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INVESTIGATING DETERMINANTS OF POST-TRAUMATIC STRESS SYMPTOMS: PSYCHOLOGICAL, PHYSIOLOGICAL, AND PERSONALITY INFLUENCES PRE- AND POST-TRAUMA

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ABSTRACT

This study explored pre-trauma psychological and physiological factors associated with post-traumatic stress symptoms (PTSS) in firefighters and police officers. A total of 91 participants underwent pre-trauma psychometric, diagnostic, and psychophysiological assessments, followed by post-trauma evaluations. Key pre-trauma predictors of elevated PTSS included lower cognitive ability (IQ), depressive symptoms, and heightened physiological responses during fear conditioning. Differential corrugator EMG responses and skin conductance (SC) reactivity significantly correlated with PTSS severity. Logistic regression analysis identified lower IQ, higher depression scores, and greater EMG responses as significant predictors of post-trauma IES-R scores. Additionally, increased SC responses predicted higher posterior probability scores. Despite mild PTSS severity, the findings underscore the importance of pre-trauma factors in predicting PTSS outcomes. The study highlights the need for early identification tools to support individuals at risk of developing PTSS or PTSD. Future research should involve larger samples, extended follow-up periods, and high-risk populations to enhance understanding of pre-trauma risk markers.

KEY WORDS: Post-traumatic stress disorder, startle, imagery, psychophysiology, risk factors

INTRODUCTION

Post-traumatic stress disorder (PTSD) is not experienced by everyone; however, many individuals may exhibit subclinical post-traumatic stress symptoms (PTSS). Despite encountering similar traumatic events, individuals often report varying levels of PTSS [1–3]. The development of PTSS or diagnosable PTSD in certain individuals may stem from vulnerabilities that existed before the trauma. Research indicates that PTSS is more common among individuals with a prior history of depression [4,5], anxiety disorders [4], introverted personality traits [6], and a tendency toward neuroticism [4, 6,7]. A significant factor contributing to these vulnerabilities is negative affectivity, a stable and highly heritable personality trait [8]. Negative affectivity encompasses emotional tendencies such as anxiety and depression and is strongly linked to PTSS. Additionally, traits like introversion, neuroticism, heightened electrodermal activity, slower habituation rates, and increased conditioning responses are closely associated with negative affectivity [9]. Both psychological and psychophysiological factors play crucial roles in the manifestation of PTSD symptoms. Many studies comparing individuals with and without PTSD rely on cross-sectional designs, making it difficult to determine whether observed differences are caused by PTSD or existed beforehand as predisposing factors. To identify psychological and psychophysiological indicators that could differentiate individuals with PTSD from those without, a comprehensive review of the PTSD literature was conducted. Potential risk markers identified from the review are summarized in Table 1, alongside demographic factors such as age, education level, gender, and race. Psychological assessments have consistently shown that individuals with PTSD report higher levels of general psychiatric distress [10–13], symptoms of depression [11,12], anxiety [14–16], and neuroticism compared to those without PTSD. Conversely, individuals without PTSD demonstrate higher levels of cognitive ability (IQ), extraversion, openness to experience, and agreeableness.

METHODS

Participants

A study was conducted at (CLG NAME) (July 2020 to May 2023), involving 91 participants who had experienced traumatic events and underwent diagnostic, psychometric, and psychophysiological evaluations. The majority of participants were male, Caucasian, and 64.9% served as firefighters. The average age was 27 years, with an average educational level of 14.1 years. Intelligence assessments using the Shipley Institute of Living Scale indicated that most participants had average IQ scores and were mentally healthy, based on measures of depression, general psychiatric symptoms, and trait anxiety. Structured clinical interviews (SCID) based on DSM-IV criteria and Clinician-Administered PTSD Scales (CAPS) were performed at firefighter training academies. The prevalence of mental health disorders among participants included alcohol dependence (2%), substance dependence (1%), major depressive disorder (1%), attention-deficit/hyperactivity disorder (ADHD) (2%), and phobias (1%). Lifetime prevalence rates, assessed using DSM-IV criteria, were higher, with alcohol dependence (10%), substance dependence (3%), major depressive disorder (3%), and panic disorder (1%). Six participants were excluded from the study for meeting the criteria for current or lifetime PTSD. On average, participants reported experiencing 1.6 types of traumatic events, as recorded on the Stressful Life Events Checklist, with their first traumatic experience occurring at an average age of 10 years (SD = 8.4).

Procedures and Measures

Diagnostic assessment prior to trauma

Each trainee completed the SCID Screen Patient Questionnaire (SSPQ) [19]. Trainees who responded "yes" to any SSPQ items underwent further evaluation using specific SCID modules, which were administered by trained diagnosticians. To assess whether the trainee met the criteria for current or past PTSD and to measure the severity of PTSD symptoms, trainees were required to report experiences of traumatic events accompanied by PTSD-like symptoms. This process enabled the identification of PTSD cases and the evaluation of symptom intensity.

Psychometric assessment before trauma

The assessment instruments administered included the Stressful Life Events Checklist (SLEC) [20], which evaluates prior traumatic experiences and personality traits such as neuroticism, extraversion, conscientiousness, agreeableness, and openness to experience. Additionally, participants completed the Symptom Checklist-90-Revised (SCL-90-R), which measures a broad range of psychological symptoms, and the State-Trait Anxiety Inventory (STAI), which assesses anxiety levels. The Shipley Institute of Living Scale, derived from the Beck Depression Inventory (BDI), was also administered to estimate participants' intellectual functioning, which is comparable to scores on the Wechsler Adult Intelligence Scale-Revised (WAIS-R).

Procedure for loud-tones

An audiologic screening test was performed to confirm that participants could detect a 1000 Hz tone at 25 dB in both ears. The procedures for stimuli presentation, laboratory assessments, and dependent measures were consistent with those used in prior PTSD studies. A Coulbourn Audio Source Module (V85-05) was used to deliver 1500-Hz pure tones lasting 500 milliseconds, with no rise or fall time (0-ms ramp). The tones were presented binaurally through headphones. The intervals between tone presentations varied randomly between 27 and 52 seconds. The psychophysiological assessments were conducted in humidity- and temperature-controlled rooms provided by the training academies. The participant, technician, and recording equipment were all situated in the same room, but the participant's view of the recording equipment and the technician was obstructed. After placing the recording electrodes, the participant received instructions consistent with those provided in previous studies [17]. Once the participant was fitted with headphones, the technician verified that the recording equipment was functioning correctly. Following a 5-minute resting period and baseline recording, a series of 15 tones was presented to the participant.

Conditioning procedure

Following the loud-tone task, participants underwent a conditioning procedure, during which conditioned stimuli (CS) were presented on a monitor positioned approximately 4 feet from the participant. The CS+ was represented by a 6-inch blue circle, and the CS- was depicted as a 6-inch white circle. Electrodes were attached to the participant's dominant hand, and they received a 500-millisecond electric shock administered through a Coulbourn Transcutaneous Aversive Finger Stimulator (E13-22). The shock intensity was pre-selected by the participant as "highly irritating but not painful." The unconditioned stimulus (UCS) level was determined based on instructions outlined in a previous study [11]. The experiment was divided into three phases, with a five-minute resting period before the start: Phase I (Habituation): The to-be CS+ and CS- were each presented five times in a pseudo-random order, ensuring that no more than two consecutive presentations of the same stimulus occurred. Each CS lasted 8 seconds, with intertrial intervals ranging from 15 to 25 seconds.
Phase II (Acquisition): During this phase, the CS+ was paired with a 500-millisecond shock pulse, establishing the conditioned response.
Phase III (Extinction): This phase consisted of ten non-reinforced presentations of the CS+, meaning the shock was no longer delivered.
Throughout all three phases, the participant's skin conductance (SC), heart rate (HR), and left corrugator electromyography (EMG) were continuously recorded to assess physiological responses.

Trauma monitoring

A bimonthly mail survey was distributed to participants who had completed the pre-trauma assessment to identify whether they had experienced a traumatic event meeting the DSM-IV Category A1 criteria, although meeting the A2 criterion was not required. Participants who reported experiencing such a qualifying ("index") event were invited to complete a post-trauma assessment.The reported traumatic experiences included:
Physical assault (n = 4),Motor vehicle accidents (n = 4),
The death or serious injury of a close friend (n = 16), and
Other traumatic events (n = 59). On average, trauma occurred 19.4 months after the initial assessment (SD = 12.2 months), while the post-traumatic assessment was conducted approximately 12.3 months following the traumatic event (SD = 11.5 months).

Loud tone psychophysiologic response scores

Psychophysiological recordings for each participant were reviewed both visually and statistically to identify any abnormal responses. If an irregular response was detected, the data for that trial was corrected by averaging the values from the immediately preceding and following trials. Overall, unusable or imputed data accounted for less than 5% of cases.In line with our previous research, which measured psychophysiological responses to loud tones, we quantified responses for each trial as follows:
Eyeblink EMG Responses: Calculated by subtracting the average orbicularis oculi muscle activity recorded 40–200 milliseconds after tone onset from the peak activity observed thereafter. Skin Conductance (SC) Responses: Determined by subtracting the average SC value recorded 1–4 seconds after the tone from the peak SC value within that time frame.Heart Rate (HR) Responses: Measured by subtracting the pre-stimulus average heart rate from the heart rate recorded within 1–4 seconds

following tone onset. To address skewness and heteroscedasticity, all response values were transformed using the square-root method. The response scores for HR, SC, and EMG were based on eyeblink reactions to the tones.
We assessed habituation in two distinct ways:
Absolute Habituation: Measured by counting the number of trials until the participant produced two consecutive non-responses. Rate of Habituation: Determined using a logarithmic model, where the square root of the response score (Y) was plotted against the logarithm of the trial number (X) for trials 2 through 15.

Psychophysiological measures of aversive conditioning
Based on previous research, the response score was calculated by averaging values from skin conductance (SC), corrugator electromyography (EMG), and heart rate (HR). These averages were taken from the maximum values recorded during the 8-second interval before the onset of the conditioned stimulus (CS). During both the acquisition and extinction phases, responses from SC, corrugator EMG, and HR were measured separately and then subtracted from their respective baseline values. Only responses to CS+ trials were analyzed to assess SC, corrugator EMG, and HR during the acquisition and extinction phases. Previous findings indicated that individuals with PTSD exhibited heightened responses to both CS+ and CS- stimuli, resulting in a minimal difference between the two conditions. This reduced difference contributed to a smaller differential conditioning score, consistent with prior studies [e.g., 18].
To better estimate reactivity to fear-related cues, only responses to CS+ trials were considered. The unconditioned response (UCR) score was calculated by subtracting the highest physiological value recorded after the unconditioned stimulus (UCS) interval from the baseline measurement.

Statistics
We summarized the variables using means and standard deviations for continuous data and percentages for categorical data. Post-trauma assessments were conducted in our laboratory with individuals who had experienced trauma. The primary psychological outcome measures were the Clinician-Administered PTSD Scale (CAPS) and the Impact of Event Scale-Revised (IES-R) scores. The severity of post-traumatic stress symptoms (PTSS) was assessed using the IES-R, consistent with previous prospective studies that assessed PTSS severity without diagnosing PTSD. For psychophysiological outcomes, the posterior probability score derived from script-driven imagery assessments was used as the primary measure. Due to low symptom severity levels, many outcome measures displayed a high degree of skewness. To address this, we dichotomized the results into "high" and "low" categories, representing the upper and lower tertiles. Because scores from the first and second tertiles were similar, they were combined to form the "low" group, while the highest tertile represented the "high" group.
Additionally, we categorized the outcome variables into:
Quartiles, comparing the highest quartile (Q4) with the lowest quartile (Q1), and
Tertiles, comparing the highest tertile (T3) with the lowest tertile (T1).
The results from all three dichotomization approaches (upper vs. lower tertiles, quartiles, and tertiles) were consistent. Although quartile and tertile comparisons used only a portion of the data (half in Q4 vs. Q1 comparisons and two-thirds in T3 vs. T1 comparisons), the "low" group created from the combined T2 and T3 tertiles utilized the entire dataset, providing a comprehensive measure of low symptom severity.

