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Abstract

Concussion, also known as mild traumatic brain injury (MTBI), represents a common injury in children, young adults, and athletes in particular. High rates of malingering have been demonstrated in individuals with MTBI when faced with monetary incentives, but research is yet to explore the impact of other incentives on test performance. The present study sought to examine the rate of effort test failure, symptom report, and neuropsychological test performance in college students assigned to one of three conditions: Fake Good, Fake Bad, and No Incentive conditions. All groups were asked to simulate concussion and provided a description of the injury and common symptoms. The Fake Good group was asked to pretend to be an athlete seeking to return to play following injury. The Fake Bad group was asked to pretend to be seeking academic accommodations after injury. The No Incentive group was provided no additional information. A sample of 171 participants was randomly assigned to one of three groups. Participants completed a symptom report, brief neuropsychological battery, and symptom validity test. The results suggested that the Fake Bad and No Incentive groups showed higher symptom report, weaker neuropsychological test performance, and higher rates of effort test failure than the Fake Good group. Regardless of group, effort test failure explained a significant amount of variance in neuropsychological test performance. The implications and limitations of the current findings are discussed, in addition to future directions for study.

THE IMPACT OF INCENTIVES ON NEUROPSYCHOLOGICAL TEST PERFORMANCE: AN ANALOG STUDY

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DISSERTATION

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in School Psychology

Syracuse University
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The Impact of Incentives on Neuropsychological Test Performance: An Analog Study

Traumatic brain injury (TBI) is defined by the Centers for Disease Control and Prevention (CDC; 2010) as a form of acquired injury that results from sudden trauma that produces damage to the brain. The American Congress of Rehabilitation Medicine (Kay, 1993) more explicitly defines concussion (or mild traumatic brain injury; MTBI) by the presence of traumatically induced physiological disruption of brain function that can be inferred by the presence of one or more of the following: any period of loss of consciousness, any memory loss immediately before or after the injury, any alteration of mental state (i.e., confusion or disorientation), and/or focal neurological deficits, which do not result in loss of consciousness greater than thirty minutes, an initial Glasgow Coma Scale score of <13, or posttraumatic amnesia longer than 24 hours. Concussion typically follows a blow, or repeated blows, to the skull or action that causes quick acceleration and deceleration of the brain; this abrupt shift in movement can result in bruising of the brain on the bony protuberances of the skull, as well as pulling and stretching of neurons (Moser et al., 2007), also known as diffuse axonal injury. When neuronal fibers are stretched or damaged as a result of mild traumatic brain injury, the consequence is a neurometabolic cascade that disrupts cell metabolism, blood flow, and neurotransmission (Moser et al., 2007). TBI represents a group of injuries graded on a continuum of severity, ranging from mild to severe, with the most severe injuries carrying the potential for death or permanent disability.

The CDC (Faul, Xu, Wald, & Coronado, 2010) estimates that 1.7 million Americans sustain a TBI each year, with approximately 1.3 million seeking emergency medical treatment for such injuries. The CDC (Faul et al., 2010) also reports that TBI is most prevalent in children ages 0-4 years, adolescents ages 15-19, and adults over the age of 65. Falls and car accidents represent the two leading causes of TBI, with falls resulting in the greatest number of emergency room visits while motor vehicle accidents result in the highest death rate. Current estimates suggest that concussions represent about 70-90% of all treated traumatic brain injuries (Ponsford et al., 2001; Sterr, Herron, Hayward, & Montaldi, 2006) ranking concussion as the most common form of acquired brain damage (De Monte, Geffen, May, & McFarland, 2009). Motor vehicle accidents are the most common causes of concussion in adults (Ropper & Gorson, 2007), while motor vehicle accidents and sports participation are the most common causes in children and adolescents (Gessel, Fields, Collins, Dick, & Comstock, 2007). Approximately 300,000 sports-related concussions occur annually in the United State alone, and account for nearly 9% of all injuries sustained in high school athletes and nearly 6% of the injuries sustained by college athletes (Gessel et al., 2007). Soldiers in battle represent another group at high risk for sustaining concussion. As demonstrated by the recent conflicts in Iraq and Afghanistan, soldiers are surviving bomb blasts at increased rates, and show similar increases in reports of concussion (Hoge et al., 2008; Snell & Halter, 2010). Despite our increased awareness of concussion as it relates to athletics and combat, some authors (i.e., Lewandowski & Reiger, 2009; Moser et al., 2007) suggest that current prevalence rate estimates of concussion may underestimate the actual rates due to underreporting and misdiagnosis. Thus, concussion has been termed the “silent epidemic” (Barth et al., 1989) as the injury may not result in overt symptoms and frequently goes undiagnosed.

Diagnosis of Concussion

Concussion presents a unique diagnostic challenge as the immediate symptoms of injury, such as loss of consciousness or alteration of mental state, are often fleeting and diminish by the time the individual presents for treatment. After the initial symptoms remit, the most common complaints following concussion include headache, fatigue, blurred vision, poor concentration, sleep disruption, and mood changes (Sterr et al., 2006). In addition, concussion is thought to impact a variety of cognitive and executive functions, such as processing speed, attention, working memory, and concentration (Lezak, Howieson, & Loring, 2004). Although most people who sustain a concussion experience a remission of symptoms within 7–10 days of injury (Yeates & Taylor, 2005) some individuals may experience disruption of cognitive, emotional, and physical systems for more than three months post injury (Sigurdardottir, Andelic, Roe, Jerstad, & Schanke, 2009; Yeates et al., 1999).

Postconcussion syndrome (PCS) is a term used to describe the long-term symptoms that can follow concussion and last from weeks to more than a year post-injury (Iverson & Lange, 2003). It is estimated that approximately 10% of individuals continue to report symptoms of concussion more than three months post-injury (Bigler, 2008). The most frequent PCS symptoms include memory disruption, headache, fatigue, irritability, anxiety, concentration difficulty, and dizziness (Binder, 1986). The literature is filled with controversy regarding the existence, course, causes, and predictors of PCS (Iverson & Lange, 2003). Post-concussion symptoms, like headache, fatigue, impatience, and poor concentration have been endorsed by high rates (40-75%) of non-injured control groups (Chan, 2001; Iverson & Lange, 2003) and by trauma patients with no concussion

(Landre, Poppe, Davis, Schmaus, & Hobbs, 2006), suggesting that the long-term symptoms of concussion are not specific to the injury. Research also suggests that the longer post-concussion symptoms last, the more likely emotional and psychological factors contribute to the condition (Landre et al., 2006). Further, as symptoms persist over time, some argue that psychological factors, such as depression, anxiety, or the desire to manage one's impression, rather than injury-related factors, maintain the symptom complaints (Mulhern & McMillan, 2006). Overall, the symptoms of concussion are nonspecific, and may be related to a variety of non-injury factors; thus, diagnostic evaluation based on symptom report alone could lead to an inaccurate diagnosis.

The diagnostic debate is also fueled by a poor understanding of the subtle physiological changes that result from concussion. Imaging techniques such as MRI and fMRI have helped to explain the relationship between brain damage and behavioral correlates in moderate to severe brain injury, but currently fail to provide information that is helpful in the diagnosis or management of concussion. More sensitive imaging techniques, such as high-resolution diffusion tensor imaging (DTI), have begun to identify white matter differences in concussed individuals when compared to healthy controls (Little et al., 2010). While these techniques are sensitive to the subtle changes in neural structures and pathways following concussion, they are not yet widely utilized in a clinical setting to diagnose concussion. Further, because there is a change in symptom presentation across time, clinicians are only beginning to explore and understand the biological timeline of concussion and the corresponding remission of symptoms. Also, there is fairly poor understanding of the individual differences that contribute to the experience of short- and long-term symptoms following injury. Unfortunately, the diagnosis and treatment of concussion are imprecise tasks due to our relatively poor understanding of the neurochemical, structural, and individual characteristics that impede or expedite symptom resolution.

Tools for Diagnosing and Monitoring Concussion

Concussions often resolve quickly, may have an unpredictable course, and cause symptoms that are not specific to the injury. In practice, clinicians are forced to rely on symptom reports as the most frequent method of diagnosis and monitoring of the change in one's condition across time. These questionnaires typically list the common symptoms of concussion and ask respondents to rate the severity of current symptoms they are experiencing on a Likert-type scale. Some symptom reports have respondents retroactively compare their current symptoms to their pre-injury status. An individual's scores can then be monitored over time to determine whether symptoms are remitting or worsening. Among the most popular questionnaires are the Rivermead Post-Concussion Symptoms Questionnaire (RPQ; King, Crawford, Wenden, Moss, & Wade, 1995) and the Concussion Symptom Inventory (CSI; Randolph et al., 2009). Each of the measures is short, with fewer than 20 questions, and requires respondents to rate their experience of common physical, cognitive, and emotional symptoms of concussion on a Likert scale. The appeal of self-report questionnaires is their ease of use and scoring, their short time for completion, and their cost-effectiveness. In addition, these measures do not require administration by a highly trained professional.

Although self-report checklists provide an easy method of collecting symptom information and are sensitive to concussion (Eyres, Carey, Gilworth, Neumann, & Tennant, 2005; Randolph et al., 2009), the common symptoms of concussion (i.e., fatigue, headaches, poor concentration, and irritability) are not specific to concussion alone. For example, those presenting with psychological concerns such as anxiety, depression, or post-traumatic stress disorder often report similar complaints of headache, fatigue, and poor concentration (Gioia, Collins, & Isquith, 2008; Landre et al., 2006). In addition, symptom reports often require individuals to compare their current condition to pre-injury functioning, which may be subject to memory distortion and bias (Shuttleworth-Edwards, 2009). For example, retrospective reports may be affected by inaccurate memories, psychological factors, and other variables, such as the "good old days" phenomenon. This phenomenon suggests that when asked to recall behaviors or past performances, people tend to overestimate their skills, abilities, and wellbeing (Henry, Moffitt, Caspi, Langley, & Silva, 1994). Research suggests that individuals who sustain concussion may report fewer pre-injury symptoms, such as headaches, fatigue, and memory problems, than their non-injured peers (Ferguson, Mittenberg, Barone, & Schneider, 1999). Further, individuals with concussion may expect a significant increase in symptoms following injury, and underestimate the incidence of symptoms prior to injury (Gunstad & Suhr, 2001).

Symptom reports alone do not provide a complete picture of concussion. Some individuals report symptoms yet show no brain or behavioral evidence of abnormality, whereas others report no symptoms yet demonstrate behavioral deficits upon examination (Slobounov et al., 2010). Symptom reports do not adequately measure compromised brain function such as slowed processing speed or memory deficits. Consequently, neuropsychological assessment has become a recommended method of monitoring the cognitive and behavioral disruption that can result from concussion (Mittenberg, Theroux-Fichera, Zielinski, & Heilbronner, 1995). A typical neuropsychological evaluation will examine an individual's performance across several domains of brain functioning, including: attention, memory and learning, visuoperception, verbal functions, academic skills, motor ability, executive functions, and emotional status (Lezak et al., 2004). A comprehensive list of commonly used neuropsychological measures is provided in Table 1. In addition to these tests an examiner may add supplemental measures to further explore an area of weakness, clarify diagnosis, or test a hypothesis regarding the nature of the deficit. These evaluations are time intensive, lasting from a few hours to more than eight hours per evaluation, and are often administered by a licensed psychologist with specialized training in assessment and neuropsychology (Zillmer, Spiers, & Culbertson, 2008).

The wealth of information gathered from a comprehensive neuropsychological assessment can be valuable in diagnosis and treatment for a wide range of brain dysfunctions, including concussion. Both the initial and subsequent meetings of the *International Conference of Concussion in Sport* (Aubry et al., 2002; McCrory et al., 2005) have concurred that the information gathered from neuropsychological assessment is integral in both diagnosing and managing concussion. The current guidelines suggest that neuropsychological testing should form the foundation of a post-concussion evaluation "and contributes significantly to both understanding of the injury and management of the individual" (Aubry et al., 2002, p. 8). In addition to these guidelines, the National Academy of Neuropsychology (NAN; Moser et al., 2007) specifically suggests a testing paradigm that includes both baseline and post-injury neuropsychological testing. While this model is typically not followed for every concussion, the pre- and post-injury comprehensive testing scheme works well in athletic situations where there is a high incidence rate of concussion and need to prevent repeated concussions (i.e., football, soccer, and hockey). NAN also supports the use of targeted assessment to evaluate the functional domains most likely impacted by concussion including memory, processing speed, attention, and reaction time.

Despite the recommendation that neuropsychological testing be utilized in both the diagnosis and management of concussion, the results of such testing tend to vary by individual and no single "concussion profile" currently exists. This makes it difficult to compare the scores of one concussed individual with that of others (Landre et al., 2006). In practice, the administration of a lengthy neuropsychological battery following a concussion may be inefficient and even unwarranted immediately after injury. Some authors (Randolph et al., 2009) suggest that neuropsychological testing should not be conducted until all symptoms of concussion have remitted or stabilized. Because concussions can resolve rather quickly, an early assessment would be akin to trying to pinpoint a moving target. A comprehensive neuropsychological battery may result in wasted time and effort, particularly if six hours of testing today would yield different results tomorrow. In addition, many commonly used neuropsychological measures were not designed for repeated use within a short time period, and thus would not be useful to monitor impairment following concussion. Also, traditional neuropsychological measures may lack the sensitivity and specificity to monitor the subtle cognitive effects of concussion (Schatz, Pardini, Lovell, Collins, & Podell, 2006), which further limits the benefits of this approach. Finally, a variety of salient individual factors, such as general intelligence, reading ability, years of education, and social class have been shown to be associated with performance on neuropsychological measures (Greiffenstein & Baker, 2003) and may further cloud the interpretation of test results.

In light of the issues of using traditional neuropsychological measures in the monitoring of concussion juxtaposed against the time of administration, resources required, and psychometric issues, an alternative assessment paradigm has been developed for both baseline testing and repeated administration following injury. Several brief neuropsychological batteries have been developed for use in athletic settings to monitor the cognitive effects of concussion. Although these batteries should not be considered comprehensive, they utilize traditional neuropsychological assessments designed to measure the cognitive processes most often disrupted by concussion: processing and motor speed, memory, attention, and other executive functions such as mental flexibility (Gioia, Isquith, Schneider, & Vaughan, 2009; Maroon et al., 2000). Because sports concussions are common and potentially dangerous if repeated, identification and monitoring of concussions is imperative to prevent secondary injury (see Cantu, 1998 and Cantu & Gean, 2010, for a full discussion of second impact syndrome), while balancing the strong desire of players to return to participation (Collins et al., 1999; Grindel, Lovell, & Collins, 2001; Maroon et al., 2000).

A major consideration in the use of brief batteries comprised of common measures to monitor the impact of concussion relates to the effect of practice. An assessment that is sensitive to the dynamic nature of concussions may also be sensitive to the effects of repeated administrations within a short time period, from the moment after injury across days of recovery. To combat the effect of practice, some batteries use alternate forms of measures or make adjustments in scoring based on multiple administrations, each attempting to control practice effects across repeated assessments. Although brief neuropsychological batteries have some appeal in helping to identify and track the cognitive deficits that result from concussion immediately after injury and across recovery time, these batteries are not commonly used in hospital emergency departments, medical facilities, or athletic situations because they take time, require trained personnel, and may not reliably predict concussion status or long-term outcome (Naunheim, Matero, & Fucetola, 2008).

Another trend in neuropsychological testing has been the development of computerized measures that can be administered in a variety of settings in a structured and timely manner following injury. Several batteries have been especially developed to allow for brief, repeated assessments across an array of tasks that are sensitive to the effects of concussion and insensitive to the effects of practice. These batteries can be useful for pre-injury evaluation, diagnosis, and the ongoing monitoring of the resolution of symptoms, thereby helping to determine when brain function has returned to normal. Computer-based monitoring of concussion has become the standard for many high school and college athletic programs (Gorny & Merten, 2005).

Among the most popular of the commercially available computerized batteries is the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT; Lovell, Collins, Podell, Powell, & Maroon, 2000). The ImPACT was developed for use in an athletic environment and for use as a pre- and post-injury measure for athletes who have sustained concussion. Thus, the ImPACT is used to both explore the specific cognitive processes disrupted by concussion but also monitor their remission over time and improve the reliability of return to play decisions.

The use of the ImPACT (Lovell et al., 2000) has become increasingly popular among high school, college, and professional sports as it is quick to administer, is appropriate for repeated administration, and boasts practical appeal for practitioners working with athletes as it can be administered by laptop at the time of injury. Research by the test's creators suggests the ImPACT is both a reliable and valid measure for the evaluation and monitoring of the cognitive effects of concussion. The ImPACT has been shown to demonstrate adequate reliability as Iverson, Lovell, and Collins (2003) found rates of test-retest reliability of the ImPACT composite scores to range from .67 (Visual Memory) to .86 (Processing Speed).

Despite the strong reliability estimates reported by the ImPACT's creators (Lovell et al., 2000) and collaborators (Collins et al., 1999; Iverson, Lovell, & Collins, 2003; Lovell et al. 2003), others have found the computerized testing programs to have less than desirable reliability and validity. For example, Broglio, Ferrara, Macciocchi, Baumgartner, and Elliot (2007) found the test-retest reliability of the ImPACT composite scores to be lower than optimal, ranging from .23 (Verbal Memory) to .39 (Reaction Time). Broglio and colleagues hypothesized these differences may be due to several factors. First, the Broglio team completed retesting at 45 and 50 days post injury, while others tended to use shorter intervals that more closely mirrored the return to play timeline for athletes. For example, Collins et al. (1999) completed testing at 3, 5, and 7 days post injury while others (Iverson et al., 2003) completed preseason testing, then retesting within 72 hours of injury. Further, Broglio et al. calculated the intraclass correlation coefficients rather than the Pearson correlation statistic to explain test-retest reliability as Pearson's r has been shown to overestimate correlation and is not sensitive to learning or practice effects. Further, Broglio et al. relied on data from healthy individuals, while most of the research by the test's creators has been conducted with concussed athletes (i.e., Collins et al., 1999; Iverson et al., 2003; Lovell, Collins, Iverson, Johnston, and Bradley, 2004).

Although reliability is an important consideration, of perhaps more importance is the ability of a measure remission of symptoms and neurocognitive improvement as an individual heals from concussion. The ImPACT has been found to be a useful tool in monitoring the changes in processing speed within the week following injury (Erlanger et al., 2003). Others (Van Kampen, Lovell, Pardini, Collins, & Fu, 2006) have found that by comparing pre- and post-concussion ImPACT scores and symptom score totals, 93% of individuals who had sustained a concussion were correctly classified. Others (Schatz et al., 2006) have found that the ImPACT is sensitive (81.9%) and specific (89.4%) to the effects of concussion and accurately differentiates between individuals with concussion (82%) and healthy controls (89%). The ImPACT has also been shown to be sensitive to memory (Lovell et al., 2004) and processing speed (Iverson et al., 2003) decline following concussion. Collectively, these data support the use of the ImPACT in identifying the immediate cognitive symptoms of concussion as well as tracking remission over time.

