Utility of P300 ERP in monitoring post-trauma mental health: A longitudinal study in military personnel returning from combat deployment

Chao Wanga,b,∗, Paul Rapp†, David Darmona,b, Amy Trongnetrpunyaa,b, Michelle E. Costanzob,c, Dominic E. Nathana,b, Christopher J. Celluccid, Michael J. Royc,e, David Keyseara

ARTICLE INFO

Keywords: Combat trauma PTSD ERP Depression Biomarker

ABSTRACT

Military service members (SMs) returning from combat are at high risk of developing neuropsychiatric conditions such as posttraumatic stress disorder (PTSD) and major depression. Symptom dynamics following re-integration into civilian life may be magnified over time such that some SMs present with delayed onset and may not reach a diagnostic threshold for months to years. Monitoring the trajectory of mental health in the aftermath of combat trauma can therefore be particularly important in enhancing diagnosis. In this study, we investigated the possible utility of the P300 event-related potential (ERP) as an objective marker for monitoring post-trauma mental health. SMs recently returned from a combat deployment were recruited to undergo a baseline assessment, with subsequent follow-up assessment at 6 or 12 months later. At each assessment, ERPs were recorded using a conventional visual oddball task and a set of psychological scores assessing PTSD, depression, and psychosocial functioning were obtained. We observed that the individuals with overall improved psychological scores at follow-up had increased P300 amplitude and shortened P300 latency, and the individuals with overall worsened psychological scores at follow-up had prolonged P300 latency. The degree of change in aggregate psychological score was significantly correlated with the magnitude of change in P300 amplitude (r = −0.72, p < 0.0001) and latency (r = 0.42, p = 0.0201). These findings suggest that the P300 may be utilized as a quantitative biomarker for tracking the changes of mental health longitudinally. It may offer clinicians an objective tool for the assessment of the dynamics of mental health following trauma, and perhaps also for monitoring recovery during treatment.

1. Introduction

Life-threatening traumatic events such as combat can have considerable impact on mental health (Hoge et al., 2004). Researchers using records from the Department of Veterans Affairs (VA) health care system from 2002 to 2008 (Seal et al., 2009) found that amongst Iraq and Afghanistan war veterans, over one-third of veterans received mental health diagnoses, with posttraumatic stress disorder (PTSD) as the most common diagnosis (21.8%), followed by major depression (17.4%). Additionally, many veterans were not diagnosed with PTSD immediately after returning from a war zone but were diagnosed several months later, signaling delayed-onset stress reactions (Miliiken et al., 2007; Seal et al., 2009; Solomon and Mikulincer, 2006). The delayed-onset highlights the need for long-term monitoring of mental health in this vulnerable population. Early signs of improvement or deterioration in mental health status may play an important role in identifying at-risk individuals and predicting recovery.

In current clinical settings, the monitoring of post-trauma mental health relies on clinical interviews and self-reported symptom checklists. Although these standard instruments are generally reliable, they are subjective and can be greatly influenced by the accuracy of patient reports. In particular, military personnel tend to underreport their mental health problems (McLay et al., 2008), likely due to concerns that this may jeopardize their job, promotion, and self-image. The development of physiological measures that can objectively identify changes in mental health would be a valuable asset in achieving better...
diagnosis and management of post-trauma mental disorders.

The brain is the central organ of stress responses, and physiological measures that directly assess brain activity, such as electroencephalogram (EEG) and event-related potentials (ERPs), provide rich information concerning underlying neural processes associated with psychopathology. Among various ERP components, the P300 may be best suited to serve as a biomarker for the assessment of post-trauma mental health, given that it is well-studied, has a relatively high signal-to-noise ratio compared to other ERPs, and conveys information about attention and working memory processes that are known to be affected in PTSD and depression (Buckley et al., 2000; Dalgleish and Watts, 1990). In particular, the P300 amplitude exhibits high within-subject test-retest reliability over short (e.g., 4 weeks) (Williams et al., 2005) and long (e.g., 12 months) (Brunner et al., 2013; Sinha et al., 1992) time periods, comparable to the reliability levels of common instruments used in psychiatry (Regier et al., 2013). However, the vast majority of the P300 studies in trauma-exposed populations have focused on between-subjects analysis for separating PTSD patients from controls (Javanbakht et al., 2011; Johnson et al., 2013; Karl et al., 2006). It is unclear whether the P300 can be used as a monitoring biomarker that varies over time within-subjects as a function of changes in symptom severities.