RESULTS
IES-R Scores and Pre-Trauma Predictors in Individuals Exposed to Trauma: A Cross-Sectional Study
Measures of post-trauma outcomes
According to the IES-R results, the mean (M) score was 5.8 with a standard deviation (SD) of 10.1, and scores ranged from 0.0 to 47.5. For Posterior Probability scores, the mean (M) was 0.36 with a

standard deviation (SD) of 0.12, and scores ranged from 0.16 to 0.96.**In univariate models, comparison of pre- and post-trauma predictors**

The IES-R and Posterior Probability scores demonstrated more conservative outcomes compared to pre-trauma predictors when analyzed using a t-test for unequal variances. Significant differences were observed between the High IES-R group and the Low IES-R group in pre-trauma scores on: Beck Depression Inventory-II (BDI-II)

Shipley Estimated IQ State-Trait Anxiety Inventory-Trait (STAI-Trait) Differential corrugator EMG response For the Posterior Probability score groups, the following measures distinguished the High from the Low groups: Shipley Estimated IQ Skin Conductance (SC) habituation non-response Heart rate (HR) response to CS+ trials during the acquisition phase

Combining pre-trauma predictors with post-trauma outcomes

A stepwise logistic regression analysis was conducted to compare IES-R scores and Posterior Probability scores. For the IES-R scores, individuals with:Lower Shipley Estimated IQ scores,Higher Beck Depression Inventory-II (BDI-II) scores, andGreater differential corrugator EMG responses during extinction were more likely to have elevated post-trauma IES-R scores.The model achieved a 70% accuracy rate in correctly classifying individuals with high IES-R scores based on the maximized sample. To assess how trauma severity and time since the traumatic event influenced laboratory outcomes, a second logistic regression analysis was performed. The analysis produced: An odds ratio (OR) of 2.02 for time-since-trauma, and An odds ratio (OR) of 0.91 for trauma severity, Based on logistic regression, individuals with lower estimated IQ scores and greater SC responses predicted higher Posterior Probability scores post-trauma. Based on the maximized sample, the Posterior Probability model had a c-statistic of 0.71, meaning 70 percent of the individuals were correctly classified. Trauma severity ratings and time since trauma were adjusted in the logistic regression analysis. When the trauma-severity and time-since-trauma variables were included in the model, their odds ratios were 2.01 and 2.04 respectively; their contributions did not differ significantly.

Table 1: Multiple Logistic Stepwise Regressions Predicting Post-trauma Outcomes from Pre-trauma Variables

Maximized Sample						
Outcome		Selected	Odds	Wald		
Measure	N	Predictor(s)	Ratio	Chi-Square	df	p
IES-R	192	Shipley Est. IQ	0.96	5.28	2	.040
		EMG Diff_E1	2.17	5.46	2	.036
		BDI-II	2.15	4.50	2	.063
Post. Prob.	190	Shipley Est. IQ	0.95	6.72	2	.018
		SC Mean Resp.	5.02	4.70	2	.056