Effort Testing in Neuropsychological Assessment

Regardless of the mode of testing, be it traditional paper-and-pencil or computerized, another threat to the validity of assessment data is the relationship between performance on the measure and the effort put forth by the examinee (Sweet et al., 2000). While it is intuitively clear that effort can impact psychological test scores, until recently clinical judgment was considered sufficient in determining whether an individual completed testing with acceptable if not optimal effort (Hunt, Ferrara, Miller, & Macciocchi, 2007). As Bush and colleagues (Bush et al., 2005) explain, a number of factors including malingering, factitious disorders, clinical factors, or opposition to the assessment can all threaten the validity of assessment data. More specifically, some (Carone, Iverson, and Bush, 2010) have argued that anger, frustration, greed, personality characteristics, and misattribution of symptoms can influence an individual's self-report of symptoms. Often, incentives exist that may influence whether an individual exaggerates symptoms. These incentives may include attempts to avoid responsibility, specific medical attention or medication, receipt of medical benefits, and monetary settlement. Much of the research in this area has surrounded individual's intentional exaggeration of their symptoms (Nelson et al., 2003; Ruff, Wylie, & Tennant, 1993) in an attempt to identify and minimize the overprovision of medication, treatment, and monetary compensation (Raine, 2009). Conversely, some individuals may be motivated to minimize their symptoms (Ruff et al., 1993; Lovell et al., 2003; Bush et al., 2005), especially when doing so results in a return to desired activities such as work or athletic competition. More specifically, we can situations in which an athlete may under-report symptoms so that she or he can return to play a sport as soon as possible.

An underlying contributor to test performance is the individual's level of motivation, which may be influenced by the presence of incentives. Motivation refers to an individual's goal oriented behavior, which is contributed to by internal and external drives (Weiten, 2010). Intrinsic factors can include enjoyment of and interest in a task, and perception of gain from the task (Eccles, 2005). Others (Vallerand, 2004) suggest three main intrinsic motivations: engagement for pleasure, engagement to learn, and engagement to promote accomplishment. Vallerand (2004) defined external motivations as rewards that are outside of the activity itself. In the area of concussion, some research (Orey, Cragar, & Berry, 2000) suggests that individuals can be motivated by external monetary reward to both minimize and maximize their self-report and neuropsychological test performance. Erdal (2009) found that individuals with external motivation (monetary compensation) showed significantly weaker performance on neuropsychological measures that those with internal motivations (attention seeking and avoidance of blame). Collectively, these findings suggest that an individual with concussion may have internal and external factors that influence their performance in testing situations.

Despite the clinical interest in identifying individuals either minimizing or maximizing their symptom reports and test performance, it has proven difficult to estimate base rates of malingering, symptom exaggeration, and symptom repression in part because those attempting to do so either do not admit it or are not caught in the act (Mittenberg, Patton, Canyock, & Condit, 2002; Slick, Tan, Strauss, & Hultsch, 2004). As defined by the American Psychiatric Association (*DSM-IV-TR*, 2000) malingering is the intentional creation of symptoms or deficits to achieve a goal (i.e., “faking bad”). Malingering may include the creation of symptoms or deficits, the exaggeration of current symptoms or deficits, and even the staging of an accident or injury. A necessary component of malingering includes some gain from exaggerating impairment; these incentives can range from monetary payment to obtaining disability status to being prescribed a desired medication. A more subtle form of symptom exaggeration is dissimulation, which can include over or under reporting of symptoms (i.e., “faking good”) and acting as though symptoms are better or worse than in reality (Sbordone, Saul, & Purisch, 2007).

Survey results from several groups (i.e., Green, Rohling, Less-Haley, & Allen, 2001; Mittenberg et al., 2002) suggest base rates of malingering in cases of concussion tend to hover around 30% in personal injury and disability litigation, whereas the rate drops significantly in medical cases not involving possible compensation. However, some research suggests that individuals may fail effort testing even in the absence of such incentives. For example, approximately 11% of a group of 200 uninjured high school athletes were found to complete neuropsychological assessment with suspect effort (Hunt et al., 2007). More recently, 17% of 193 children ages 8 through 17 years were found to have failed at least one objective measure of effort. Of the 33 children who failed effort testing, only one case was thought to be influenced by litigation or incentives (Kirkwood & Kirk, 2010). The high rates of malingering in the face of various incentives are of concern when working with an individual presenting with concussion who may be seeking such incentives, including monetary compensation, return to sports or work, or accommodations in school. Equally important to concussion is the exploration of dissimulation, which is currently absent from the literature in the area of concussion.

Effort is a serious concern in evaluating the impact of concussion specifically, as well as performance on neuropsychological evaluations more generally. Psychologists may be interested in identifying poor effort or feigned performance in forensic, medical, and treatment settings and in cases in which an individual may receive benefits for malingered impairment. Given that people who intentionally fake bad are not likely to self-disclose their malingering, it is important to identify those who may be faking. The National Academy of Neuropsychology recommends several methods of assessing symptom validity including evaluating consistency across measures, examining patterns of neurocognitive test performance, using validity scales from psychological tests, symptom validity tests, and forced-choice tests (Moser et al., 2005). Consistency can be evaluated by comparing information across a variety of sources, such as the patient's self-report of symptoms with a medical history, comparing symptom reports with observations of behavior, and evaluating whether response patterns are consistent with known patterns of cognitive functioning. Further, performance on neurocognitive measures can be considered against known patterns of invalid responding, inconsistency between observations and test performance, or comparing test results and background information or collateral reports.

Psychological tests, symptom validity tests (SVTs), and forced-choice tests are perhaps the most well-known methods of exploring suspect effort or malingered performance across forensic, clinical, and medical settings. Some psychological measures, such as the Minnesota Multiphasic Personality Inventory-2 (MMPI-2; Butcher et al., 2001) and newly developed MMPI-2-Restructured Form (MMPI-2-RF; Tellegan & Ben-Porath, 2008), have indices built into the measure to help determine whether the individual responds reliably and consistently throughout the assessment. Specifically, the MMPI-2 includes seven indices designed to identify feigned performance. These scales are meant to identify the over-report of rare symptoms, the endorsement of obvious symptoms of psychological disorders, the over-report of symptoms erroneously believed to represent psychological dysfunction, and feigned severity of symptoms. Score elevations on one or more of these scales signals the clinician that the responses may not be valid and additional exploration into the respondent's effort is warranted. The validity information on the MMPI-2 is extensive, and beyond the scope of the current review (see Rogers, Sewell, Martin, & Vitacco, 2003). The MMPI-2 has been established as a reliable and valid method for evaluating malingering in general (Rogers et al., 2003) and in cases of concussion (Thomas & Youngjohn, 2009).

Symptom validity tests (SVTs) and forced-choice tests are specifically designed to evaluate whether individuals are exaggerating their cognitive deficits on measures that are easily passed by those with severe brain injury and/or compromised cognitive aptitude. Symptom validity can be defined as the truthfulness of an examinee's presentation, self-report of symptoms, or neuropsychological test performance (Bush et al., 2005). The Test of Memory Malingering (TOMM; Tombaugh, 1996) is a commonly used SVT in the clinical setting. The TOMM includes two learning trials in which 50 common objects are individually presented. At the end of each learning trial, individuals are presented with 50 recognition panels and the individual is asked to choose the item that appeared in the learning trials. After a delay, a Recognition Trial is completed, where the individual is again asked to choose the target item from the original presentations. The TOMM has been shown to demonstrate high sensitivity and specificity to poor effort, and accurately differentiate between those responding with full or poor effort (Rees, Tombaugh, Gansler, & Moczynski, 1998).

Two commonly used examples of forced choice tests include the Word Memory Test (WMT; Green, 2003; Green, Allen, & Astner, 1995) and the shortened version, the Medical Symptom Validity Test (MSVT; Green, 2004). Forced-choice tests are commonly referred to as effort tests, and designed to identify an individual's effort to perform well (Bush et al., 2005). Both the WMT and MSVT were designed to appear to measure verbal memory but instead provides an index of the validity of an individual's performance. Individuals are presented pairs of words, and asked to recall those words immediately after presentation (Immediate Recall; IR) and following a delay (Delayed Recall; DR). A Consistency (CS) score is calculated on how well the person performed across IR and DR conditions. Effort is considered suspect if performance falls below the criterion of 82.5% (WMT) or 85% (MSVT) on the IR, DR, or CS trials. A more thorough discussion of the WMT and MSVT follows in the next section.

From this brief review of the methods used for evaluating effort, it has become clear that effort is an important consideration when analyzing assessment data (for a complete review of malingering, effort, and psychological assessment see Iverson, 2007 and Rogers, 2008). Regardless of the method employed, effort testing has become an accepted and desired adjunct to psychological assessment, particularly when various factors or incentives might influence examinee performance. Symptom validity tests and forced-choice tests of effort provide an appealing method of identifying malingering; performance that falls below chance or the cut-off is interpreted as evidence of deliberate feigning, given that performance below criterion suggests that the respondent knew the correct response and consciously chose the alternative (Orey et al., 2000). The use of these measures is strongly recommended in assessments that bear on decisions to return to work, play a sport, award compensation, decide competence, seek test accommodations, and provision of treatment (e.g., by obtaining a diagnosis of ADHD, an individual can gain access to stimulant medication). As the use of effort testing expands into clinical practice, it appears it is only a matter of time until effort testing is a standard component across all clinical evaluations, whether the patient is referred for a medical, psychiatric, neurologic, or educational evaluation.

Effort Testing and Concussion

Perhaps the most intriguing research in the area of concussion, effort, and malingering has stemmed from the work of Green and colleagues (Green, 2007; Green, Flaro, & Courtney, 2009; Green, Iverson, & Allen, 1999; Green, Rohling, Lees-Haley, & Allen, 2001). Early work by these collaborators focused mostly on the comparison in effort test failure by individuals with mild traumatic brain injury compared to individuals with more serious brain injury (Green et al., 1999; Green et al., 2001). For example, the authors (Green et al., 1999) administered several forced choice symptom validity measures, including the Word Memory Test (WMT; Green, 2003; Green, Allen, & Astner, 1995) to individuals with mild traumatic brain injury and moderate-to-severe brain injury. Individuals in the mild head injury group showed significantly weaker performance than the other groups across each of the scales of the WMT. Further, group differences could not be explained by IQ or years of education as the groups were similar across both. The authors noted the paradox between a minor injury and weaker effort test scores and concluded it was unlikely the poor performance was caused by a minor injury. Rather, they hypothesized that these participants purposely minimized their performance.

In another study Green et al., (2001) utilized a sample of 904 patients referred for a neuropsychological assessment, 470 of which were head injury referrals. Each individual was administered a comprehensive neuropsychological assessment that included measures of executive functioning, memory and learning, verbal comprehension, attention and working memory, perceptual organization, psychomotor skills, and symptom validity including the WMT (Green, 2003; Green et al., 1995). Test results were converted into *z*-scores and a single index *z*-score was created for each person to create an Overall Test Battery Mean (OTBM). Similarly, the authors created an overall symptom validity (SV) *z*-score using symptom validity test data.

Using the entire sample of 904 participants, effort explained between 40–54 % of the variance in the participants overall performance across neuropsychological measures. The authors also explored the rates of effort test failure by referral source and diagnosis. Patients referred by the Worker’s Compensation Board showed the highest rate of failure at 35%, while 25% of individuals involved in personal injury litigation and 23% involved in disability insurance claims failed effort testing. Individuals presenting with mild head injury (with less than 24 hours of post-traumatic amnesia) showed a failure rate of 34% while individuals with post-traumatic amnesia lasting more than one day showed an 18% failure rate. Individuals presenting with neurological disorders showed a similarly low rate of failure at 16%. These rates showed that individuals with monetary incentive to appear impaired showed higher rates of effort test failure.

In exploring the differences between only those participants with head injury, the authors separated the participants into groups based on the severity of injury. Overall, the OTBM score difference between those with genuine mild head injuries and genuine severe head injuries was .27 SD. Interestingly, the difference between those who failed effort testing scored 1.21 standard deviations below those who passed effort testing. In addition, individuals with mild head injury who passed the WMT (Green, 2003; Green et al., 1995) scored .12 standard deviations below the normal mean, while those presenting with mild head injury who failed effort testing scored 1.24 standard deviations below the normal mean. Finally, the authors found effort explained 53% of the variance in neuropsychological test score performance, while education only explained 11% and age only 4%. In addition, effort explained far more variance in neuropsychological test scores than presence or severity of brain injury. In sum, individuals with mild head injuries who failed effort testing tended to perform worse than their peers who passed effort testing and individuals with more severe head injuries. Also, individuals who were faced with monetary incentive and had mild injuries showed higher rates of effort test failure than those with more significant head injury in the absence of monetary incentive. Together, these results suggest that effort impacts neuropsychological test performance more than head injury severity, age, and education.

In a 2007 follow-up study, Green utilized the same participant data with the addition of 403 consecutive cases that presented for neuropsychological evaluation. As with the previous study, referral sources often included Worker's Compensation, private insurance companies, and lawyer recommendation. The methods and measures used mirror those from the 2001 study.

Of the total sample (n = 1,307), 31% failed effort testing by scoring below 82.5% on any one of three WMT (Green, 2003; Green et al., 1995) scales. Scores of those who failed effort testing were then compared with scores of 25 individuals with diagnosed dementia. Those who failed effort testing showed weaker performance that those with dementia across the early measure of the WMT (i.e., Immediate Recall and Delayed Recall). Further, those who failed effort testing showed higher performance on the more difficult subtests of the WMT; this pattern of responding suggests those who failed effort testing possess the cognitive skills to successfully complete the measure. The results from neuropsychological testing were also similar when comparing the performance of those who failed effort testing to those who passed; there was a significant difference between those who passed and failed effort testing on measures of verbal memory, visual memory, motor speed, working memory, performance IQ, and verbal IQ. Further, individuals that passed effort testing but performed in the less than optimal range showed a predictable reduction in test performance when compared to those who scored in the optimal effort range. As with the previous studies, Green concluded that the effort with which an individual completes testing explains more variance in test scores than brain injury or other factors like education or age.

The most recent work of Green and colleagues (Green et al., 2009) explored rates of effort test failure on both the WMT (Green, 2003; Green et al., 1995) and the shortened version, the Medical Symptom Validity Test (MSVT; Green, 2004). The authors utilized retrospective analysis of 163 individuals with moderate-to-severe traumatic brain injury (MSTBI) and 309 individuals with concussion. A small comparison group of healthy school-age children (ages 7–11) was recruited from Canadian schools (*n* = 55). An additional comparison group was created retrospectively from children referred for clinical assessment for a variety of diagnoses including fetal alcohol syndrome, conduct disorder, and ADHD (*n* = 422). From this group of children, a subgroup with developmental disorders and memory impairment was created (*n* = 25). Two groups of adult participants were created. One group was asked to take the test with full effort (*n* = 148) while the second was asked to simulate memory impairment in a way to avoid detection (*n* = 89). Two parallel groups of children were created (*n* = 81 and *n* = 27, respectively).

The authors presented the rates of effort test failure by group. All but 2 of 55 healthy children successfully passed the MSVT (Green, 2004) by scoring at or above 85% across the IR, DR, and CS subscales. The healthy adult participants instructed to provide optimal effort showed similar performance with all but 7 of the 148 passing the MSVT. All of the children and nearly all (87 of 89) of the adult simulators were able to successfully feign memory deficits and fail the MSVT. From these data, the authors found that the MSVT was able to accurately classify individuals who gave poor effect, as they calculated an average sensitivity of 98.3% to poor effort. Further, the test was determined to show a high specificity to poor effort (96%). Together, these data suggest that the MSVT is useful in identifying individuals who approach testing with low effort and is unlikely to give false positive results.

The authors compared the rates of failure of two clinical groups on the WMT (Green, 2003; Green, et al, 1995) and the MSVT (Green, 2004): adults with mild TBI and adults with moderate-to-severe MTBI (MSTBI). On the both the WMT and MSVT, the mild TBI group showed a significantly higher rate of failure (48%) than the moderate-to-severe TBI group (48% to 22.7%, and 42% to 16%, respectively). Both groups showed a significantly higher rate of effort test failure on both the MSVT and WMT than children evaluated clinically. These findings suggest that failure on the easy MSVT subtests was 9 times more frequent in MTBI cases than in children with developmental disabilities.

The compendium of work by Green and colleagues (Green, 2007; Green et al., 2009; Green et al., 1999; Green et al., 2001) has demonstrated that even children with developmental disabilities or memory impairment can pass effort tests such as the WMT (Green, 2003; Green et al., 1995) and MSVT (Green, 2004) reliably, whereas adults presenting with mild head injury and external incentives to malinger show significantly higher rates of failure. In addition, adults with mild head injuries showed much higher rates of effort test failure than their more seriously injured adult peers. Similarly, others (Bianchini, Curtis, & Greve, 2006) found individuals with mild TBI were more likely than their more severely injured peers to have positive hits on measures of malingering. In addition, Green and colleagues (Green, 2007, Green et al., 2009) demonstrated that individuals who fail effort testing also show a predictable and significant decline in neuropsychological test performance. As stated clearly by Green, if we accept that MSVT and WMT test failure in adults is the result of concussion, we must also accept that a mild injury can cause memory impairment so severe that when compared to children with documented memory or cognitive impairment, adults with concussion should be expected to perform more than two standard deviations lower on standardized neuropsychological measures. Instead, it seems a more likely conclusion is that adults with concussion showed higher rates of failure across the MSVT and WMT because they approached testing with less than optimal effort in an attempt to maximize impairment to obtain monetary compensation. In support of this conclusion, the work of Green and colleagues has consistently shown that adults with concussion showed a higher failure rate than healthy and impaired children, child and adult simulators, and adults with documented dementia. Further, effort consistently explained more than 50% of the variance in neuropsychological test scores, far more than intellectual ability, age, or education. In addition, it appears that a significant portion of individuals with concussion do not complete neuropsychological measures with their full effort, even simple tasks that can be passed by children with developmental disabilities and documented memory impairment.