In this study, we employed a longitudinal design to investigate the potential utility of P300 measures in monitoring mental health progression in the aftermath of combat trauma. We recruited military service members recently returned from a combat deployment in either Iraq or Afghanistan to undergo a baseline assessment, with subsequent follow-up assessment at 6 or 12 months. The P300 ERPs were measured using a conventional visual oddball task paradigm. The mental health status was indicated by the symptom severity ratings of PTSD and depression, as well as by ratings of psychosocial functioning and emotional well-being. Given the documented delayed-onset PTSD findings among war veterans, we expect that some participants would exhibit deteriorated mental health status at follow-up while some others would exhibit improvement. We hypothesize that the improvement or deterioration in mental health status could be indicated by changes of P300 amplitude and/or latency. More specifically, those with improved mental health at follow-up would show enhanced P300 amplitude and/or shortened P300 latency, whereas those with deteriorated mental health at follow-up would show diminished P300 amplitude and/or delayed P300 latency. We further hypothesize that the changes in P300 measures may quantitatively correlate with the changes in psychosocial functioning and symptom severities of PTSD and depression.

2. Methods and Materials

2.1. Participants

Thirty military service members (age 30.4 ± 7.2 years, 27 men and 3 women) who had returned from a deployment in either Iraq or Afghanistan were included in this study. They completed a baseline ERP and psychological assessment within two months of their return, and a subsequent follow-up assessment at 6 or 12 months (ten participants at 6 months and twenty participants at 12 months). All participants did not meet the diagnostic criteria for PTSD, major depressive disorder, or post-concussion syndrome at the time of baseline assessment (Wang et al., 2017b, 2017a).

All participants provided written informed consent in accordance with the protocol approved by institutional review boards at Uniformed Services University, Walter Reed National Military Medical Center, and the National Institutes of Health.

2.2. Psychological measures

At both baseline and follow-up assessments, all participants were administered a series of psychological assessments including PTSD Checklist-Military Version (PCL-M) (Forbes et al., 2001) and Clinician Administered PTSD Scale (CAPS) (Weathers et al., 2001) for assessing PTSD, Patient Health Questionnaire-9 (PHQ-9) (Spitzer RL et al., 1999) for assessing depression, and 36-Item Short Form Survey (SF-36) (Ware and Sherbourne, 1992) for assessing health-related quality of life. For SF-36, the two summary scores – Physical Component Summary (PCS) and Mental Component Summary (MCS) (Farivar et al., 2007; Ware et al., 1995) – were used in analysis.

2.3. Principal component analysis (PCA) on psychological scores

To summarize the mental health status using a single score, we performed PCA on the scores of CAPS total, PCL-M, PHQ-9, and MCS. These four scores are highly correlated measures (for correlation matrix see Supplemental Materials Table S1) and a single aggregate score that summarizes them should be more informative than any one of the scores for indicating post-trauma mental health status. The PCS score was not included because it measures physical health rather than mental health. PCA was performed on a data matrix that contained the four scores at both baseline and follow-up for each participant. Before performing PCA, each score was normalized by subtracting the sample mean and dividing by the sample standard deviation. These normalized scores were then projected onto the first principal component to give the aggregate scores at baseline and follow-up. The first principal component accounted for 72.0% of the original variance of the data. The projection of the scores onto the first principal component is given by:

\[
\text{Aggregated psychological score (1st principal component)} = 0.53^*(\text{CAPS}) + 0.52^*(\text{PCL-M}) + 0.52^*(\text{PHQ-9}) - 0.44^*(\text{MCS})
\]

For CAPS, PCL-M, and PHQ-9, higher scores indicate more severe symptoms, whereas for MCS higher scores indicate better health. We see that the coefficient for MCS score is negative and the rest are positive. Therefore, for the aggregate psychological score, higher scores indicate poorer status of mental health. We also note that the four coefficients are of comparable magnitude, showing that the four scores (normalized) were similarly weighted in the aggregate score.

For analysis purposes, we divided the participants into an Improved group and a Deteriorated group based on the changes of their aggregate psychological scores at follow-up compared to baseline. If the aggregate psychological score of a participant increased, we considered this a deterioration in his/her mental health and thus included that participant in the Deteriorated group; conversely, if the aggregate psychological score of a participant decreased, we considered his/her mental health to have improved and included that participant in the Improved group.

2.4. EEG recording

Scalp EEG was recorded at both baseline and follow-up assessments while participants performed a visual oddball task. The experiment took place in an acoustically and magnetically shielded room. Visual stimuli were presented by a digital tachistoscope of our own design and construction. The tachistoscope is a 5 × 5 square array of yellow, light-emitting diodes. Each diode is 1 cm in diameter. Given spacing between LEDs, the array is 6 × 6 cm. The standard visual stimulus was a vertical stimulus which consists of the five vertical center line LEDs illuminated simultaneously for 40 msec. The target visual stimulus was a horizontal stimulus which is composed of the five horizontal center line LEDs illuminated simultaneously for 40 msec. Each subject received 125 stimuli in total, of which about 21% (26 ± 1 trials) were target and 79% (99 ± 1 trials) were standard stimuli. The subjects were instructed to maintain a silent count of the number of target stimulus presentations and to report their count at the end. The inter-stimulus onset time was varied randomly between 1.4 and 1.8 s. The experiment lasts about
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات