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ERP correlates of malingered executive dysfunction

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ABSTRACT

Assessment of malingering has become an integral part of many neuropsychological evaluations, particularly in forensic settings. However, traditional malingering measures are known to be vulnerable to both manipulation and coaching. Consequently, recent research has attempted to identify physiological indices of cognitive functioning that are less susceptible to overt manipulation. While prior studies have explored the validity of physiological assessment of memory deficits, this study evaluates the effectiveness of a physiological measure of executive functioning. This study used EEG recording in conjunction with a three-stimulus oddball design to compare neural responses in simulated malingerers feigning cognitive deficits associated with traumatic brain injury (TBI) and controls. Specifically, the study explored the efficacy of an event-related potential (ERP) known as P3a, which is believed to be an index of frontal lobe executive processes, specifically the attentional orienting response. The results of this study demonstrated that simulated malingerers did not produce a P3a response that was significantly different from control participants. Furthermore, the P3a in simulated malingerers did not demonstrate any of the properties reported in prior studies with TBI patients. Not only were malingerers unable to produce a significant change in their basic orienting response, but the very process of attempting to employ additional strategies to appear impaired produced other physiological markers of deception. Therefore, the P3a component appeared to be unaffected by an individual's motivation or overt performance, which suggests that it may have potential for development as a physiological measure for differentiating between malingerers and those with genuine TBI.

1. Introduction

Cases of traumatic brain injury represent a significant concern in the United States and approximately 75% of the 1.7 million brain injuries that occur annually, are classified as mild in nature (CDC, 2012). While the majority of individuals sustaining a mild traumatic brain injury (mTBI) make a full recovery within weeks of their injury, it is estimated that in 15 to 30% of patients, cognitive symptoms persist for three months post injury and in some cases, result in long-term disability (Shenton et al., 2012). mTBI is particularly difficult to reliably diagnose as it is typically characterized by diffuse axonal injury caused by the stretching of brain tissue, which often cannot be detected using traditional neuroimaging techniques (Shenton et al., 2012; Taber and Hurley, 2013). Therefore, diagnosis and characterization of these injuries typically rely on traditional behavioral measures of neurocognitive functioning (for review, see Lezak et al., 2004).

Individuals suffering a mTBI typically manifest neurocognitive symptoms that include diminished processing speed, memory deficits, executive dysfunction, and difficulties sustaining attention (Echemendia et al., 2001; McAllister, 2011). Furthermore, as these injuries often occur subsequent to a motor vehicle accident or fall, many seek compensation through civil litigation (Ruff and Jamora, 2008). General damages awarded to personal injury claimants are intended to correlate with the degree of impairment, pain and suffering, and future repercussions associated with their injuries (Greenberg, 2003). These factors may provide some plaintiffs with substantial motivation to intentionally exaggerate the degree of their impairment. While the prevalence rate of malingering is unknown and often contested, it is believed to occur in a substantial number of civil litigations involving claims of mTBI (e.g., Larrabee, 2003). Currently, determinations of inadequate effort or malingering are made based on clinical findings and interpretation of behavioral measures of symptom validity; however, these tests have been demonstrated to be susceptible to both careless responding (low effort) and the intentional exaggeration of symptoms (malingering) (Larrabee, 2007; Vagnini et al., 2008), and are also potentially influenced by examiner bias (McGrath et al., 2010). This vulnerability, in addition to the concern that behavioral tests for malingering may be susceptible to coaching, has prompted several researchers to investigate whether ERP

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paradigms can provide suitable physiological markers for the detection of malingered cognitive dysfunction (e.g., Ellwanger et al., 1996; Rosenfeld et al., 1995, 1998, 1999; Tardif et al., 2000, 2002; Vagnini et al., 2008; van Hooff et al., 2009).

Numerous ERP studies have focused on identifying the neural correlates of concealing information (for review see Ben-Shakhar, 2012). These studies focus on guilty knowledge detection, rather than identification of malingered cognitive impairments, and as such, an extensive literature review of these is beyond the scope of this paper. However, concealed information ERP studies have consistently demonstrated that deceptive responding is typically slower than honest responding (Hu et al., 2011; Proverbio et al., 2013) and produces unique physiological markers, that result from increased activity in the prefrontal cortex, medial frontal cortex, and the anterior cingulate cortex (e.g., Johnson et al., 2003). In contrast, there are relatively few research studies that specifically address the detection of malingered cognitive deficits, and to our knowledge, these have only focused on a single domain of cognitive functioning: malingered memory impairments (e.g., Ellwanger et al., 1996; Rosenfeld et al., 1995, 1998, 1999; Tardif et al., 2000, 2002; Vagnini et al., 2008; van Hooff et al., 2009).

Attempts to identify malingered memory deficits utilizing ERP techniques have been moderately successful. While some studies have explored the utility of the old/new effect in identifying recognition of previously viewed items (Tardif et al., 2000, 2002; Vagnini et al., 2008; van Hooff et al., 2009), ERP malingering studies have also employed P300 paradigms to assess for malingered, including identification of long-term recall of autobiographical facts (Ellwanger et al., 1996; Rosenfeld et al., 1995), newly acquired information (Ellwanger et al., 1996), and working memory impairments during match-to-sample tasks (Rosenfeld et al., 1998, 1999). While memory dysfunction is the single most common neurocognitive complaint among those being referred for neuropsychological assessment for mTBI (Lezak et al., 2004), it is rarely the only cognitive symptom reported. Rapid acceleration–deceleration forces associated with closed head injuries typically result in focal insult to the frontal poles, as well as diffuse axonal injury between frontal regions and their supporting subcortical networks (Tallus et al., 2013). Not surprisingly, the majority of mTBI cases are also believed to experience some disruption of attention and general executive abilities (McDonald et al., 2002; Stablum et al., 1996).