Symptom Over and Under Reporting

Individuals with concussion may be motivated to modify their symptom reports for a variety of reasons. As demonstrated by the work of Green and colleagues, some individuals with concussion may be motivated by monetary incentives, such as Worker's Compensation, to over-report the symptoms of concussion. As effort testing has become increasingly integrated into clinical practice, research has identified the relationship between monetary incentives and the experience of prolonged post-concussion symptoms (Bianchini et al., 2006). As discussed previously, the current estimates suggest that in cases of financial compensation, approximately 30% of individuals are thought to involve exaggeration of symptoms or impairment (Green et al., 2001; Mittenberg et al., 2002). In sum, research suggests that individuals with concussion and monetary incentives are both more prone to effort test failure and more apt to over-report the symptoms of concussion than those without monetary incentive.

Alternative motivations to monetary incentives may exist for some individuals with concussion who exaggerate their symptoms or impairment. For example, some may be motivated to appear more impaired in an attempt to obtain academic accommodations. Specifically, students that have suffered a concussion may require a variety of academic supports to stay current with their work. These types of accommodations can include reduction of homework, modified testing procedures (such as extended time or the allowance of breaks), and/or increased flexibility in assignment requirements (Kirkwood, Yeates, & Wilson, 2006). These accommodations can be informal or provided through either a Section 504 plan or an Individualized Education Plan (IEP; Kirkwood et al., 2006). Typically, a student seeking formal accommodations at the post-secondary level would be required to provide documentation of injury and deficit to their college Office of Disability Services, which in turn would decide the appropriateness of educational accommodations. Students with a recent history of concussion may perceive these accommodations as incentives for a variety of reasons. Some students may believe that that their academic ability has been diminished by the concussion and perceive that the accommodations will help them perform to their academic capacity. In contrast, some individuals who have been provided accommodations following concussion may have found the accommodations to be helpful and seek to retain them even after the symptoms of concussion remit. Additionally, some individuals without significant cognitive disruption following concussion may be motivated to obtain desired accommodations by manipulating symptom reports and minimizing test performance.

Student's willingness to malinger symptoms of concussion to obtain academic accommodations may not be surprising if we consider students from the general population report they would prefer to have access to such testing accommodations (Lang, Elliot, Bolt, & Kratochwill, 2008; Lewandowski, Lovett, Panahon, Lambert, & Systma, 2012). As summarized by Frazier and colleagues (Frazier, Frazier, Busch, Kerwood, & Demaree, 2008), students may be willing to simulate a learning disability (LD) when faced with the potential of school failure, removal of previously obtained accommodations, or exposed to increasingly demanding educational workload and requirements. As high stakes tests, such as the Graduate Record Exam (GRE) and

Scholastic Aptitude Test (SAT) have become inextricably linked to pre- and post-secondary academic success, students may be more likely to seek alternative methods of increasing their performance (Banerjee & Shaw, 2007; Pitoniak & Royer, 2001). Although accommodations are designed to help even the playing field for individuals with disability and should theoretically not boost non-disabled individuals' performance (Pitoniak & Royer, 2001), they may be appealing for some non-disabled students to pursue. Recent exploration into the rate of effort test failure in college students presenting for screening evaluations to rule out a learning disability suggests failure rates of approximately 20% (Osmon & Mano, 2008), with a similar estimate for students presenting for ADHD screening (Harrison, 2006). This suggests that a substantial subset of individuals who present for an ADHD or LD evaluation may falsify or exaggerate their impairment.

In contrast to the individual who over-reports symptoms to obtain academic accommodations, athletes with a history of concussion who are motivated to return to play may be more likely to minimize their symptom reports (fake good) and perform optimally on neuropsychological measures. Interestingly, some literature (Brooks, 2007) suggests that adolescent athletes may be more likely to underreport their concussion symptoms presumably to avoid being removed from play. The motivation for concealing impairment can also involve the potential loss of one's position or scholarship, letting down teammates, coaches, and fans, missing out on professional opportunities, and being considered a failure by fans and teammates (Barth et al., 1989). Despite the recent media attention to the importance of preventing an early return to sports participation following head injury, particularly in contact sports like football and hockey, there are no estimates of the percentage of athletes returning to play before the symptoms of concussion fully remit.

The return to sports participation following concussion makes for an important and sometimes controversial decision. Often, the decision is based largely on the behaviors and symptoms reports of the athletes who may be motivated to return to play as quickly as possible. If symptoms are not fully resolved, athletes may be at risk for another concussion and more severe consequences (Sarmiento, Mitchko, Klein, & Wong, 2010). Although several sets of guidelines for return-to-play decisions exist, they all concur that athletes must avoid contact sports until cerebral symptoms have subsided (Swaine & Friedman, 2001). Further, the severity of the concussion and length of loss of consciousness must be considered; those athletes with no or very brief loss of consciousness should be removed from sports for a week while those with loss of consciousness of longer duration should be removed for two weeks (Swaine & Friedman, 2001). In addition, both meetings of the *International Conference of Concussion in Sport* (2001 and 2004; Aubry et al., 2002; McCrory et al., 2005) recommended that athletes should not return to play until neuroimaging results are unremarkable and they are free of signs or symptoms of concussion both at rest and after exertion. However, research has found that athletes who reported they were symptom free still showed cognitive impairment on a brief neuropsychological measure (Broglio, Macciocchi, & Ferrara, 2007). Similarly, others (Fazio, Lovell, Pardini, & Collins, 2007) found that concussed student athletes who claimed to be asymptomatic performed worse than normal controls and better than a group of symptomatic concussed athletes. These studies suggest that the effects of concussion can linger, that those with concussion may not be able to accurately report when the cognitive effects or symptoms have resolved totally, that symptom report is an insufficient method of monitoring the cognitive effects of injury, and that athletes in particular may under report any problems in an effort to return to sports play.

Analog Research on Effort

The assessment of individuals with concussion requires information from multiple methods and sources rather than self-report alone. Ideally, symptom report would be augmented by neuropsychological test results and effort testing. All need to be interpreted within the context of the possible motivations for maximizing or minimizing symptom reports and performance. In the concussion literature, the research on performance in the context of incentives has focused almost exclusively on financial incentives. Fortunately, research with other clinical disorders has examined other contingencies that might affect one's self report and performance on an assessment.

An area of research and clinical practice that has encountered similar methodological and diagnostic issues as concussion is Attention Deficit Hyperactivity Disorder (ADHD). The diagnosis of ADHD is primarily based on observation or report of specific symptoms. Clinicians that assess individuals presenting with ADHD must often rely on self-reports of non-specific symptoms for diagnosis (Harrison, Edwards, & Parker, 2007). As with symptom scales for concussion, ADHD symptom checklists are plagued by the non-specificity of some ADHD symptoms and prone to over identification of individuals as positive for ADHD (Harrison, 2006). Unfortunately, self-report questionnaires are also relatively easy to falsify in both concussion and ADHD.

Using a sample of healthy undergraduate students (n = 80), Jachimowicz and Geiselman (2004) provided participants with the *DSM-IV-TR* (American Psychological

Association, 2000) diagnostic criteria for ADHD. After studying the diagnostic criteria for five minutes, the participants were asked to complete one of four diagnostic measures, and respond as if they struggled with ADHD. The results indicated that 65-95% of participants were able to successfully respond in a manner indicative of ADHD, depending on the self-report measure used. Similarly, Harrison et al., (2007) found ADHD takes little coaching to successfully fake. The authors assigned healthy university students (*n* = 70) to one of two groups: Honest Normals or Faking. Participants in the Honest Normals group were instructed to simply complete the measures with their best effort. Participants in the Faking group were provided with the *DMS-IV-TR* diagnostic criteria for ADHD and were instructed to perform in a manner indicative of ADHD. Participants from both groups completed the Conners Adult ADHD Rating Scale (Conners, Erhardt, & Sparrow, 1998) and the Woodcock Johnson Psychoeducational Battery – Third Edition (WJ-III; McGrew & Woodcock, 2001). The results indicated that participants in the Faking group were able to successfully modify their performance on both the symptom report and cognitive measure. Also, when compared to a group of students with verified ADHD diagnoses (*n* = 72) the Faking group showed weaker performance across the cognitive measure. Collectively, research suggests that ADHD, like concussion, is easy to fake.

Another similarity between ADHD and concussion is that there appear to be incentives for some people to obtain a diagnosis. In cases of ADHD, these incentives may include access to medication such as Ritalin that can be used or sold, and access to special academic accommodations that may make school and standardized exams less strenuous. There has been increasing concern that college students, for example, have caught on to how easy it is to obtain the diagnosis of ADHD and receive the accompanying benefits. In fact, the number of diagnoses of ADHD in college age students is increasing at an alarming rate (Harrison, 2006). Together, these circumstances suggest that assessment of ADHD should include the evaluation of effort or symptom validity.

As with concussion, those working with an ADHD population are forced to rely on symptom reports of nonspecific symptoms that are completed by individuals who may be motivated for a variety of reasons to appear impaired. As with concussion, neuropsychological evaluations of ADHD typically incorporate symptom reports, self-report questionnaires, and measures of neurocognitive function and general academic achievement (Sullivan, May, & Gallaby, 2007). As in concussion, these test results can then be used to determine whether an individual requires formal academic support through a Section 504 or Individualized Education Plan (IEP). As with concussion, there appears to be a growing trend in the literature to explore how individuals with ADHD may modify their performance on these types of evaluations.

The research in the area of ADHD can also help to inform the process of identifying individuals with a history of concussion who manipulate symptom reports and neuropsychological test performance in an attempt to obtain academic accommodations. In recent years, there has been a sharp increase in the number of adults and post-secondary students requesting an evaluation to explore the possibility of an ADHD diagnosis (Harrison et al., 2007). As such, it has become increasingly salient to separate those individuals with legitimate difficulties and those seeking secondary gain. Harrison

(2006) estimated that approximately 20% of students seeking ADHD disability status at the university level willfully fake their symptoms of ADHD.

A recent study by Sullivan and colleagues (Sullivan, et al., 2007) suggests the estimates by Harrison (2006) may underestimate the rate of faking bad in university students presenting for an ADHD evaluation. Using a university sample of students presenting for an evaluation of ADHD, LD, or ADHD/LD combined, the authors found significantly higher rate of WMT failure (47.6%) in individuals presenting with ADHD than LD (15.4%) and ADHD/LD combined (9.4%). Overall, as participants' presenting with ADHD reported higher numbers of symptoms of ADHD, they also demonstrated weaker performance across the WMT; this pattern of responding suggests that students who presented for ADHD evaluations may have minimized test performance while maximizing symptom report.

A similar study (Frazier et al., 2008) utilized healthy college students who were randomly assigned to a control group, simulated ADHD, or simulated reading disability (RD). Both simulated clinical groups were asked to pretend as though there were experiencing difficulties in school, provided information on the benefits of academic accommodations, and a brief description of disorder-specific symptoms. Participants in both simulation groups were asked to fake in a convincing manner so as to avoid detection. In the control condition, participants were asked to provide their best effort throughout the evaluation. Several measures of effort were utilized, including the Validity Indicator Profile (VIP; Frederick, 2003), Rey Fifteen Item Test (Rey FIT; Rey, 1964) and Victoria Symptom Validity Test (VSVT; Slick, Hopp, Strauss, & Thompson, 1997). As expected, the simulated ADHD and RD groups showed significantly weaker performance across all measures of symptom validity than the control group. Interestingly, the authors also found that the RD group showed weaker performance than the ADHD on verbal components of the VIP and VSVT, suggesting that they attenuated their feigned performance to reading-specific tasks.

Based on these data, it appears those working with a university sample should anticipate that a significant portion of students presenting for ADHD and LD evaluations may not approach testing with their full effort. The estimates from 24.5% to 47.6 % of poor effort in combined ADHD/LD and ADHD evaluations are similar to the estimates found by others (i.e., Constantinou, Bauer, Ashendorf, Fisher, & McCaffrey, 2005). Further, the results suggest that relying on self-report of symptoms alone appears inappropriate, considering the ease with which symptom reports can by modified and the relative insensitivity of self-report questionnaires to faking.

Interestingly, significantly less research has focused on the exploration of the rates of effort test failure in students presenting with learning disabilities. One group (Lindstrom, Lindstrom, Coleman, Nelson, & Gregg, 2009) compared performance on several measures of effort across three groups: healthy controls, simulated learning disabled, and legitimate learning disabled. The authors noted that a significant portion of the individuals in the legitimate LD group had “motive to feign” although no further explanation was provided. The results showed high rates of effort test failure in the simulated LD group, ranging from 32% to 41% across WMT trials, and significantly lower rates of failure in the legitimate LD (3–5%) and healthy control (<1%) groups.

As demonstrated by this review of the literature in the areas of concussion and ADHD, analog studies represent a common method of exploring malingering (Demakis

2004; Rogers & Cruise, 1998). As Rogers and Cruise explain, participants are randomly assigned to malingering conditions and the results compared to parallel clinical samples. The same authors found that participants were able to successfully modify their responses on symptom reports to match the value of the incentive offered. Similarly, previous analog research by Demakis (1999) demonstrated that undergraduates were able to consistently perform similarly to actual malingerers on several neuropsychological measures. Several authors have found the simulators' scores on neuropsychological measures are often similar to those of real-world comparison groups, such as individuals with TBI (Sweet et al., 2000; Mittenberg et al., 1995).

Analog research represents an appealing method of studying malingering for a variety of disorders. However, the use of analog design presents several limitations. Most notably is the concern about the generalizability, or external validity, of the results (Rogers & Cruise, 1998). As stated by Rogers and Cavanaugh (as cited by Rogers & Cruise, 1998) analog research requires individuals to comply when asked to fake, while in reality, malingerers fake when asked to comply. In relying on analog design to study the complex relationship between malingered performance and test performance, the potential exists to errantly assume the generalizability from an analog group to a clinical group without regard for the contributions of the injury or disorder to performance. In addition, the setting of analog research may result in decreased ecological validity. Analog studies are often conducted in groups, in a lab setting, without actual ramifications or incentives for responding in the instructed manner. In actuality, individuals who malinger face a variety of incentives or consequences for their performance, and complete their evaluation individually with a psychologist or neuropsychologist.

Despite the limitations inherent to their use, analog designs provide a method to explore the phenomena that may not be feasibly studied with a large-scale clinical study. More specifically, it is difficult to study patterns malingered or low-effort performance as those who malinger may be unwilling to admit it. By conducting analog studies, researchers are able to identify potential correlates of malingered performance in a group provided explicit instruction to malinger. These results provide insight into the methods and patterns by which performance is simulated, thereby allowing more comprehensive analysis of test data in practice. Lastly, simulation studies allow researchers to explore the impact of explicit coaching on successful malingering, an unethical and problematic practice when using a clinical group. Despite the limitations to generalizability, simulation studies provide unique insight into the relationships between feigned performance, incentives, and pre-assessment variables such as coaching, which would be otherwise difficult to obtain using a clinical sample.

Current Study

Head injuries are very common, especially mild ones labeled as concussions. Concussions are dynamic in nature, and it appears that in most cases the brain injury resolves quickly and completely. However, for some, effects of concussion may persist. Typically, clinicians evaluate the effects of concussion through use of self-report measures, which can be inaccurate, biased, and measure symptoms that are not specific to concussion. The reliance on self-report measures is particularly problematic when practical or psychological reasons exist for maintaining or denying symptoms. The use on self-report of the non-specific symptoms of concussion is aided by both traditional and computerized neuropsychological testing, but the impact of effort on these measures is unclear. In addition, both computerized and traditional neuropsychological testing are prone to problems of performance validity as studies have found high rates of malingering (validity failure) among those with brain injury and other clinical groups (i.e., ADHD) that encounter incentives. The need for additional study of the relationship between non-monetary incentives, concussion, and symptom report is clear as no study as yet has investigated both symptom exaggeration (fake bad) and symptom repression (fake good) of concussion in the same study.

The current study sought to examine two realistic incentive scenarios that could influence the test performance of students with concussion. All participants were provided identical instructions on concussion: they were asked to pretend as though they sustained a concussion and provided with the common symptoms of the injury. The manipulation occurred when one group was provided instruction to pretend to be college athletes faced with the return to sports participation (Fake Good), and another group asked to pretend to be college students preparing for a high stakes exams faced with the attainment of academic accommodations (Fake Bad). The third group was provided no additional information (No Incentive). All participants were asked to keep all information in mind while completing the questionnaires and psychological measures.

The current study was designed to answer several questions that arise from the current trends in research and gaps in our understanding of the relationships between external motivation, concussion, and neuropsychological testing. First, the study was designed to replicate the results found by others (Harrison et al., 2007; Jachimowicz &

Geiselman, 2004) that suggest individuals who are provided scripts and a description of a disorder (i.e., concussion) can respond similarly to individuals with that disorder. At the most basic level, it was expected that participants would be able to modify their response patterns in a manner that is similar to individuals with an actual concussion.

Assuming that participants would be able to successfully simulate a concussion, group comparisons by incentive condition were planned across several domains: frequency of effort test failure, symptom report, and neuropsychological test performance. Collectively, it was hypothesized that the groups would show a consistent pattern of performance across these domains. Specifically, it was expected that the Fake Bad group would show significantly weaker performance than the Fake Good and No Incentive groups across domains. The Fake Bad group was expected to group to show the highest rate of effort test failure, the highest symptom report, and the weakest neuropsychological test performance. Given that it anticipated there would be an adequate number of participants who failed effort testing, it was planned to compare the neuropsychological test performance of individuals who passed and failed effort testing, regardless of group.

Method

Participants

The current study utilized a college-age sample recruited through the Department of Psychology research pool at Syracuse University. Potential participants were recruited via SONA, the online system by which individuals in the subject pool are able view and enroll for participation in studies. Additionally, participants were recruited via mass email and campus flyers that provided details of the study and contact information for the investigator. A total sample of 198 students was recruited. G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) estimates for each of the planned statistical procedures suggested the current sample size was adequate. Specifically, for the comparison of effort test failure between three groups, a medium effect size (ϕc) of .25, alpha of .05, and a power value of .80 with three groups, the total number of participants required for sufficient results using chi-squared test was $n = 155$. For a one-way analysis of variance on mean symptom report and correct SDMT items, respectively, using an effect size of .25 (f), alpha of .05, and a power value of .80 with three groups, the total number of participants required was $n = 159$. Using the same alpha and power values, the sample size needed for analysis of neuropsychological variables (including the 4 composite scores of the ImPACT), with the assumption of a small effect size of .10 (f), three groups, and four response variables, was estimated to be $n = 81$.

From the total sample, data from three individuals was removed due to withdrawal from the study, while data from two participants was removed for failure to complete the demographic information. Of the remaining sample ($n = 193$), a small portion had failed to indicate either their status as a college athlete ($n = 4$) or disability status ($n = 3$). Given that no one participant was missing more than one item from the demographic questionnaire, data from these participants was retained. Finally, students who self-reported a learning disability ($n = 8$), attention disorder ($n = 8$), or multiple disabilities including either a learning disability or attention disorder ($n = 6$) were removed, leaving a final sample of 171 students.

Demographic information for each of the groups is summarized in Table 2. In sum, 171 participants were included in this study, ranging in age from 18–24 years (M =

19.41 years, *SD* = 1.47 years). The majority of the sample was female (65.5%), college freshmen (52.6%), non-athletes (71.9%), non-disabled (96.5%), and had no history of concussion (83.0%). Chi-square tests were used to explore whether the groups exhibited significant differences across the demographic categories of sex, year in school, disability status, athletic status, or concussion history. Given that multiple comparisons were run, a Bonferroni correction was implemented and resulted in an alpha of .01. There were no significant differences between the groups on sex χ^2 (2, n = 171) = 5.49, p = .06, year in school χ^2 (2, n = 171) = 3.93, p = .69, disability status χ^2 (2, n = 168) = 1.71, p = .43, athletic status χ^2 (2, n = 167) = 1.24, p = .87, or concussion history χ^2 (2, n = 171) = 10.76, p = .10. The results of a one-way analysis of variance showed there were no significant age differences by group, F(2, 168) = .05, p = .95.

Measures

Manipulation Check.

Memory Complaints Inventory.

The Memory Complaints Inventory (MCI; Green, 2003) was used in the current study as a manipulation check to evaluate whether participants manipulated their performance as instructed. Group means from the General Memory Problems (GMP) subscale score were compared to the mean GMP score of healthy adults provided by the test creator. The percentage of participants in each group who had higher GMP scores than healthy volunteers was also calculated.

The MCI (Green, 2003) is a brief, computerized program designed to measure an individual’s self-reported memory complaints. The measure has 58 items, responded to on a Likert scale, that comprise nine subscales: General Memory Problems, Numeric

Process Problems, Visual-Spatial Problems, Verbal Memory Problems, Pain Interferes with Memory, Memory Interferes with Work, Remote Memory Problems, Amnesia Complex Behavior, and Amnesia Antisocial Behavior. The first six scales list common memory complaints, while the final three include very rare and implausible memory complaints. These scales were designed to identify individuals who purposefully exaggerate memory complaints.

Exploration into the psychometric properties of the MCI is ongoing, although some research is starting to suggest promising results (Flaro, Green, & Blaskewitz, in press). More specifically, the MCI Total Score has shown low correlations with actual measures of memory ability. Further, the MCI total score has been shown to more highly correlate with other measures of effort, such as the Word Memory Test (Green, 2003). These results suggest that the MCI shows divergent validity from well-validated measures of memory and higher convergent validity with measures of effort. The MCI took approximately ten minutes to complete.

Integrity of Intervention Form (IIF).

Subjects were asked to complete a brief questionnaire designed to evaluate whether they adhered to the scripts (as did Demakis, 1999 and Gorny & Merten, 2005) to help monitor the quality of the data collected. The IFF was designed to help descriptively assess the extent to which participants understood and internalized the script. This manipulation check included questions such as “How were you instructed to perform at the beginning of the session today?” and “Do you feel you did a good job of action as you were instructed?” The results from the IIF was used to create three categorical variables: Consistency (whether the participant’s report of their condition matched the actual condition), Relative Performance (whether they participants felt they performed better than, worse than, or similar to how they would have performed in the absence of any instruction), and Simulation Success (whether the participant felt he/she did a good job of acting as instructed by the script). A copy of the IIF has been included as Appendix A. The IIF took approximately one minute to complete.

Effort Testing.

Medical Symptom Validity Test.

The computerized version of the Medical Symptom Validity Test (MSVT; Green, 2004) was used to assess effort. The MSVT presents individuals with ten word pairs twice, and then asks them to identify words from the original list (Immediate Recall; IR). After a delay of ten minutes, a recognition task is completed using different foils (Delayed Recall; DR). A Consistency (CS) score is calculated on how well the person performed across IR and DR conditions. The MSVT also included a Paired Recall (PR) and Free Recall (FR) trials. In the PR trial, the individual is provided the first word of the pair and the respondent required to provide the matched pair, whereas the FR trial requires the individual to recall as many words as they can from the original list, in any order. The PR and FR trial scores are considered more difficult than the IR, DR, and CS trials, and are typically analyzed individually. If a person shows stronger performance on the PR and/or FR trials than the IR, DR, or CS trials, it can be inferred the person purposefully minimized their performance on the early subtests. MSVT data were used to create a dichotomous variable labeled Effort Test Failure: Any individual who performed below 85% on the IR, DR, or CS was considered to fail effort testing. This variable corresponds to the clinical use of the MSVT to determine whether an individual provides valid or invalid effort during an evaluation. Conversely, individuals who scored at or above 85% across the IR, DR, and CS scores were coded as passing. The decision to dichotomize effort as pass of fail mimics the use of the MSVT clinically to evaluate the validity of a respondent's test results. The coding of the results from the MSVT as pass or fail also corresponds to current practice in research (i.e. Green, 2007; Green et al., 2001). The frequency of Effort Test Failure was compared by group.

The MSVT (Green, 2004) has been shown to demonstrate near perfect sensitivity to poor effort in simulated adult and child malingerers (Green et al., 2009; Merten, Green, Henry, Blaskewitz, & Brockhaus, 2005; Singhal, Green, Ashaye, Shankar, & Adams, 2009), and adults presenting for clinical evaluation (Carone, 2008). The MSVT has been shown to be insensitive to legitimate cognitive impairment as Carone (2008) demonstrated that even children with moderate-to-severe head injury pass at higher rates than adults with mild traumatic head injury. Similarly, children with significant cognitive impairment have been shown to pass the MSVT easily (Richman et al., 2006). Others (Singhal et al., 2009) have demonstrated low rates of false positives in cases of adults with documented dementia. Additionally, performance on the MSVT has been shown to correctly highly to performance on the WMT, suggesting strong convergent validity (Green, 2007). The MSVT, both immediate and delayed trials, took approximately fifteen minutes to complete.

Symptom Report.

Postconcussion Scale.

The Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT; Lovell et al., 2000) includes a Postconcussion Scale that requires individuals to rate the presence of 22 common symptoms of concussion on a scale of 1 to 7. These scores produce a Total Symptom Score. Total Symptom Score was compared across the groups. The test creator provides norm-based classifications for healthy adults ranging from Low to Very High. A variable was created, Symptom Impairment, with an unimpaired code assigned to symptom scores that fell in the Low-Normal to Normal range, and an impaired code assigned to score in the Unusual, High, and Very High range. This variable was meant to simulate the clinical decision of determining when an individual is free of symptoms in return to school, work, or play scenarios.

The Postconcussion Scale has been shown to possess high internal consistency for both healthy (α = .88 - .94) and concussed individuals (α = .93) and shown high test-retest reliability (.80) within the first several days of injury (Lovell, 2006).

Neuropsychological Testing.

Immediate Post-Concussion Assessment and Cognitive Testing.

The Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT; Lovell et al., 2000) was developed for use in an athletic environment and for use as a pre- and post-injury measure of the specific cognitive processes disrupted by concussion. The four composite scores (Verbal Memory, Visual Memory, Visual Motor Speed, and Reaction Time) were used as dependent measures to assess neuropsychological performance across groups.

The ImPACT (Lovell et al., 2000) is a brief, computerized, neuropsychological measure that takes approximately twenty-five minutes to complete and is scored automatically. The ImPACT includes six individual subtests, each measuring a unique component of cognitive functioning: Word Memory (verbal recognition memory), Design

Memory (spatial recognition memory), X's and O's (visual working memory, processing speed), Symbol Match (memory, visual motor speed), Color Match (impulse inhibition, visual motor speed), Three Letters Memory (verbal working memory, processing speed). These scores then produce four composite scores: Verbal Memory, Visual Memory, Reaction Time, and Visual Motor Speed. Higher scores across the Verbal Memory, Visual Memory, and Visual Motor Speed composites indicate stronger performance. A lower score on the Reaction Time indicates stronger performance. The ImPACT test creators provide norms for healthy adults across each of the four composites.

The ImPACT has been shown to demonstrate adequate psychometric properties as Iverson et al., (2003) found rates of test-retest reliability of the composite scores to range from .67 (Visual Memory) to .86 (Visual Motor Speed), with the Verbal memory (.70) and Reaction Time (.79) composites falling in between. The ImPACT has also been shown to be both sensitive (81.9%) and specific (89.4%) to the presence of concussion when the Symptom Score and four composite scores are combined (Schatz et al., 2006). The ImPACT composite scores have been shown to correlate with traditional neuropsychological measures (Iverson, Franzen, Lovell, & Collins, 2004). Specifically, the Visual and Verbal Memory composites showed a medium significant correlation to the Brief Visuospatial Memory Test-Revised scores (BVMT-R; Benedict, 1997), which did not correlate to other ImPACT composite scores (i.e., Processing Speed and Reaction Time). Further, the Reaction Time and Visual Motor Speed composites have been shown to correlate with other measures of processing speed, such as the Symbol Digit Modality Test (SDMT; Smith, 1982). The Visual Motor Speed Composite has also been shown to correlate with the Trailmaking Test. Collectively, these results provide examples of the convergent and divergent validity of the ImPACT composite scales. The ImPACT took approximately twenty-five minutes to complete.

Symbol Digit Modality Test.

The number of items correct from the written version of the Symbol Digit Modality Test (SDMT; Smith, 1982) was used in the current study as a secondary measure of participant's neurocognitive functioning. The SDMT is designed to measures visual tracking, scanning, and motor speed. The measure presents individuals with a set of unique symbols paired with a unique target number. Respondents are required to quickly identify and write in the correct number for a series of symbols. The SDMT number of items correct was used as a dependent measure in the current study. The SDMT was chosen for use as previous research as it has been shown to be sensitive to the immediate effects of concussion (Barth et al., 1989), and accurately discriminate between individuals with head injury and healthy controls (Barr, 2001). The SDMT has also been shown to correlate strongly with the Processing Speed and Reaction Time Composite scores of ImPACT (Lovell et al., 2000). Additionally, the SDMT has been shown to demonstrate stronger test-retest reliability than the ImPACT, ranging from .80 (Barr, 2001) to .82 (Hinton-Bayre & Geffen, 2005). The SDMT also shows strong correlation to other measures of attention, concentration, and processing speed, including the Digit Symbol subtests of previous versions of the Wechsler Adult Intelligence Scale (Barr, 2001). The SDMT, including the teaching trial, took approximately three minutes to complete.

A summary of the domains of measurement and corresponding measures is provided in Table 3.

Demographic Information.

Demographic Information Form.

Subjects were asked to complete a brief questionnaire that recruited information about their age, educational level, athletic status, concussion history, and disability status. The Demographic Information Form has been included as Appendix B. The measure was designed to help identify individuals who met exclusionary criteria based upon diagnoses of attention and/or learning disabilities. In addition, demographic characteristics were examined to describe each group and ensure equivalence across the groups on the aforementioned demographic categories. The demographic form took approximately two minutes to complete.

Group Membership.

Script of Experimental Condition.

The scripts were constructed such that participants in each group were asked to pretend they had sustained a concussion and provided the common list of symptoms. As the work of Gorny and Merten (2005) suggests, the more detailed the information provided to the participants, the more likely they will be able to successfully minimize their effort while also avoiding effort test failure. Injury-related information, such as method of injury and the common symptoms of concussion are held constant in each incentive condition. Each script provided a unique, but parallel, incentive condition: academic accommodations (Fake Bad), return to play (Fake Good), or no incentive. The incentive conditions between the Fake Good and Fake Bad groups were designed to present parallel but opposing motivations for simulating performance. The Fake Bad group was provided the following incentive condition:

> You are also being asked to pretend that you are currently a senior in college and preparing to take the Graduate Record Exam (GRE). The test is next weekend. If you do well on the GRE, your chances of getting into a good graduate program are greater. If you do poorly on the GRE, you will likely have to wait to apply to graduate programs until you are able to get more experience in your area of study.
>
> College students who have a concussion can qualify for extended time on the GRE. To ensure you receive extended time on the upcoming GRE, you will need to perform on the following tasks in a way that suggests you **are** suffering from the symptoms of concussion.
>
> Please keep all of this information in mind as you complete the following measures.

The Fake Good group was provided the following incentive condition:

> You are also being asked to pretend that you are a senior in college and the starting point guard on the basketball team. The big game is next weekend. If you do well in the game, your chances of getting onto a good professional team are greater. If you do poorly in the game, you will likely have to wait to try out for professional teams until you are able to get more experience at your position.
>
> College students who have a concussion can be removed from athletic competition to avoid further injury. To ensure you can play in the upcoming game, you will need to perform on the following tasks in a way that suggests that you are **not** suffering from the symptoms of concussion.
>
> Please keep all of this information in mind as you complete the following measures.

Prior to use in the current study, the experimental scripts were piloted with volunteers recruited from the Psychology Department at Syracuse University. The volunteers included graduate and undergraduate research assistants. Volunteers were randomly assigned scripts from one of the three conditions and asked to complete a brief symptom report adapted from the ImPACT Postconcussion Scale (Lovell et al., 2000). The results from this piloting showed the volunteers were able to understand the language of the scripts, internalize the incentive condition, and modify their symptom report as instructed. The experimental script for each condition has been included as Appendix C.

Procedures

All data collection was conducted in a lab with ten computers connected to the internet. Each of the data collection sessions were run by the primary investigator. Across all sessions, the primary investigator tracked the steps completed using a copy of the Experimenter Script (Appendix D). During 11 of 21 (52%) of the data collection sessions, a research assistant was present to assist with procedural integrity and administration of the protocol. In the experimental sessions, the procedural integrity estimate was approximately 99%. The cause for disagreements came from word errors in reading the script. Prior to the participants' arrival, all computers were prepared by loading the ImPACT (Lovell et al., 2000), MSVT (Green, 2004), and MCI (Green, 2003) programs so that each participant completed all computerized measures on a single computer. A blank piece of paper was placed over each computer screen to prevent participants from engaging with the materials prior to use. A paper participant packet, including the consent document, a written script of the experimental condition, SDMT, MSVT delayed, Integrity of Intervention Form, and Demographic Form was placed in front of each computer, along with two pencils. All participant packets followed this fixed order.

Upon presenting for participation, individuals were randomly assigned one of three incentive groups: No Incentive, return to play (Fake Good), or academic accommodations (Fake Bad). Every data collection session began with the primary investigator explaining the study and reading the consent document aloud. All participants signed the paper-and-pencil consent document prior to participation in the study. Participants were then asked to read the Experimental Script that described concussion, the incentive condition, and instructions on how to perform to obtain the incentive. Participants were given approximately five minutes to read the scripts.

Once participants had read the script, they were directed to remove the paper covering their computer screen, instructed to read the ImPACT's (Lovell et al., 2000) instructions, and reminded to act in the manner described in the script. The ImPACT program automatically prompted students through the Postconcussion Scale and each of the six subtests. After the participants completed the ImPACT, the primary investigator or research assistant accessed computerized version of the MSVT (Green, 2004), covered the monitor with a piece of blank paper, and instructed the participant to wait quietly. Once all participants had finished the ImPACT, participants were instructed to review their paper script. They were given approximately one minute to review the information. Next, they were reminded to act as instructed and directed to the MSVT loaded on their computer screen. After participants completed the MSVT, the primary investigator or research assistant minimized the MSVT, loaded the computerized version of the MCI (Green, 2003), and placed a blank piece of paper over the computer screen. Participants were instructed to sit quietly while waiting for the others to finish. When all the participants had completed the MSVT, the participants were allowed to review their scripts for another minute. Next, participants were reminded to perform in the manner explained in the script, and directed to the computer screen where they were provided instructions to complete the MCI. As participants completed the MCI, the primary investigator or research assistant minimized the MCI, maximized the MSVT, placed the blank paper over the computer screen, and reminded the participant to sit quietly while waiting for the other participants to finish. Once all participants had completed the MCI, the participants were instructed to turn to the SDMT (Smith, 1982) in their participant packet. Participants were provided instructions on how to complete the SDMT and asked to complete the first ten items. The primary investigator and research assistant checked to ensure each participant understood the task. Then participants were reminded to perform in the manner instructed in their script, and administered the SDMT. Once all participants completed the SDMT, they were instructed to return to the MSVT delayed task on their computer screen; as participants finished, they were instructed to place the blank sheet over the computer screen and sit quietly. Next, the participants were prompted through the paper-and-pencil Paired Recall and Free Recall portions of the MSVT as a group. Finally, the group was instructed to independently complete the Integrity of Intervention Form and Demographic Information Form. Once all participants completed these forms, the group was thanked for their help, asked to verify their identity for the purposes of assigning credit, and given credit for participation via SONA. Each data collection session lasted approximately 60 minutes.

Research Design and Statistical Analyses

The current study was designed as an analog study with a between-subjects experimental design, with group being the primary independent variable. The dependent variables of interest included: effort test failure (MSVT; Green, 2004), symptom impairment, symptom report, and neuropsychological test performance (ImPACT; Lovell et al., 2000, SDMT; Smith, 1982). A chi-square analysis was used to compare rates of effort test failure between the groups and frequency of impaired-range symptom report by group. Follow-up pairwise chi-square analyses were adopted to further explore group differences in effort test failure. Effect sizes corresponding to chi-square analyses were Cramer's phi (ϕc) for omnibus tests, while the phi coefficient (ϕ) for post-hoc comparisons. Both Cramer's phi and phi have similar ranges of interpretation as follows: .10 small effect, .30 medium effect, and .50 large effect. To compare omnibus group differences in symptom report, a Kruskal-Wallis (see next section) test was used, and followed by Mann-Whitney post-hoc tests when omnibus group effects were found. Effect sizes for Kruskal-Wallis tests were reported as eta-squared (μ^2) and relied upon the following conventions: .01 small effect, .06 medium effect, and .16 large effect. Effect sizes for Mann-Whitney tests are reported as *r* with the following conventions for analysis: .10 small effect, .30 medium effect, and .50 large effect. Group differences on neuropsychological measures, including the SDMT and four ImPACT Index scores, were compared using five separate Kruskal-Wallis tests with follow-up Mann-Whitney post-hoc tests when omnibus group effects were found. Finally, five separate Kruskal-Wallis tests were utilized to compare the differences in neuropsychological test scores in individuals who passed effort testing and those who failed, regardless of group. Across omnibus and post-hoc procedures, Bonferroni corrections were utilized to control for the effect of repeated contrasts.

Results

Assessment for Violation of Assumptions

Exploratory data analyses (Tukey, 1977) were utilized to determine whether the assumptions of parametric statistical procedures were met. Across all dependent variables, the data did not follow a normal distribution and demonstrated significant skew and kurtosis. The Kolmogorov-Smirnov test of normality was used to evaluate the significance of these effects. The results indicated that each of the dependent variables followed a non-normal distribution for at least one of the groups (alpha level .05). Accordingly, it was decided that analogous non-parametric statistical analyses would be employed rather than attempting to transform the data. Thus, the Kruskal-Wallis one-way analysis of variance was utilized to explore differences in symptom report by group and Mann-Whitney *U* tests were utilized to explore post-hoc comparisons. The Kruskal-Wallis test is analogous to ANOVA but tests group differences based upon ranks, rather than means. Scores are ranked for each participant, and sum ranks are computed for each group. The Mann-Whitney test is parallel to a *t* test for independent samples but does not assume central tendency of the samples. Five separate Kruskal-Wallis tests were utilized to examine group differences in each of the four ImPACT (Lovell et. al, 2000) Index scores and SDMT (Smith, 1982) score. When omnibus group effects were identified, a Mann-Whitney *U* post-hoc procedure was used to further explain group differences. Chi-square tests were used to explore the frequency of effort test failure and symptom impairment between groups. Post hoc comparisons were made using chi-square tests with the two groups of interest. Bonferroni corrections were employed to account for repeated contrasts and the corresponding alpha levels are reported in the results section.

Results of the Manipulation Check

Before analyzing the data, group performance from the General Memory Complaints subscale of the MCI (Green, 2003) was explored to determine whether participants performed as instructed by their script. The MCI creators provide a mean MCI score 7.11 (*SD* = 5.14) compiled from 108 healthy adults, to which mean group scores from the current study were compared. The Fake Bad group showed a mean MCI score of 12.38 (*SD* = 4.97), the Fake Good group 2.58 (*SD* = 4.67), and the No Incentive group 11.26 (*SD* = 6.57). Additionally, 81.13% of the participants in the Fake Bad group showed a mean MCI score greater than 7.11, while 67.89% of the No Incentive participants obtained a higher MCI average than the healthy adults. Only 9.68% of the Fake Good participants showed a higher MCI mean score than the healthy adults. In sum, these patterns of performance indicate that the Fake Bad group endorsed more memory complaints than both healthy adults, and members of the Fake Good and No Incentive groups. These results are commensurate with the expectation that the Fake Bad group would report the highest number of memory complaints, with the Fake Good and No Incentive groups reporting fewer. Further, the results indicate that the manipulation was effective in influencing participants self-reported memory complaints.

Data collected from the IIF further supported the effectiveness of the manipulation. First, the Fake Bad and Fake Good groups were able to accurately recall their experimental condition, as 96% and 89% of participants correctly identified group membership, respectively. Of the No Incentive group, 59% of the participants correctly identified their condition. The consistency score varied significantly by group, χ^2 (2, n = 171) = 28.43, $p < 0.001$, $\phi c = 0.41$. Of the entire sample (n = 171), 81% of participants were able to correctly identify their condition. Relative performance data revealed that participants in the Fake Good group tended to report that they performed as instructed, with 90% reporting they performed similar to or better than they would have absent specific instructions. A majority of participants in the Fake Bad group, 68%, reported they performed worse than typical. Of the No Incentive group, 45% indicated they performed worse than typical, 27% indicated they performed as well as usual, and 28% indicated they performed better than usual. Across groups, participants reported they did a good job of performing as instructed with 87% of the Fake Good group, 83% of the Fake Bad group, and 73% of the No Incentive group reporting successful simulation.

Together, the results from the IIF and MCI (Green, 2003) lend credence to the assumption that participants would perform as instructed by their experimental scripts. Given that participants were able to successfully modify a self-report of memory complaints, identify their experimental condition, match test performance to their condition, and were satisfied with their adherence to the protocol, it was assumed that the scripts were sufficient to produce the intended alteration of performance across domains.

Symptom Report

Based upon the successful manipulation and the a priori hypothesis that symptom report would vary by group, group differences in symptom report from the Postconcussion Scale of the ImPACT (Lovell et al., 2000) were explored. The Postconcussion Scale produces a Total Symptom Score for each participant, which were compared between groups using a Kruskal-Wallis test. The results indicated a large and significant difference between the mean rank of symptom score by group, $H(2, n = 171) = 58.21$, $p < .001$, $\mu^2 = .34$, with the mean rank of 112.57 the Fake Bad, 48.07 for the Fake Good, and 102.85 for the No Incentive groups. Follow-up pairwise comparisons between the groups were conducted using the Mann-Whitney *U* test with a Bonferroni correction for repeated contrasts ($\alpha = .017$). The results indicated a large and significant difference between the Fake Bad and Fake Good groups, $U = 426.50$, $n^1 = 53$, $n^2 = 62$, $p < .001$, $r = .51$. The Fake Bad group had an average rank of 80.95, while the Fake Good had an average rank of 38.38. A moderate and significant difference was also found between the Fake Good and No Incentive groups, $U = 601.00$, $n^1 = 62$, $n^2 = 56$, $p < .001$, $r = .41$, where the Fake Good group had a mean rank of 41.19 and the No Incentive group showing a mean rank of 79.77. No significant difference was found between the Fake Bad and No Incentive groups, $U = 1292.50$, $n^1 = 53$, $n^2 = 56$, $p = .25$. The Fake Bad group had an average rank of 58.61 while the No Incentive group had an average rank of 51.58.

To further explore the differences in symptom report by group, the impairment variable created from the Postconcussion Scale norms (Lovell, et al., 2000) was used. Each participant was given a dichotomous score of Impaired or Unimpaired. An unimpaired code was assigned to symptom scores that fell in the Low-Normal to Normal range, and an impaired code assigned to score in the Unusual, High, and Very High range. A chi-square test was used to compare the frequency of impairment by group. The results indicated a strong and significant difference by group, χ^2 (2, $n = 171$) = 43.03, $p < 0.001$, $\phi c = 0.50$. Follow up pairwise comparisons between the groups' frequencies of impairment were conducted using the Chi-square test with a Bonferroni correction for repeated contrasts ($\alpha = .017$). A strong and significant difference was found between the frequency of impaired ratings of the Fake Bad and Fake Good groups, χ^2 (1, n = 115) = 30.16, p < .001, $\phi = .51$. A moderately strong and significant difference was also found between the Fake Good and No Incentive groups, χ^2 (1, n = 118) = 20.13, p < .001, $\phi = .41$. No significant difference was found in the frequency of impairment between the Fake Bad and No Incentive groups, χ^2 (1, n = 109) = 3.93, $p = .05$. Within group analysis of symptom impairment indicated that all participants in the Fake Bad group (n=53) reported impaired range symptom scores, while approximately 56% of the Fake Good and 93% of the No Incentive groups reported Impaired range scores.

Overall, these results suggest the groups differed across both the frequency of impairment and the average rank of symptom report. As expected, the Fake Bad group reported significantly more symptoms and more frequently reported impaired range symptoms than the Fake Good group. Unexpectedly, No Incentive group also reported more frequent impairment and more symptoms than the Fake Good group. Together, these results partially confirm the hypothesis that the Fake Bad group would show significantly higher symptom report than the Fake Good group and No Incentive group. These results are summarized in Tables 4, 5, and 6.

Neuropsychological Test Performance

It was expected that the Fake Bad group would perform significantly worse than the No Incentive and Fake Good groups across measures of neuropsychological test performance, including the ImPACT (Lovell, et al., 2004) composite scores and the SDMT (Smith, 1982). Group performance across each of the four composite scores of the ImPACT and SDMT was explored by using five separate Kruskal-Wallis tests. A Bonferroni correction was employed given the number of tests run, which resulted in an alpha of .01. The groups showed significant differences in performance across each of the neuropsychological scores: Verbal Memory, $H(2, n = 171) = 37.31$, $p < .001$, $\mu^2 = .22$, Visual Memory, $H(2, n = 171) = 34.23$, $p < .001$, $\mu^2 = .20$, Visual Motor Speed, $H(2, n = 171) = 32.28$, $p < .001$, $\mu^2 = .19$, Reaction Time, $H(2, n = 171) = 14.89$, $p = .001$, $\mu^2 = .09$, and SDMT score, $H(2, n = 171) = 33.20$, $p < .001$, $\mu^2 = .20$. Across the ImPACT composite scores and SDMT, the groups showed the same pattern of responding, with the

Fake Bad group showing the weakest performance, followed by the No Incentive group, and the Fake Good group showing the strongest performance. These results are summarized in Table 7.

To further evaluate the significance of group differences across each of the ImPACT (Lovell et al., 2000) composite scores and SDMT (Smith, 1982), pairwise comparisons between the groups were conducted using the Mann-Whitney *U* test with a Bonferroni correction for repeated contrasts ($\alpha = .0025$). The results indicated that the Fake Bad and Fake Good groups showed significantly different performance across each of the ImPACT composites and SDMT, with the Fake Good showing significantly stronger performance across the measures: Verbal Memory, $U = 634.50$, $n^1 = 53$, $n^2 = 62$, $p < .001$, $r = .53$, Visual Memory, $U = 709.50$, $n^1 = 53$, $n^2 = 62$, $p < .001$, $r = .48$, Visual Motor Speed, $U = 674.50$, $n^1 = 53$, $n^2 = 62$, $p < .001$, $r = .51$, Reaction Time, $U = 1023.50$, $n^1 = 53$, $n^2 = 62$, $p = .001$, $r = .32$, and SDMT, $U = 622.00$, $n^1 = 53$, $n^2 = 62$, $p < .001$, $r = .53$. The results further suggested small (Reaction Time) to moderate (Verbal Memory, Visual Memory, and Visual Motor Speed) effect sizes for the significant differences between the groups across the ImPACT and a large effect size across the SDMT. The results indicated that the No Incentive group showed significantly weaker performance than the Fake Good group across each of the ImPACT composites and SDMT: Verbal Memory, $U = 923.00$, $n^1 = 56$, $n^2 = 62$, $p < .001$, $r = .40$, Visual Memory, $U = 871.00$, $n^1 = 56$, $n^2 = 62$, $p < .001$, $r = .43$, Visual Motor Speed, $U = 1025.50$, $n^1 = 56$, $n^2 = 62$, $p < .001$, $r = .35$, Reaction Time, $U = 1174.50$, $n^1 = 56$, $n^2 = 62$, $p = .002$, $r = .28$, and SDMT, $U = 1048.00$, $n^1 = 62$, $n^2 = 56$, $p < .001$, $r = .34$. The results suggested small (Visual Motor Speed and Reaction Time) to moderate (SDMT, Verbal Memory, and

Visual Memory) effect sizes for the significant differences between groups. As with the previous findings in the domains of symptom report and effort testing, the Fake Bad and No Incentive Groups were not found to differ significantly across the ImPACT composite scores or SDMT: Verbal Memory, U = 1157.00, n^{1} = 53, n^{2} = 56, p = .05, Visual Memory (U = 1308.50, n^{1} = 56, n^{2} = 62, p = .29, Visual Motor Speed (U = 1176.00, n^{1} = 56, n^{2} = 62, p = .06), Reaction Time (U = 1350.50, n^{1} = 56, n^{2} = 62, p = .42), and SDMT, U = 1224.00, n^{1} = 56, n^{2} = 62, p = .115. These comparisons are summarized in Table 8.

Effort Testing

Data collected from the Medical Symptom Validity Test (MSVT; Green, 2004) produced five scores: Immediate Recall (IR), Delayed Recall (DR), Consistency (CS), Paired Recall (PR), and Free Recall (FR). Group performance on the MSVT is descriptively summarized in Table 9. As indicated by the user manual, individuals are considered to have given suspect effort with a score of < 85% on IR, DR, or CS (Green, 2004). A variable was created to capture performance across these three subtests such that performance below 85% on any one of these three scores was coded as an effort test failure, and performance of 85% and above across the subtests was coded as an effort test pass. To test the hypothesis that the groups would differ in their rate of effort test failure, the percentage of group members who passed effort testing was calculated for each group. It was hypothesized that the Fake Bad group would show the highest rate of effort test failure with the No Incentive and Fake Good groups showing significantly lower rates of failure. As expected, the Fake Bad group showed the lowest rate of passing effort testing with 35.8% of the group passing; the No Incentive had a passing rate of 55.4%, while the Fake Good group had a passing rate of 96.8 %.

To further explore group differences in MSVT (Green, 2004) performance, the frequency of effort test failure by group was compared using a chi-square test. The results showed significantly different rates of effort test failure by group, χ^2 (2, n = 171) = 49.14, p < .001, ϕc = .54. Follow up pairwise comparisons between the groups were conducted using chi-square tests with a Bonferroni correction for repeated contrasts (α = .017). A strong and significant difference was found between the frequency of effort test failure of the Fake Bad and Fake Good groups, χ^2 (1, n = 115) = 49.32, p < .001, ϕ = .66. A significant and moderately strong difference was also found between the Fake Good and No Incentive groups, χ^2 (1, n = 118) = 28.60, p < .001, ϕ = .49. A significant difference was not found in the frequency of effort test failure between the Fake Bad and No Incentive groups, χ^2 (1, n = 109) = 4.17, p = .04. The results from the MSVT are summarized in Table 10.

To explore the relationship between effort test failure and neuropsychological test performance, five Mann-Whitney U tests were utilized to compare those who passed effort testing and those who failed (regardless of group membership) across each of the neuropsychological measures. A Bonferroni correction was utilized to reflect the large number of repeated contrasts (α = .01). Significant group differences were found across each of the neuropsychological measures: Verbal Memory, U = 700.00, n^1 = 61, n^2 = 110, p < .001, r = .65, Visual Memory, U = 958.00, n^1 = 61, n^2 = 110, p < .001, r = .59, Visual Motor Speed, U = 999.50, n^1 = 61, n^2 = 110, p < .001, r = .58, Reaction Time U = 1415.50, n^1 = 61, n^2 = 110, p < .001, r = .48, and SDMT U = 1010.50, n^1 = 61, n^2 = 110, p < .001, r = .58), such that those who passed effort testing showed significantly stronger performance across each measure. Table 10 includes a summary of these data.

Collectively, these results partially confirm the hypothesis that the groups would show significantly different performance across neuropsychological measures. A significant omnibus effect for group was found across the ImPACT (Lovell, et al., 2000) and SDMT (Smith, 1982), with the Fake Bad group showing significantly weaker performance than the Fake Good group across measures. Unexpectedly, the No Incentive group showed similar performance to the Fake Bad group, and significantly weaker performance than the Fake Good group, across each of the neuropsychological measures. The results showed that individuals who passed effort testing showed significantly stronger performance than those who failed, across neuropsychological measures.

Discussion

The purpose of the current study was to evaluate whether incentives for modifying performance would influence the symptom report, neuropsychological test performance, and effort test failure in individuals instructed to pretend as though they had recently sustained a concussion. The results support two major findings. First, the data suggest that the symptoms and neurocognitive impairment of concussion can be faked. Second, poor effort is of significant concern when evaluating neuropsychological test data.

The results of the current study showed that the symptoms of concussion are easily faked in both directions. As expected, the Fake Bad group showed a higher rate of impairment than the Fake Good group as measured by the Postconcussion Scale of the ImPACT (Lovell et al., 2000). The No Incentive group, which was only provided information on the symptoms of concussion, also showed a higher impairment rate than the Fake Good group. Further, 100% of the Fake Bad group reported Impaired range symptoms, while 93% and 56% of the No Incentive and Fake Good group participants reported Impaired range symptoms, respectively. These results provide support to the conclusion that even after a short exposure to a list of symptoms, participants instructed to fake bad were able to modify their symptom report to match clinical levels. When compared to the symptom report of athletes with concussion provided by the ImPACT manual (Lovell, 2006), participants in the No Incentive and Fake Bad groups showed higher symptom report. In both the current study and comparable studies (Harrison, Edwards, & Parker, 2007; Martin, Hayes, Gouvier, 1996), participants were able to willfully create symptoms indicative of impairment related to ADHD and concussion, respectively. These data illustrate the need for multiple measures of impairment when working with individuals who present with common symptoms of concussion, such as headache, fatigue, and irritability, who may have an incentive to exaggerate or fake symptoms.

The current study also identified significant differences in neuropsychological test performance by group. The No Incentive and Fake Bad group showed consistently weaker performance across neuropsychological measures than the Fake Good group. Group membership was found to account for between 9-22% of the variance in neuropsychological test scores. Collectively, these results provide evidence that individuals in the Fake Bad and No Incentive groups, who over-reported the subjective symptoms of concussion, also showed a decline in their objective performance on commonly used psychological measures. Although the current study did not recruit a comparison group of individuals with legitimate concussion, others have evaluated the neurocognitive performance of individuals with concussion using similar methods as the current study. Specifically, Broglio, Macciocchi, and Ferrara (2007) administered the ImPACT (Lovell et al., 2000) to a small sample (*n* = 21) of concussed college athletes. Other investigators (Iverson, Lovell, & Collins, 2005; Schatz, Pardini, Lovell, Collins, & Podell, 2006) tracked the neurocognitive performance of concussed high school students following concussion. Both the Fake Bad and No Incentive groups from the current study showed weaker performance across the ImPACT composites and SDMT (Smith, 1982) than individuals with legitimate concussion. Similar patterns of performance were found in research on groups with concussion and ADHD (Green, 2007; Green et al., 2001; Harrison, Edwards, & Parker, 2007; Martin, Hayes, & Gouvier, 1996). These studies tended to show that not only are the general and subjective symptoms of certain disorders and injuries easy to fake, but so are the neurocognitive deficits typically associated with these disorders or injuries. These results also suggest that individuals who fake clinical disorders show weaker performance than those with legitimate clinical diagnoses.

The current study also identified significant differences in the rate of effort test failure by group. The Fake Bad group showed the highest rate of effort test failure (64.2%), followed by the No Incentive group (44.6%), and the Fake Good group (3.2%). Further, the Fake Bad and No Incentive groups showed a significantly higher rate of effort test failure than the Fake Good group. The current results are similar to those found by others (Green et al., 2009; Harrison, Edwards, & Parker, 2007) who reported that both children and adults can easily modify their performance to pass or fail effort testing when provided instruction to do so. Other studies have found that symptom validity tests are insensitive to the effects of explicit instruction on how to perform in a manner to avoid detection (Brennan, Meyer, David, Pella, Hill, & Gouvier, 2009; Jelicic, Ceunen, Peters,

& Merckelbach, 2011). However, these studies are not specific to concussion, and more research in the area of effort testing needs to be completed before conclusions can be made about the sensitivity of effort tests to feigned head injury. Further, these results suggest that non-monetary incentives, such as the return to sports participation or the provision of academic accommodations, can influence performance in a significant and predictable manner. While research in the area of ADHD and learning disabilities (Constantineau et al., 2005; Harrison, 2006; Sullivan et al., 2007) has begun to suggest that a subset of students willfully malinger symptoms in an attempt to obtain academic incentives, these results are the first to suggest the incentives may be appealing to individuals with concussion. Additionally, recent work has shown that both typical and disabled students rated extended time as a highly desirable test accommodation, 87.1% and 88.3% respectively (Lewandowski, Lovett, Panahon, Lambert, & Systma, 2012). Given the notion that even typical students may find academic accommodations to be appealing incentives, and the ease with which the common symptoms of concussion can be simulated, the need for increased awareness and use of effort measures is clear.