DISCUSSION

Rather than evaluating predictor variables retrospectively, this study explored possible physiological, psychological, and demographic factors contributing to PTSS among firefighters and police officers. Previous research has suggested that psychological and physiological markers linked to PTSS are inherent rather than developed after trauma. Notably, no cases of PTSD were diagnosed among police and firefighters exposed to traumatic events based on DSM-IV criteria. The absence of clinical PTSD cases was unexpected. PTSD rates were "conservatively" estimated at 17% [4]. However, prospective studies indicate that PTSD prevalence among police officers and firefighters is relatively low. In one study, none of the 67 traumatized firefighters exhibited PTSD symptoms. The low incidence of PTSD among police and firefighters may be attributed to self-selection bias and professional training. Active police officers and firefighters may be less likely to report psychopathological symptoms. As PTSD could not be utilized as a predictor for PTSS, the study focused on pre-trauma factors influencing PTSS. Although PTSS levels were relatively mild, combined scores for depression, IQ, and differential corrugator EMG readings significantly predicted elevated PTSS levels during extinction trials. Evidence suggests that higher IQ offers protection against PTSD, while an increased differential corrugator EMG response predicts a higher IES score. Impairments in corrugator EMG responses, lower IQ, and more severe pre-trauma depressive symptoms were linked to PTSS. Pre-trauma depression symptoms may signal a negative emotional state [8]. Corrugator EMG activity correlates with emotional valence in the brain. A heightened differential corrugator EMG response following fear conditioning may indicate a tendency to sustain negative emotions. Higher IQ appears to facilitate better management of positive emotional responses. Individuals with lower IQs may struggle to regulate negative emotions, impairing their mental resilience. Psychophysiological reactivity was best predicted by decreased intelligence and heightened sensitivity to loud sounds. Previous studies did not measure psychophysiological outcomes of PTSS. Research suggests that individual variations in sympathetic nervous system activity can predict both psychophysiological and subjective PTSS outcomes. Post-trauma reactivity to trauma reminders is associated with lower IQ. Results from loud-tone studies, which evaluate "unconditioned" responses, suggest that sympathetic and parasympathetic nervous system activity can distinguish PTSS and PTSD responses. Unlike skin conductance (SC), heart rate (HR) is influenced by parasympathetic nervous system activity. PTSS/PTSD is associated with heightened SC reactivity, while HR reactivity is acquired. Most studies on PTSD patients reported HR reactivity, whereas SC reactivity findings were less consistent, with only two studies observing increased SC responses. SC reactivity reflects sympathetic activity, whereas HR reactivity reflects parasympathetic activity. Loud-tone tests stimulate autonomic responses. Heightened sensitivity of the sympathetic nervous system may lead to PTSS/PTSD, while reduced parasympathetic tone may result from this heightened sensitivity. Additionally, a significant correlation was observed between HR response to CS+ stimuli and probability scores. Psychophysiological reactivity to trauma-related imagery may correlate positively with pre-trauma conditioning ability. However, subjective PTSS scores (IES-R) were not predicted by SC responses to loud tones or HR responses to CS+ stimuli during conditioning. This suggests that psychophysiological reactivity, rather than PTSS severity, accounts for the observed relationships. Several measures of psychophysiological reactivity showed no association with probability scores, challenging the idea that these responses are simply concordant. The study had several limitations. The relatively mild PTSS severity may have limited the strength of associations between predictors and outcomes. Additionally, relationships could have been underestimated due to the restricted range of scores. A delay in follow-up assessments after trauma may have further weakened associations. Nonetheless, results remained consistent after adjusting for time elapsed since trauma. Differential corrugator EMG scores predicted IES-R outcomes as expected; however, the Low IES-R group displayed an unexpected response pattern. Specifically, the Low IES-R group exhibited larger corrugator responses to CS- than to CS+, resulting in a negative differential score. Despite the unusual pattern, the large sample size for the Low IES-R group suggests the negative mean value is reliable. The underlying cause of this pattern remains unclear. Typically, corrugator activity is associated with negative emotions. It is possible that participants anticipated a shift in associative relationships, suspecting that the CS- would predict the UCS after the CS+ failed. The Low IES-R group may have engaged in more cognitive processing than the High IES-R group. Regardless of the underlying cause, the distinct responses to CS+ and CS- during extinction merit further investigation.

CONCLUSIONS

This research investigated psychological and physiological factors present before trauma that are linked to post-traumatic stress symptoms (PTSS). Elevated PTSS scores were associated with lower pre-trauma cognitive ability, depressive symptoms, and heightened physiological reactions during fear conditioning. Reduced estimated cognitive function was connected to increased sensitivity to trauma-related stimuli. However, post-traumatic symptoms appeared to follow a normal distribution, indicating a range of symptom severity. Despite obstacles, advancing methods to identify individuals at elevated risk for PTSS or PTSD before trauma remains essential for personalised interventions.

Future studies aim to extend observation periods, increase sample sizes, and focus on high-risk groups to deepen insights into pre-trauma risk factors for PTSS and PTSD.

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