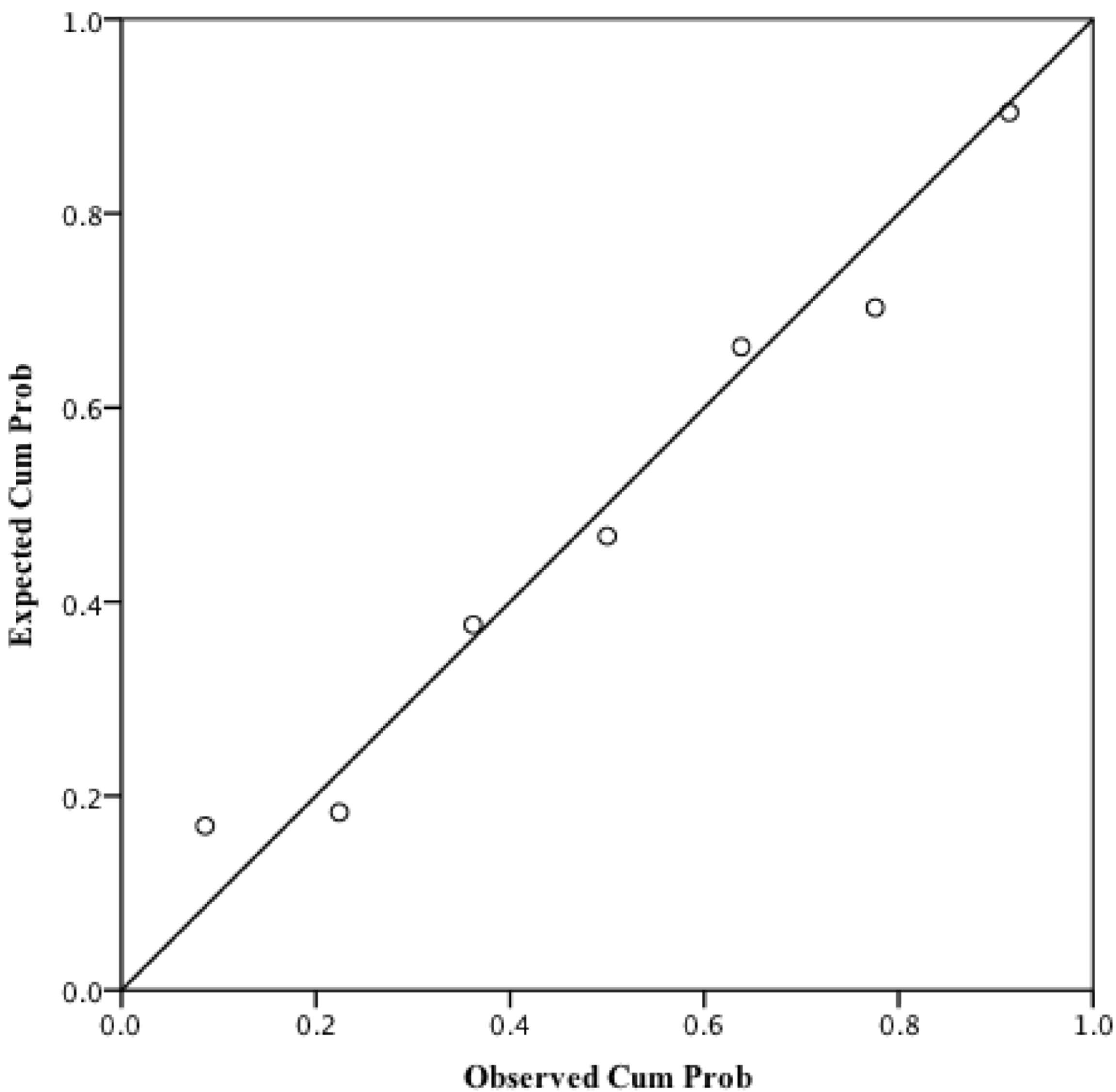

Figure 5. Model-Normal probability plot, P-Plot of regression standardized residuals. Dependent variables: BIS score, Independent variables: avoidance, arousal, and re-experiencing.