While group membership accounted for a significant portion of the variance in neuropsychological test scores, effort also played a significant role in performance. Those who passed effort testing showed significantly stronger performance across neuropsychological measures. These results indicate that effort, regardless of incentive condition, explained between 23% and 42% of the variance in neuropsychological test performance. These findings are consistent with those of Green et al. (2001) who found that effort explained 53% of the variance in neuropsychological test performance of individuals with head injury. In the same study, education (11%) and age (4%) accounted for far less variance than effort. Overall, these results provide compelling evidence that effort should be considered when analyzing neuropsychological test results, especially when the individual may have incentive to fake bad.

Surprisingly, across all measures the No Incentive group consistently performed in a manner similar to the Fake Bad group, rather than the Fake Good group. Although it was initially expected that the No Incentive group would show weaker performance than the Fake Good group and stronger performance than the Fake Bad group across domains, there exist several explanations for why an alternative pattern was observed. First, in the No Incentive condition, participants were given no explicit information on how to modify their performance. While all groups were provided information on concussion and the common side effects, the Fake Good group was given explicit instruction to minimize symptom report and maximize performance to ensure the return to athletic play. In contrast, the Fake Bad group was instructed to maximize symptom report and depress test performance. The lack of explicit instruction to the No Incentive group may have made it more difficult for participants to assess how strong or weak to perform. This explanation seems to be supported by several pieces of data. First, the No Incentive group showed the most difficulty identifying its experimental condition, with 58.9% of the group correctly reporting group membership. The No Incentive group was significantly less accurate than the Fake Bad (96.2%) and Fake Good (88.7%) groups' rate of correct identification. The majority of the No Incentive group who incorrectly identified their group (56.5%) reported they had been instructed to pretend they were a student preparing to take the GRE, while the other 44.5% indicated they were instructed to pretend to be an athlete seeking to return to play. Of the participants in the No Incentive group who incorrectly identified their group, only 35.8% (8 of 23) reported that they had not done a good job of following the script. Of these participants, 87.5% reported they had become confused or forgotten how to respond during the session. Interestingly, 55.3% of the No Incentive condition participants reported that they performed the *same as or better than* they would have in the absence of the experimental script. These data suggest that participants in the No Incentive group may have been confused about their instructions or struggled to anchor their performance to a reference point in the absence of actual impairment. Despite the self-reported difficulties of the No Incentive group, it is important to note that they appeared to internalize the experimental script. The group consistently performed in a manner indicative of concussion, across measures. Although participants reported confusion, they were able to successfully simulate impairment across measures.

Limitations

Despite the robust differences in symptom report, neuropsychological test performance, and effort test failure by group, the current study is not without limitation. The most salient of these limitations are inherent to the use of a simulation design, including four characteristics: Lack of comparison groups, absence of true incentives, language used in the scripts, and reliance on conscious motivations for performance.

Perhaps most notably, the study recruited a healthy sample of undergraduate students, rather than concussed individuals. Also, the current study did not recruit a comparison group of healthy participants, which would have provided frame of reference for delineating the current results. It would have been valuable to compare symptom report, effort test failure, and neuropsychological test performance to a healthy comparison group recruited from the same population.

Although comparison groups of concussed and healthy individuals were not recruited, comparisons between the current study and similar research are informative. When the data from the current study were compared to similar data collected from concussed athletes (Broglio, Macciocchi, & Ferrara, 2007; Iverson et al., 2005; Schatz et al., 2007), interesting trends emerge. First, athletes with concussion reported similar symptom scores to the Fake Good group, which are much lower than those of the Fake Bad and No Incentive groups. The Fake Good group showed a much larger range of scores and higher variability in symptom report than both concussed athletes and the Fake Bad and No Incentive groups. Across the ImPACT (Lovell et al., 2000), the Fake Good group showed stronger performance than concussed athletes and the Fake Bad and No Incentive groups. Table 11 provides a summary of these data. This comparison, albeit indirect, suggests that participants in the Fake Bad and No Incentive groups demonstrated higher symptom report and weaker neuropsychological test performance than individuals with concussion. This comparison also shows that individuals who simulate concussion may actually perform worse than individuals with concussion. A similar pattern has been demonstrated by the work of Green and colleagues (Green et al., 1999; Green et al., 2001; Green et al., 2009). Work in the areas of ADHD and learning disabilities have also shown that individuals who fake bad tend to perform worse than those with legitimate diagnoses (Harrison et al., 2007; Lindstrom et al., 2009).

A secondary effect of failing to include a healthy comparison groups is that it is difficult to evaluate whether participants in the Fake Good group were able to optimize their performance. However, it is valuable to consider the low rate of effort test failure (3.2%) demonstrated by the Fake Good group is than the rate of effort test failure in healthy volunteers in the absence of incentives, which has been shown to range between 11-17% (Hunt et al, 2007; Kirkwood & Kirk, 2010). In comparing the No Incentive groups to test-based norms from the MCI (Green, 2003), the No Incentive group reported fewer general memory complaints. These data provide some evidence to suggest that the Fake Good group in the current study appeared to purposefully maximize test performance.

The results from the current study are further limited in that participant's actual performance had no implications for the attainment of academic accommodations or the return to athletic play. More specifically, while the incentives used represent "real world" scenarios that may influence performance, the current study did not provide actual incentives for performance. Regardless of experimental group, participants' performance had no legitimate consequence for their academic and athletic standing, or even the credit they earned for participating in the experiment. Further, given that no real incentive was attached to performance, it seems unlikely that the same cognitive or emotional demands of malingering were activated in the participants. Also, the incentives presented in the current study may not have represented salient goals for the participants, given that they represented a healthy, uninjured sample. Despite the lack of realism with the incentives, robust effects were found across symptom report and neuropsychological test performance by group and highlight future directions for research.

The experimental scripts may have also limited the internal validity of the current study. This appears to salient concern for the No Incentive condition, in which participants had more difficulty than participants from the other groups correctly identifying their experimental condition and reported they became confused about how to perform. Simply put, a substantial portion of the No Incentive group simply did not know how to perform. This finding is interesting in that it suggests that individuals can more easily fake a disorder when provided explicit instruction on how to do so.

Of additional concern are the participant's conceptions of the information contained within the experimental scripts. The current study required participants to pretend to have sustained a minor head injury, but also pretend to be seeking an external gain. Both simulation factors could be susceptible to individual differences of the participants. For example, participants may have varied in their conceptualization of symptoms of concussion. Across groups, participants were asked to imagine they had sustained a concussion as a result of a car accident; some participants may have imagined a minor car accident, while others imagined a major collision. Participants in the Fake Bad and Fake Good groups were also asked to pretend to be preparing for the Graduate Record Exam or an important basketball game. For some students, these may not have represented important incentives, and this may have impacted their ability to assume the instructed role. Participants may have varied in their ability to estimate how they would perform on such tests normally let alone how to perform given an imaginary incentive. It is conceivable that it may have been difficult for participants to keep their typical performance, injury scenario, and incentive condition in mind while attempting to complete the measures. Although participants were frequently prompted to review their experimental script, it may have presented a cognitive challenge to continually monitor performance. Some participants may have varied in their willingness to purposefully modify their performance, regardless of condition. Subjects were provided an opportunity to disclose poor adherence to the protocol, without penalty, via the Integrity of

Intervention Form, but some participants may not have felt comfortable disclosing their failure to act as instructed.

It is important to note the lack of standardization of the experimental scripts. Although the scripts were designed to be equivalent in length and content, they were created by the author for use in the study. The verbiage used may have influenced group performance, in addition to the incentive presented. For example, each of the groups was told that concussion represents a *mild* head injury. Further, each of the groups was primed to pretend that they had recently sustained a concussion. It appears that these factors may have influenced group performance in several ways. First, it seems that individuals in each of the groups showed high reliance upon the experimental scripts. The Fake Bad group, despite being told to exaggerate impairment, showed similar performance to the No Incentive group. This suggests that the Fake Bad group may have relied heavily upon the clue of *mild* head injury. Conversely, the No Incentive group, absent incentive, appeared to rely upon the information about impairment and symptoms, and successfully simulated concussion. The influence of the script and the salience of the information may partially explain why the Fake Good group showed a higher report of symptoms than what may be expected. It will be important that future research explore the components of script that appear to be most related to feigned performance.

In the current study, poor performance (i.e., elevated symptom report, low neuropsychological test performance, and effort test failure) was conceptualized as a conscious choice. Individuals who failed effort testing were assumed to have done so in an attempt to appear impaired by concussion. However, this assumption ignores the unconscious motivations that may influence their clinical presentation. For example, “diagnosis threat” was first used by Surh and Gunstead (2002) to explain how an individual with concussion show low performance on a task because they are primed to believe that individuals with concussion are generally regarded as performing poorly on the task. It may be the case that simply exposing individuals to the symptoms of concussion influenced their performance across measures, rather than the incentive condition. Accordingly, it is plausible that there may be alternative, unconscious factors that contributed to participants’ performance that went unmeasured. It may be the case that exploring these unconscious factors would help explain effort test failure in 10-17% of healthy individuals in the absence of incentives (Hunt et al, 2007; Kirkwood & Kirk, 2010).

With the limitations to the internal and external validity in mind, the results are among the first to suggest that non-monetary incentives to modify performance may influence the psychological test results in individuals seeking these incentives. Consistent and robust differences were found between the Fake Good and Fake Bad groups across measures of effort, symptom report, and neuropsychological test performance. The importance of effort is highlighted as the current results show a strong and significant relationship between effort and performance on neuropsychological measures.

Future Directions for Research

The limitations of the current study inform directions for future research. Given the lack of generalizability to a clinical sample, it is imperative to explore the differences in test performance between individuals with actual concussion with individuals instructed to feign concussion. This will allow for a direct comparison of neurocognitive performance between these groups.

The current study suggests that the provision of academic accommodations and return to sports play may be salient incentives to modify performance, especially in a college setting. The current data suggest that concussion is easily faked, while others have recently illustrated the desirability of academic accommodations (Lewandowski et al., 2012). Continued exploration into the appeal of these incentives for individuals with concussion will further inform our clinical practices. Concurrently, we should continue to investigate whether healthy students find these (and other) incentives appealing enough to modify symptom report and/or neurocognitive test performance. By measuring the desirability of common incentives, such as access to monetary reimbursement, reduction in work or school workload, sympathy from friends and family, and academic accommodations, clinicians can more adequately screen for feigned performance when these incentives are present. Related to the return to play incentive, it may be beneficial to explore what factors contribute to an athlete's willingness to minimize symptom report. These factors may include the avoidance of monetary or opportunity loss, length of season, or perceived threat of additional or long-term injury. A more comprehensive understanding of the factors that contribute to feigned performance will aid in the development of adequate screening methods.

As our knowledge of the relationship between incentives and neuropsychological test performance grows, we should also seek to broaden the use of symptom validity measures. Despite increasing awareness of purposeful underperformance on pre-season baseline testing in professional sports (Leahy, 2011), little work has explored the introduction of effort testing to baseline evaluations. This would allow us to quantify the rate of faking bad at baseline. This data could help improve our current practices for screening both pre- and post-injury, and strengthen the validity of our return to play decisions following injury. It would be interesting to explore how knowledge of effort testing would influence performance. For example, if examinees are told their effort will be measured prior to testing, would it influence performance (i.e., reduce malingering)? This research may also have practical value; for example, it would be pertinent to evaluate whether the introduction of effort testing to pre-season baseline testing protocols would be an effective method of dissuading athletes from faking bad at baseline.

General Conclusions

Limitations aside, the current study demonstrated that concussion is an injury that can be easily faked with little explicit coaching. The current results are among the first to suggest that the symptoms of concussion can be easily modified in either direction, such that individuals can both minimize and maximize their self-report of symptoms. This finding has implications for the way in which we conceptualize incentives and suggests that non-monetary incentives may represent desirable outcomes for some people. In the current study, participants successfully modified symptom report and demonstrated predictable changes in neuropsychological test performance in the face of non-monetary incentives. The current results also support the notion that effort contributes significantly to both self-report and objective measures of performance. The findings from the current study support several conclusions. First, it must not be assumed that individuals all approach an evaluation with their full effort. It must be recognized that some individuals will purposefully fake bad. As such, the use of symptom validity measures is appropriate across many evaluations, but especially those evaluations in which external incentive to modify performance exist. Without the use of effort measures, individuals who fake bad may go undetected. Together, it seems pertinent to broaden our current conceptualization of the external gains that could influence performance beyond monetary reimbursement while also casting a wider net of symptom validity testing to accommodate this change. More research is required to more comprehensively explore the relationship between effort test failure, non-monetary incentives, and concussion, with the goal of increasing the validity of our decisions based upon neuropsychological test data.

Appendix A

Integrity of Intervention Form

How were you instructed to perform at the beginning of the session today?

- ☐ Like an athlete who wanted to return to sports participation
- ☐ Like a student getting ready to take the GRE
- ☐ I was not given any instructions on how to perform

Had I not been given any instructions on how to perform, my scores today were:

- ☐ Better than how I would typically perform
- ☐ Similar to how I would typically perform
- ☐ Worse than how I would typically perform

Do you feel you did a good job of acting as you were instructed?

- ☐ Yes
- ☐ No

If no, what happened?

- ☐ I did not understand the instructions
- ☐ I got confused or forgot my instructions
- ☐ I just wanted to earn my research credit
- ☐ Other____

Appendix B

Demographic Information Form

Please complete the following information as yourself:

1) **Age:__________**

2) **Sex**:
☐ Male
☐ Female

3) **Class Status**:
☐ Freshman
☐ Sophomore
☐ Junior
☐ Senior
☐ Graduate

4) **Student Athlete Status**
☐ I am currently a student athlete at Syracuse University (varsity sports)
☐ I currently participate in club sports at Syracuse University
☐ I am not a current member of a club or varsity sport at Syracuse University

5) **Concussion History**
☐ I have no history of concussion
☐ I have sustained one (1) concussion within the past 5 years
☐ I have sustained two (2) concussions in the past 5 years
☐ I have sustained 3 (3) or more concussions in the past 5 years

6) **Disability Status**
☐ I am a student without a disability
☐ I am a student with a physical disability
☐ I am a student with a learning disability
☐ I am a student with an attention disability
☐ I am a student with another disability (please indicate):

____

Appendix C

Scripts provided to participants in each experimental condition

Accommodations Condition (Fake Bad)

You are being asked to pretend that you are a college student who sustained a concussion in a car accident. Concussion is a type of mild brain injury that can impact the way you think and learn. The common symptoms of concussion include headaches, fatigue, irritability, memory and concentration problems, and slowed thinking. Other symptoms of concussion can include dizziness, nausea, and sensitivity to bright lights or loud noises.

You are also being asked to pretend that you are currently a senior in college and preparing to take the Graduate Record Exam (GRE). The test is next weekend. If you do well on the GRE, your chances of getting into a good graduate program are greater. If you do poorly on the GRE, you will likely have to wait to apply to graduate programs until you are able to get more experience in your area of study.

College students who have a concussion can qualify for extended time on the GRE. To ensure you receive extended time on the upcoming GRE, you will need to perform on the following tasks in a way that suggests you **are** suffering from the symptoms of concussion.

Please keep all of this information in mind as you complete the following measures.

Return to Play Condition (Fake Good)

You are being asked to pretend that you are a college student who sustained a concussion in a car accident. Concussion is a type of mild brain injury that can impact the way you think and learn. The common symptoms of concussion include headaches, fatigue, irritability, memory and concentration problems, and slowed thinking. Other symptoms of concussion can include dizziness, nausea, and sensitivity to bright lights or loud noises.

You are also being asked to pretend that you are a senior in college and the starting point guard on the basketball team. The big game is next weekend. If you do well in the game, your chances of getting onto a good professional team are greater. If you do poorly in the game, you will likely have to wait to try out for professional teams until you are able to get more experience at your position.

College students who have a concussion can be removed from athletic competition to avoid further injury. To ensure you can play in the upcoming game, you will need to perform on the following tasks in a way that suggests that you are **not** suffering from the symptoms of concussion.

Please keep all of this information in mind as you complete the following measures.

No Incentive Condition

You are being asked to pretend that you are a college student who sustained a concussion in a car accident. Concussion is a type of mild brain injury that can impact the way you think and learn. The common symptoms of concussion include headaches, fatigue, irritability, memory and concentration problems, and slowed thinking. Other symptoms of concussion can include dizziness, nausea, and sensitivity to bright lights or loud noises.

Please keep all of this information in mind as you complete the following measures.

Appendix D

Researcher Script

- Prior to participant's arrival:
  i) Turn on all 10 computers, load MSVT, MCI and ImPACT
  ii) Place blank sheet of paper over each screen
  iii) At each seat, place participation packet including:

(1) Consent to Participate
(2) Script
(3) SDMT
(4) MSVT Forms
(5) Integrity of Intervention Form
(6) Demographic Form

b) Place a pencil at each station

1) As participants arrive say: "Please choose a seat. We will begin the study shortly."

Consent

☐ Once all participants have arrived, close the door and say: "You are here to participate in a study designed to evaluate the effect of concussion on test performance. Let's begin by reading through the consent form. Please follow along as I read aloud." When finished reading ask: "Does anyone have any questions?" Say: "If you agree to participate in the current study, please sign and print your name and include the date."

Once all participants have completed the consent, say:

☐ "Please turn to page 3 of your participant packet. Read the description quietly to yourself and follow the instructions for the remainder of the study."

"Does everyone understand what you are to do?"

"Please place your participant packet to the side with the front page facing you."

ImPACT

☐ "In a moment, I will ask you to flip over the paper on your computer screen. Please do not enter any information unless I tell you to do so. Please flip over your paper now. On the first screen, please enter your date of birth. When you have done so, please click "Next.""

☐ "On the following screen, please DO NOT enter your real name. For your first name, please type the letter "J" followed by your ID number located at the top of your participant packet. For your last name, please type the letter "D" followed by your ID number. Please identify your gender. Do not list your height, weight, or handedness. Does anyone have any questions?"

- ☐ " will now ask you click the "Next" button until you get to the screen that says "Current Symptoms and Conditions – Page 1. If you need help, please raise your hand."