In addition to its utility in assessing recognition memory, the P300 elicited in oddball paradigms has been shown to be correlated with frontal lobe-mediated executive abilities (e.g., Andersson et al., 2008; Fabiani et al., 1998; Fjell et al., 2007; Hanagasi et al., 2002). The P300 has been delineated into two distinct subcomponents: P3a and P3b (Squires et al., 1975). P3a is elicited when a change in stimulus is detected (e.g., in response to novel or unexpected distracter stimuli) regardless of whether an overt behavioral response is required. In contrast, P3b is produced in response to conscious task-relevant processing, such as responding to a specific 'target' tone (Polich, 2007). Therefore, P3a is believed to reflect an involuntary executive orienting response that is thought to be an innate survival mechanism (Friedman et al., 2001; Knight, 1984), and several studies have demonstrated that diminished P3a amplitudes are predictive of poorer executive abilities (Andersson et al., 2008; Fabiani et al., 1998; Fjell et al., 2007; Hanagasi et al., 2002).

The correlation between executive functioning and the P3a elicited during an auditory oddball design is further supported by source localization studies which suggest that the frontal lobe plays a significant role in the generation of the P3a (for review, see Linden, 2005). Furthermore, patients with frontal lobe lesions have been shown to produce either a diminished P3a, or no P3a at all, in response to novel distracters (Knight, 1984; Knight et al., 1995). However, it has been suggested that a P3a component that reflects significant frontal lobe executive involvement is only generated when there is sufficient attentional focus on the primary task, and when distracter stimuli adequately disrupt that focus (Polich, 2003, 2007). Within a three-stimulus oddball design, this requires that the target and standard tone stimuli are perceptually similar to each other, making the differentiation between these two stimuli difficult enough to demand the required attentional shift when a distracter is presented (Polich, 2003). The ability to discriminate subtle differences between stimuli (e.g., 5%) has been demonstrated, even among patients with mild to moderate brain injuries (e.g., Elting et al., 2008; Potter and Barrett, 1999; Potter et al., 2001; Rugg et al., 1993; Segalowitz et al., 2001; Solbakk et al., 2000), provided the auditory system has not been compromised as a result of injury (Jay, 2000).

Research investigating how mTBI affects the P3a has been somewhat limited by the use of small sample sizes and inconsistent inclusion criteria. However, the majority of studies have shown that mTBI patients have decreased P3a amplitudes relative to healthy controls (Elting et al., 2008; Potter and Barrett, 1999; Reinvang et al., 2000; Segalowitz et al., 2001; Solbakk et al., 2000). Other populations with deficits in attention and executive functioning have also been shown to have reductions in P3a amplitude (e.g. Andersson et al., 2008; Barceló, 2003; Baving et al., 2006; Friedman et al., 2008; Hanagasi et al., 2002).

The current study investigated the applicability of the P3a as a physiological measure of symptom validity for deficits in inattention and executive dysfunction. We used a three-stimulus auditory oddball design (Knight, 1984) in a population of healthy individuals with intact cognitive functioning, and compared the P300 responses of honest responders to those of simulated malingerers. We expected P3b responses to be elicited when the participants responded to the target stimuli that occurred infrequently within the standard stimuli (Polich, 2007). However, our hypotheses focused on the P3a response to the infrequently occurring distracter stimuli (Polich, 2007), to which no overt response was required. Previous research has demonstrated that reduced P3a amplitudes correlate with executive dysfunction in a variety of populations (e.g. Andersson et al., 2008; Barceló, 2003; Baving et al., 2006; Friedman et al., 2008; Hanagasi et al., 2002), including those with TBI (e.g. Potter and Barrett, 1999; Reinvang et al., 2000; Segalowitz et al., 2001; Solbakk et al., 2000). However, because the P3a is believed to represent an involuntary orienting response to novel stimuli (Courchesne et al., 1975; Daffner et al., 2000), we hypothesized that healthy malingerers would be unable to suppress their physiological orienting response to distracter items, and so would produce a P3a that would be comparable in amplitude to those responding honestly. If this prediction is correct, then the relative amplitude of the P3a component may be a useful biomarker of malingering, as others have shown the P3a to be diminished in patients with genuine mTBI (Elting et al., 2008; Potter and Barrett, 1999; Potter et al., 2001; Rugg et al., 1993; Segalowitz et al., 2001; Solbakk et al., 2000). Furthermore, we investigated whether there were any unique behavioral or physiological indicators that differentiated malingerers from honest responders during the ERP task.

2. Methods

2.1. Participants

The sample comprised 36 adults (13 males) between 20 and 36 years of age ($M = 25.0$ years, $SD = 4.7$). Participants were recruited from the general public through advertisement as well as from a pool of undergraduate students in psychology. All received $40 or course credit for their participation in the study. This study was approved by the Institutional Review Board (IRB) at John Jay College of Criminal Justice, CUNY.

All participants denied any history of psychiatric or neurological illness or injury. To ensure adequate intellectual and executive functioning, all participants were required to have an estimated IQ score of 80 or higher on the Wechsler Test of Adult Reading (WTAR; The Psychological Corporation, 2001), and a score above the 9th percentile on the Stroop Color-Word Interference Test (Golden, 1978).