- ☐ "Please follow the directions as listed on top of the page. For this measure, a 1 means low or rarely and 6 means high or always. **IT IS VERY IMPORTANT THAT YOU REMEMBER TO RESPOND AS YOU WERE INSTRUCTED AT THE BEGINNING OF THE EXPERIMENT.** There are 6 pages of symptoms and conditions. When you finish answers the symptom questions, please sit quietly. If you have any questions, please raise your hand. Do not begin the actual test until I tell you. Please complete the symptom questions now."

- ☐ Once all participants have finished, say: "You will be asked to complete several short activities. You will be provided with instructions on how to respond to each activity on the screen. When I say begin, please follow the instructions on the screen. If you have any issues, please raise your hand. When you finish, please raise your hand and a research assistant will help you. **IT IS VERY IMPORTANT THAT YOU REMEMBER TO RESPOND AS YOU WERE INSTRUCTED AT THE BEGINNING OF THE EXPERIMENT.** Do you have any questions? Begin"

As students finish the ImPACT, minimize the browser, and open the MSVT program.

MSVTi

- ☐ "Before we begin, the next measure, please turn to page 4 of your participant packet and review the information. Remember to keep this information in mind as we proceed through the experiment."

- ☐ Say "Please place your participant packet to the side and flip the paper off your computer screen. Before we begin this measure, please confirm the highlighted ID number in the section for first and last name on the screen matches the ID number listed on your participant packet."

- ☐ Say: "This measure has two parts. **IT IS VERY IMPORTANT THAT YOU REMEMBER TO RESPOND AS YOU WERE INSTRUCTED AT THE BEGINNING OF THE EXPERIMENT.** When you finish the first portion, please raise your hand and a research assistant will help you. To begin, click “Testing” then “Begin MSVT”. Select “English” and click “yes”. Click on the screen to begin the task.”

As students finish the immediate subtests of the MSVT, minimize the screen, and open the Memory Complaints Inventory. MSVTd must not be completed for 10 minutes.

MCI

☐ “Before we begin, the next measure, please turn to page 4 of your participant packet and review the information. Keep this in mind as we proceed through the experiment.”

☐ Say: “Before we begin, please confirm the ID number listed in the section for first and last name matches the ID number listed on your participant packet. Do not begin the measure until I say. **IT IS VERY IMPORTANT THAT YOU REMEMBER TO RESPOND AS YOU WERE INSTRUCTED AT THE BEGINNING OF THE EXPERIMENT.** When you finish the measure, please sit quietly. If you have any problems, please raise your hand. To begin this measure, please click “Testing” at the top of the screen and select Administer MCI. Then select English, and click the screen to begin. Remember to respond to the items as you were instructed at the beginning of the study. Please raise your hand if you have any issues or when you finish the measure.”

Once all students have been administered MCI, minimize the screen and re-open MSVT. Flip the paper over the screen. Once all participants have completed the MCI say

SDMT

☐ “Please turn to page 5 of your participant packet. This is a different task. Look at the boxes. Each box has a unique symbol and a number underneath. You are to fill in the numbers that correspond with each symbol. Start at the top left and work across the rows. When you come to the end of one row, move to the next. Work in order and do not skip any. When I say begin, please complete the first 10 boxes up to the thick line to practice.”

☐ Once everyone has finished, say: “When I say Begin, I want you to do the rest in the same way. Work in order and do not skip any. Work until I tell you to stop. **IT IS VERY IMPORTANT TO THAT YOU REMEMBER TO RESPOND AS YOU WERE INSTRUCTED AT THE BEGINNING OF THE EXPERIMENT** Begin”

☐ After 120s say “Stop. Please put your participant packet to the side.”

MSVTd

☐ Say "Please flip your paper over off the screen. On the top of the screen, find the section marked "Testing" and click "Resume MSVT. Follow the directions on the screen. Please perform in the manner instructed at the beginning of the study. When the screen asks for the password, please flip your paper over the screen."

i) Once all participants have completed this MSVT, say "Please turn to page 6 of your participant packet. I will say the first word in each pair. Please write down the word that went with it.

   ☐ Say "Ice. Which word went with ICE? If you're not sure, make your best guess." Allow time for all participants to respond.

   ☐ Say "Jet. Which word went with JET? If you're not sure, make your best guess."

   ☐ Say "Picture. Which word went with PICTURE? If you're not sure, make your best guess."

   ☐ Say "Skate. Which word went with SKATE? If you're not sure, make your best guess."

   ☐ Say "Clock. Which word went with CLOCK? If you're not sure, make your best guess."

   ☐ Say "Pizza. Which word went with PIZZA? If you're not sure, make your best guess."

   ☐ Say "Skipping. Which word went with SKIPPING? If you're not sure, make your best guess."

   ☐ Say "Soccer. Which word went with SOCCER? If you're not sure, make your best guess."

   ☐ Say "Gas. Which word went with GAS? If you're not sure, make your best guess."

   ☐ Say "Wood. Which word went with WOOD? If you're not sure, make your best guess."

ii) Say "Please turn to page 7 of your participant packet. Now I want you to write down all of the words you can remember from the original list. You can write them in any order, in pairs, or one at a time"

iii) When all participants have finished the MSVT say "Please turn to page 8 of your participant packet. Please complete the next two pages independently. Please respond to these items as yourself, NOT as you were instructed at the beginning of the study. If you are confused, please raise your hand. When you finish, please turn your packet over and sit quietly."

iv) Once all participants have completed the rating forms say "You have now completed participation in the current study. Thank you for your time today. Please sign the PSY 205 log as you leave and take a copy of the consent form. You will be awarded 1 hour of research participation for your help today."

Post Data Collection

2) Once participants leave, collect participant packets, and save MSVT and MCI data at each station and either prepare for the next subject or log off computers.

Table 1

Commonly used neuropsychological measures in concussion management

Measure	Ability Evaluated
Brief Visuospatial Memory Test-Revised[2]	Visual memory
California Verbal Learning Test[2]	Verbal memory
Continuous Performance Test[2]	Sustained attention, vigilance
Controlled Oral Word Association Test[1,2,3]	Word fluency, word retrieval
Cued Reaction Time[2]	
Delayed Recall from HVLT[3]	Delayed verbal memory
Digit Span[1,3]	Attention Span
Figure Detection[2]	Constructional Skills
Grooved Pegboard[1,3]	Motor speed, coordination
Halstead-Reitan Neuropsychological Test Battery[2]	Various
Hopkins Verbal Learning Test[1,2,3]	Verbal memory
Memory for Designs Test[2]	Visual Memory
Paced Auditory Serial Addition Test[2]	Complex attention, concentration
Reaction Times[2]	Visuospatial attention
Rey Auditory Verbal Learning Test[2]	Verbal memory, attention, concentration
Rey-Osterreith Complex Figure Test[2]	
Selective Reminding Test[2]	Verbal memory
Speed and Capacity of Language Processing Test[2]	Language comprehension, visual scanning, psychomotor speed
Stroop Test[3]	Mental flexibility, attention
Symbol Digit Modalities Test[1,2,3]	Visual Scanning, attention
Trailmaking Test[1,2,3]	Visual scanning, mental flexibility
Verbal Fluency Test[2]	Language
Wechsler Adult Intelligence Scale-Revised[2]	Psychomotor speed, visual memory, attention, concentration
Wechsler Memory Scale-Revised[2]	Verbal memory, visual memory, story learning, word learning
Wisconsin Card Sorting Task[2]	Executive functions, nonverbal problem solving

1 Collins et al., 1999
2 Grindel, Lovell, & Collins, 2001
3 Maroon et al., 2000

Table 2

Demographic characteristics of sample

	Fake Bad (n=53)		Fake Good (n=62)		No Incentive (n=56)		Total Sample (n=171)	
	n	%	*n*	%	*n*	%	*n*	%
Sex								
Male	17	32.1	28	45.2	14	25.0	59	34.5
Female	36	67.9	34	54.8	42	75.0	112	65.5
Year in School								
Freshman	28	52.8	28	45.2	34	60.7	90	52.6
Sophomore	6	11.3	9	14.5	7	12.5	22	12.9
Junior	13	24.5	16	25.8	8	14.3	37	21.6
Senior	6	11.3	9	14.5	7	12.5	22	12.9
Athletic Status								
Varsity Athlete	7	13.2	5	8.1	6	10.7	18	10.5
Club Athlete	8	15.1	11	17.7	7	12.5	26	15.2
Non-Athlete	37	69.8	46	74.2	40	71.4	123	71.9
No Response	1	1.9	0	0	3	5.4	4	2.3
Disability Status								
Non-disabled	51	96.2	60	96.8	54	96.4	165	96.5
Other	1	1.9	2	3.2	0	0	3	1.8
No Response	1	1.9	0	0	2	3.6	3	1.8
Concussion History								
No previous	40	75.5	51	82.3	51	91.1	142	83.0
1 concussion	8	15.1	9	14.5	4	7.1	21	12.3
2 concussions	5	9.4	2	3.2	0	0	7	4.1
3 concussions	0	0	0	0	1	1.8	1	0.6

Table 3

Domains of measurement, measures used, and dependent variables

Domains and Measures	Dependent Variables
Manipulation Check	
Memory Complaints Inventory	General Memory Problems score
Integrity of Intervention Form	Consistency Relative Performance Simulation Success
Effort Testing	
Medical Symptom Validity Test	Pass/Fail
Symptom Report	
Postconcussion Scale	Total Symptom Score Symptom Impairment
Neuropsychological Test Performance	
Immediate Post-Concussion Assessment and Cognitive Testing	Verbal Memory Visual Memory Visual Motor Speed Reaction Time
Symbol Digit Modalities Test	Number of correct items

Table 4

Kruskal-Wallis test using symptom score as the dependent variable

Group	*n*	Mean	Median	Mean Rank
Fake Bad	53	71.81	72.00	112.57
Fake Good	62	25.40	14.00	48.07
No Incentive	56	65.54	64.50	102.85

$\chi^2 = 58.21$, df (2), $p < .001$, $\mu^2 = .34$**
**Large effect size

Table 5

Post-hoc comparison using symptom score as the dependent variable

Groups	Mann-Whitney *U*	*Z*	*p*	*r*
Fake Bad – Fake Good	426.50	-6.84	<.001	.51**
No Incentive – Fake Good	601.00	-6.13	<.001	.41*

*Medium effect
**Large effect

Table 6

Crosstabulation and post-hoc comparison of symptom impairment by group

Symptom Report	Group					
	Fake Bad (*n*=53)	Fake Good (*n*=62)	No Incentive (*n*=56)	χ^2	*p*	ϕc
Impaired	53	35	52	43.03	< .001	.50**
Non-Impaired	0	27	4			

Symptom Report	Group				
	Fake Bad (*n*=53)	Fake Good (*n*=62)	χ^2	*p*	ϕ
Impaired	53	35	30.16	< .001	.51**
Non-Impaired	0	27			

	Group				
	No Incentive (*n*=56)	Fake Good (*n*=62)	χ^2	*p*	ϕ
Impaired	52	35	20.13	< .001	.41*
Non-Impaired	4	27			

*Medium effect
**Large effect

Table 7

Kruskal-Wallis tests using ImPACT index scores and SDMT as dependent variables

	Verbal Memory			
Group	*n*	Mean	Median	Mean
Fake Bad	53	61.26	62.00	60.58
Fake Good	62	84.15	88.00	115.38
No Incentive	56	68.96	72.00	77.32
$\chi^2 = 37.31$, $p < .001$, $\mu^2 = .22$**				
	Visual Memory			
Group	*n*	Mean	Median	Mean
Fake Bad	53	53.11	52.00	65.08
Fake Good	62	72.89	74.00	115.01
No Incentive	56	56.91	55.50	73.69
$\chi^2 = 34.23$, $p < .001$, $\mu^2 = .20$**				
	Visual Motor			
Group	*n*	Mean	Median	Mean
Fake Bad	53	27.21	27.28	61.92
Fake Good	62	39.05	37.83	113.08
No Incentive	56	31.28	33.88	78.81
$\chi^2 = 32.28$, $p < .001$, $\mu^2 = .19$**				
	Reaction Time			
Group	*n*	Mean	Median	Mean
Fake Bad	53	.91	.74	100.21
Fake Good	62	.64	.63	66.95
No Incentive	56	.83	.69	93.64
$\chi^2 = 14.89$, $p = .001$, $\mu^2 = .09$*				
	SDMT			
Group	*n*	Mean	Median	Mean
Fake Bad	53	50.36	51.00	61.83
Fake Good	62	70.87	71.50	113.56
No Incentive	56	56.59	57.50	78.36
$\chi^2 = 33.20$, $p < .001$, $\mu^2 = .20$**				

*Medium effect

**Large effect

Table 8

Post-hoc comparison of group and ImPACT index and SDMT scores

	Verbal Memory			
Contrast	Mann-Whitney *U*	*Z*	*p*	*r*
Fake Bad – Fake Good	634.50	-5.66	<.001	.53**
No Incentive – Fake Good	923.00	-4.38	<.001	.40*

	Visual Memory			
Contrast	Mann-Whitney *U*	*Z*	*p*	*r*
Fake Bad – Fake Good	709.50	-5.24	<.001	.48*
No Incentive – Fake Good	871.00	-4.66	<.001	.43*

	Visual Motor Speed			
Contrast	Mann-Whitney *U*	*Z*	*p*	*r*
Fake Bad – Fake Good	674.50	-5.43	<.001	.51**
No Incentive – Fake Good	1025.50	-3.83	<.001	.35*

	Reaction Time			
Contrast	Mann-Whitney *U*	*Z*	*p*	*r*
Fake Bad – Fake Good	1023.50	-3.48	.001	.32*
No Incentive – Fake Good	1174.50	-3.03	.002	.28*

	SDMT			
Contrast	Mann-Whitney *U*	*Z*	*p*	*r*
Fake Bad – Fake Good	622.00	-5.73	<.001	.52**
No Incentive – Fake Good	1048.00	-3.71	<.001	.34*

*Medium effect
**Large effect

Table 9

Group means, and standard deviations for MSVT

	Fake Bad (*n*=53)	Fake Good (*n*=62)	No Incentive (*n*=56)
MSVT Immediate Recall	73.96 (27.20)	98.47 (5.77)	80.63 (26.18)
MSVT Delayed Recall	70.00 (27.54)	98.23 (3.15)	78.48 (27.20)
MSVT Consistency	73.21 (21.17)	96.85 (6.85)	83.66 (18.89)
MSVT Paired Recall	67.36 (26.97)	96.29 (10.28)	75.00 (27.44)
MSVT Free Recall	47.36 (20.65)	70.10 (21.16)	52.77 (25.95)

Table 10

Crosstabulation and post-hoc comparisons of group and effort test failure

Effort Test	Group					
	Fake Bad (n=53)	Fake Good (n=62)	No Incentive (n=56)	χ^2	p	ϕc
Passed	19	60	31	49.14	< .001	.54**
Failed	34	2	25			

Effort Test	Group				
	Fake Bad (n=53)	Fake Good (n=62)	χ^2	p	ϕ
Passed	19	60	49.32	< .001	.66**
Failed	34	2			

	Group				
	No Incentive (n=56)	Fake Good (n=62)	χ^2	p	ϕ
Passed	31	60	28.60	< .001	. 49*
Failed	25	2			

*Medium effect
**Large effect

Table 11

Comparison of current results to similar studies

Current Study

Measure	Fake Bad (*n* = 53)		Fake Good (*n* = 62)		No Incentive (*n* = 56)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Symptom Score	71.81	24.32	25.40	31.05	65.54	28.16
Verbal Memory	61.26	21.17	84.15	14.33	68.96	20.07
Visual Memory	53.11	19.73	72.89	13.38	56.91	17.92
Visual Motor	27.21	11.36	39.05	6.88	31.28	10.95
Reaction Time	.91	.44	.64	.10	.83	.37
SDMT Raw	50.36	21.06	70.87	14.65	56.59	19.97

Similar Studies

Measure	Broglio et al., 2007 MTBI Athletes (*n* = 21)		Iverson et al., 2005 MTBI Athletes (*n* = 72)		Schatz et al., 2006 MTBI Athletes (*n* = 72)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Symptom Score	25.86	20.45	17.40	16.30	26.50	22.10
Verbal Memory	78.00	19.00	81.20	12.40	79.10	12.30
Visual Memory	64.00	14.00	72.30	14.90	65.90	14.80
Visual Motor	36.06	10.40	35.60	8.30	32.70	7.50
Reaction Time	.66	.18	.58	.12	.66	.15
SDMT Raw			58.00	10.00		

References

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (Revised 4th ed.). Washington, DC: Author.

Aubry, M., Cantu, R., Dvorak, J., Graf-Baumann, T., Johnston, K., Kelly, J., Lovell, M., McCrory, P., Meeuwisse, W., & Schamasch, P. (2002). Summary and agreement statement of the first International Conference of Concussion in Sport, Vienna 2001. *British Journal of Sports Medicine, 36,* 6-10.

Banerjee, M., & Shaw, S. F. (2007). High-stakes test accommodations: Documentation review by testing agencies in an era of change. *Assessment for Effective Intervention, 32,* 171-180.

Barr, W. B. (2001). Methodologic issues in neuropsychological testing. *Journal of Athletic Training, 36,* 297–302.

Barth, J. T., Alves, W. A., Ryan, T., Macciocchi, S. N., Rimel, R. W., Jane, J. A., & Nelson, W. E. (1989). Mild head injury in sports: Neuropsychological sequelae and recovery of function. In H. S. Levin, H. M., Eisenberg, & A. R. Benton (Eds.), *Mild Head Injury* (pp. 257-275). New York: Oxford Press.

Benedict, R.H.B. (1997). *Brief Visuospatial Memory Test–Revised: Professional manual*. Odessa, FL: Psychological Assessment Resources, Inc.

Bianchini, K. J., Curtis, K. L., & Greve, K. W. (2006). Compensation and malingering in traumatic brain injury: A dose-response relationship? *The Clinical Neuropsychologist, 20,* 831-847.

Bigler E. D. (2008). Neuropsychology and clinical neuroscience of persistent post-concussive syndrome. *Journal of the International Neuropsychological Society, 14*, 1-22.

Binder, L. M. (1986). Persisting symptoms after mild head injury: A review of postconcussive syndrome. *Journal of Clinical and Experimental Neuropsychology, 8*, 323-346.

Brennan, A. M., Meyer, S., David, E., Pella, R., Hill, B. D., & Gouvier, W. (2009). The vulnerability to coaching across measures of effort. *The Clinical Neuropsychologist*, *23,* 314-328. doi:10.1080/13854040802054151.

Brolio, S. P., Ferrara, M. S., Macciocchi, S. N., Baumgartner, T. A., & Elliot, R. (2007). Test-retest reliability of computerized concussion assessment programs. J*ournal of Athletic Training, 42,* 509-514.

Broglio, S. O., Macciocchi, S. N., & Ferrara, M. S. (2007). Neurocognitive performance of concussed athletes when symptom free. *Journal of Athletic Training*, *42*, 504-508.

Brooks, D. A. (2007). Use of computer based testing of youth hockey players with concussion. *Neurorehabilitation, 22,* 169-179.

Bush, S. S., Ruff, R. M., Troster, A. ., Barth, J. T., Koffler, S. P., Pliskin, N. H., Reynolds, C. R., & Silver, C. H. (2005). Symptom validity assessment: Practice issues and medical necessity. *Archives of Clinical Neuropsychology, 20*, 419-426.

Butcher, J. N., Graham, J. R., Ben-Porath, Y. S., Tellegen, A., Dahlstrom, W. G., & Kaemmer, B. (2001). *MMPI-2: Manual for administration, scoring, and interpretation*

(Rev. ed.). Minneapolis: University of Minnesota Press.

Cantu R. C. (1998). Second-impact syndrome. *Clinics in Sports Medicine*, *17*, 37-44.

Cantu R. C., & Gean A. D. (2010). Second-impact syndrome and a small subdural hematoma: An uncommon catastrophic result of repetitive head injury with a characteristic imaging appearance. *Journal of Neurotrauma*, *27*, 1557-64.

Carone, D. (2008). Children with moderate/severe brain damage/dysfunction outperform adults with mild-to-no brain damage on the Medical Symptom Validity Test. *Brain Injury, 22*, 960-971.

Carone, D., Iverson, G. L., & Bush, S. S. (2010). A model to approaching and providing feedback to patients regarding invalid test performance in clinical neuropsychological evaluations. *The Clinical Neuropsychologist, 24*, 759-778.

Cato, M., Brewster, J., Ryan, T., & Giuliano, A. J. (2002). Coaching and the ability to simulate mild traumatic brain injury symptoms. *The Clinical Neuropsychologist, 16*, 524-535. doi:10.1076/clin.16.4.524.13901.

Centers for Disease Control. *What is Brain Injury?* Retrieved May 21, 2010 from: http://www.cdc.gov/ncipc/tbi/TBI.htm.

Chan, R. K. (2001). Base rate of post-concussion symptoms among normal people and its neuropsychological correlates. *Clinical Rehabilitation, 15*, 266-273.

Collins, M. W., Grindel, S. H., Lovell, M. R., Dede, D. E., Moser, D. J., Phalin, B. R., … McKeag, D. B. (1999). Relationship between concussion and neuropsychological performance in college football players. *Journal of the American Medical Association, 282*, 964-970.

Conners, C., Erhardt, D., & Sparrow, E. (1998). *The Conners Adult ADHD Rating Scale* (CAARS). Toronto Multi-Health Systems Inc.

Constantinou, M., Bauer, L., Ashendorf, L., Fisher, J. M., & McCaffrey, R. J. (2005). Is poor performance on recognition memory effort measures indicative of generalized poor performance on neuropsychological tests? *Archives of Clinical Neuropsychology, 20*, 191-198.

Demakis, G. J. (1999). Serial malingering on verbal and nonverbal fluency and memory measures: An analog investigation. *Archives of Clinical Neuropsychology, 14,* 401-410.

Demakis, G. J. (2004). Applicability of clinically-derived malingering cutoffs on the California Verbal Learning Test and the Wechsler Adult Intelligence Test-Revised to an analog malingering study. *Applied Neuropsychology, 11*, 220-226.

De Monte, V. E., Geffen, G. M., May, C. R., & McFarland, K. (2009). Improved sensitivity of the rapid screen of mild traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology, 32*, 19-27.

Dunn, T. M., Shear, P. K., Howe, S., & Ris, M. (2003). Detecting neuropsychological malingering: Effects of coaching and information. *Archives of Clinical Neuropsychology, 18*(2), 121-134. doi:10.1016/S0887-6177(01)00188-3.

Eccles, J. S. (2005). Subjective task value and the Eccles et al. model of achievement-related choices. In A.J. Elliot, C.S. Dweck (Eds.), *Handbook of Competence and Motivation* (pp. 105–121). New York: Guilford Press.

Erdal, K. (2004). The effects of motivation, coaching, and knowledge of neuropsychology on the simulated malingering of head injury. *Archives of Clinical Neuropsychology, 19,* 73-88. doi:10.1016/S0887-6177(02)00214-7.

Erdal, K. (2009). Why one fakes a head injury affects how one fakes a head injury. *Applied Neuropsychology*, *16*(1), 42-48. doi:10.1080/09084280802644136.

Erlanger, D., Feldman, D., Kutner, K., Kaushik, T., Kroger, H., Fester, J., Barth, J., Freeman, J., & Broshek, D. (2003). Development and validation of a web-based neuropsychological test protocol for sport-related return-to-play decision-making. *Archives of Clinical Neuropsychology, 18,* 293-316.

Eyres, S., Carey, A., Gilworth, G., Neumann, & Tennant, A. (2005). Construct validity and reliability of the Rivermead Post-Concussion Symptoms Questionnaire. *Clinical Rehabilitation, 19*, 878-887.

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences.
Behavior Research Methods, 39, 175-191.

Faul, M., Xu, L., Wald, M. M., & Coronado V. G. (2010). *Traumatic Brain Injury in the United States: Emergency Department Visits, Hospitalizations and Deaths 2002–2006.* Atlanta (GA): Centers for Disease Control and Prevention, National Center for Injury Prevention and Control.

Fazio, V., Lovell, M. R., Pardini, J., & Collins, M. W. (2007). The relationship between post-concussion symptoms and neurocognitive performance in concussed athletes. *NeuroRehabilitation, 22,* 207-216.

Ferguson, R. J., Mittenberg, W., Barone, D. F., & Schneider, B. (1999). Postconcussion syndrome following sports-related head injury: Expectation as etiology. *Neuropsychology, 13*, 582-589.

Flaro, L., Green, P. & Blaskewitz, N. (In press). Die bedeutung der beschwerdenvalidierung im kindesalter. *Praxis der Rechtspsychologie*.

Frazier, T. W., Frazier, A. R., Busch, R. M., Kerwood, M. A., & Demaree, H. A. (2008). Detection of simulated ADHD and reading disorder using symptom validity measures. *Archives of Clinical Neuropsychology, 23*, 501-509.

Frederick, R. (1997). *Validity Indicator Profile manual*. Minnetonka, MN: NCS Assessments.

Gessel, L. M., Fields, S. K., Collins, C. L., Dick, R. W., & Comstock, D. (2007). Concussions among United States high school and collegiate athletes. *Journal of Athletic Training, 42*, 495-503.

Gioia, G. A., Collins, M., & Isquith, P. K. (2008). Improving identification and diagnosis of mild traumatic brain injury with evidence: Pyschometric support for the Acute Concussion Evaluation. *Journal of Head Trauma Rehabilitation, 23*, 230-242.

Gioia, G. A., Isquith, P. K., Schneider, J. C., Vaughan, C. G. (2009). New approaches to assessment and monitoring of concussion in children. *Topics in Language Disorders, 29*, 266-281.

Green, P. (2003) *Memory Complaints Inventory* (program): Green's Publishing, Edmonton, Alberta, Canada: Green's Publishing.

Green, P. (2003, revised 2005) *Word Memory Test for Windows: User's manual and program*. Edmonton, Alberta, Canada: Green's Publishing.

Green, P. (2004). *Manual for the Medical Symptom Validity Test for Windows*. Edmonton, Canada: Green's Publishing.

Green, P. (2007). The pervasive influence of effort on neuropsychological tests. *Physical Medicine and Rehabilitation Clinics of North America*, *18*, 43-68.

Green, P., Allen, L. M., & Astner, K. (1995). *The Word Memory Test: A User's Guide to the Oral and Computer-Administered Forms,* US Version 1.1. Durham, NC: CogniSyst, Inc.

Green, P., Flaro, L., & Courtney, J. (2009). Examining false positives on the Word Memory Test in adults with mild traumatic brain injury. *Brain Injury*, *23*, 741-750.

Green P., Iverson, G. L., & Allen, L. (1999). Detecting malingering in head injury litigation with the Word Memory Test. *Brain Injury, 13*, 813-819.

Green, P., Rohling, M. M. L., Lees-Haley, P. R., & Allen, L. M. (2001). Effort has a greater effect on test scores than severe brain injury in compensation claimants. *Brain Injury, 15*, 1045-1060.

Greiffenstein, M. F., & Baker, W. J. (2003). Premorbid clues? Preinjury scholastic performance and present neuropsychological functioning in late concussion syndrome. *The Clinical Neuropsychologist*, *17*, 561-573.

Grindel, S. H., Lovell, M. R., & Collins, M. (2001). The assessment of sport-related concussion: The evidence behind neuropsychological testing and management. *Clinical Journal of Sports Medicine, 11*, 134-143.

Gorny, ., & Merten, T. (2005). Symptom information, warning, coaching: How do they affect successful feigning in neuropsychological assessment? *Journal of Forensic Neuropsychology, 4,* 71-97.

Gunstad, J., & Suhr, J. A. (2001). "Expectation as etiology" versus "the good old days": Postconcussion syndrome symptom reporting in athletes, headache sufferers, and depressed individuals. *Journal of the International Neuropsychological Society, 7,* 323-333.

Harrison, A. G. (2006). Adults faking ADHD: You must be kidding! *The ADHD Report, 14*(4), 1-7.

Harrison, A. G., Edwards, M. J., & Parker, K. C. H. (2007). Identifying students faking ADHD: Preliminary findings and strategies for detection. *Archives of Clinical Neuropsychology*, *22*, 577-588.

Henry, B., Moffitt, T. E., Caspi, A., Langley, J., & Silva, P. A. (1994). On the "Remembrance of Things Past": A longitudinal evaluation of the retrospective method. *Psychological Assessment, 6*(2), 92-101.

Hinton-Bayre, A., & Geffen, G. (2005). Comparability, reliability, and practice effects on alternate forms of the Digit Symbol Substitution and Symbol Digit Modalities Tests. *Psychological Assessment*, *17*, 237-241.

Hoge, C., McGurk, D., Thomas, J., Cox, A., Engel, C., & Castro, C. (2008). Mild Traumatic Brain Injury in U.S. Soldiers Returning from Iraq. *The New England Journal of Medicine, 358,* 453-63. doi: 1421641271).

Hunt, T. N., Ferrera, M. S., Miller, L. S., & Macciocchi, S. (2007). The effect of effort on baseline neuropsychological test scores in high school football athletes. *Archives of Clinical Neuropsychology, 22*, 625-621.

Iverson, G. L., Franzen, M. D., Lovell, M. R., & Collins, M. W. (2004). *Construct validity of ImPACT in athletes with concussions*. Paper presented at the annual conference of the National Academy of Neuropsychology, Seattle, WA. Abstract retrieved from http://impacttest.com/publications/page/reliability.

Iverson, G. L., & Lange, R. T. (2003). Examination of "Postconcussion-Like" symptoms in a healthy sample. *Applied Neuropsychology, 10*(3), 137-144.

Iverson, G. L., Lovell, M. R., & Collins, M. W. (2003). Interpreting change on ImPACT following sport concussion. *The Clinical Neuropsychologist, 17*, 460-467.

Iverson, G. L., Lovell, M. R., & Collins, M. W. (2005). Validity of ImPACT for measuring processing speed following sports-related concussion. *Journal of Clinical and Experimental Neuropsychology, 27*, 683-689. doi: 10.1081/138033390490918435

Jachimowicz, G., & Gesiselman, R. E. (2004). Comparison of ease of falsification of attention deficit hyperactivity disorder diagnosis using standard behavioral rating scales. *Cognitive Science Outline, 2*, 6-20.

Jelicic, M., Ceunen, E., Peters, M. V., & Merckelbach, H. (2011). Detecting coached feigning using the Test of Memory Malingering (TOMM) and the Structured Inventory of Malingered Symptomatology (SIMS). *Journal of Clinical Psychology, 67*(9), 850-855. doi:10.1002/jclp.20805.

Kay T. (1993). Mild traumatic brain injury committee of the head injury interdisciplinary special interest group of the American Congress of Rehabilitation Medicine. Definition of mild traumatic brain injury. *Journal of Head Trauma Rehabilitation, 8*, 86–87.

King, N., Crawford, S., Wenden, F., Moss, N., & Wade, D. (1995). The Rivermead Post Concussion Symptoms Questionnaire: A measure of symptoms commonly experienced after head injury and its reliability. *Journal of Neurology, 242*, 587-592.

Kirkwood, M. W., & Kirk, J. W. (2010). The base rate of suboptimal effort in a pediatric mild TBI sample: Performance on the Medical Symptom Validity Test. *The Clinical Neuropsychologist*, *24*, 860-872.

Kirkwood, M. W., Yeates, K.O., & Wilson, P. E. (2006). Pediatric sports-related concussion: A review of the clinical management of an oft-neglected population. *Pediatrics*, *117*, 1359-1371.

Landre, N., Poppe, C. J., Davis, N., Schmaus, B., and Hobbs, S. E. (2006). Cognitive functioning and postconcussive symptoms in trauma patients with and without mild TBI. *Archives of Clinical Neuropsychology*, *21*, 255-273.

Lang, S. C., Elliot, S. N., Bolt, & Kratochwill, T. R. (2008). The effects of testing accommodations on students' performances and reactions to testing. *School Psychology Quarterly*, *23*, 107-124. doi: 10.1037/1045-3830.23.1.107

Leahy, S. (April 27, 2011). Peyton Manning admits to tanking NFL's baseline concussion test. *USA Today*. Retrieved from http://content.usatoday.com/communities/thehuddle/post/2011/04/peyton-manning-admits-to-tanking-nfls-baseline-concussion-test/1#.T3JOjNVdXeQ

Lewandowksi, L., Lovett, B. J., Panahon, C. J., Lambert, T., & Systma, M. R. (2012, February). *Test accommodation preferences in college students.* Poster presentation at the 44th Annual Convention of the National Association of School Psychologists, Philadelphia, PA.

Lewandowski, L. J., & Rieger, B. (2009). The role of school psychologist in concussion. *Journal of Applied School Psychology, 25*, 95-110.

Lezak, M. D., Howieson, D. B., & Loring, D. W. (2004). *Neuropsychological Assessment* (4th Edition). New York: Oxford University Press.

Lindstrom, W., Lindstrom, J., Coleman, C., Nelson, J., & Gregg, N. (2009). The diagnostic accuracy of symptom validity tests when used with postsecondary students with learning disabilities: A preliminary investigation. *Archives of Clinical Neuropsychology, 24*, 659-669.

Little, D. M., Kraus, M. F., Joseph, J., Geary, E. K., Susmaras, T., Zhou, X. J., Pliskin, N., & Gorelick, P. B. (2010). Thalamic integrity underlies executive dysfunction in traumatic brain injury. *Neurology, 74*, 558-564.

Lovell, M. R. (2006). *Technical Manual: Immediate Post-concussion Assement and Cognitive Testing*. Pittsburgh, PA: NeuroHealth Systems, LLC.

Lovell, M. R., Collins, M. W., Iverson, G. L., Field, M., Maroon, J. C., Cantu, R., Podell, K., Powell, J. W., Belza, M., & Fu, F. H. (2003). Recovery from mild concussion in high school athletes. *Journal of Neurosurgery, 98*, 296-301.

Lovell, M. R., Collins, M. W., Iverson, G. L., Johnston, K. M., & Bradley, J. P. (2004). Grade I or "ding" concussions in high school athletes. *American Journal of Sports Medicine, 32,* 47-54.

Lovell, M. R., Collins, M. W., Podell, K., Powell, J., & Maroon, J. C. (2000). *ImPACT: Immediate Post-concussion Assessment and Cognitive Testing*. Pittsburgh, PA: NeuroHealth Systems, LLC.

Maroon, J. C., Lovell, M. R., Norwig, J., Podell, K., Powell, J., & Hartl, R. (2000). Cerebral concussion in athletes: Evaluation and neuropsychological testing. *Neurosurgery, 47,* 659-672.

McCrory, P., Johnston, K., Meeuwisse, W., Cantu, R., Dvorak, J., Graf-Baumann, T., Kelly, J....Schamasch, P. (2005). Summary and agreement statement of the second international conference on concussion in sport: Prague 2004. *The Physician and Sports Medicine, 33*(4), 29-44.

McGrew, K. S., & Woodcock, R. W. (2001). *Technical manual. Woodcock–Johnson-III*. Itasca, IL: Riverside Publishing.

Merten, T., Green, P., Henry, M., Blaskewitz, N. & R. Brockhaus. (2005). Analog validation of German-language symptom validity tests and the influence of coaching. *Archives of Clinical Neuropsychology 20,* 719–726.

Mittenberg, W., Patton, C., Canyock, E. M., & Condit, D. C. (2002). Baserates of malingering and symptom exaggeration. *Journal of Clinical and Experimental Neuropsychology, 24,* 1094-1102.

Mittenberg, W., Theroux-Fichera, S., Zielinski, R. E., & Heilbronner, R. L. (1995). Identification of malingered head injury on the Wechsler Adult Intelligence Scale-Revised. *Professional Psychology: Research and Practice, 26*, 491-498.

Moser, R. S., Iverson, G. L., Echemendia, R. J., Lovell, M. R., Schatz, P., Webbe, F. M.,…Barth, J. T. (2007). NAN Position Paper: Neuropsychological evaluation in the diagnosis and management of sports-related concussion. *Archives of Clinical Neuropsychology*, *22*, 909-916.

Mulhern, S., & McMillan, T. M. (2006). Knowledge and expectation of postconcussion symptom in the general population. *Journal of Psychosomatic Research, 61*, 439-445.

Naunheim, R. S., Matero, D., & Fucetola, R. (2008). Assessment of patients with mild concussion in the emergency department. *Journal of Head Trauma Rehabilitation*, *23*(2), 116-122.

Nelson, N. W., Boone, K., Dueck, A., Wagener, L., Lu, P., & Grills, C. (2003). Relationship between eight measures of suspect effort. *The Clinical Neuropsychologist*, *17*, 263-272.

Orey, S. A., Cragar, D. E., & Berry, D. R. (2000). The effects of two motivational manipulations on the neuropsychological performance of mildly head-injured college students. *Archives Of Clinical Neuropsychology*, *15*, 335-348. doi:10.1016/S0887-6177(99)00024-4

Osmon, D. C., & Mano, Q. R. (2008). Malingered attention deficit hyperactivity disorder: Effort, depression, and dependence in the pursuit of academic accommodations.

In J. E. Morgan & J. J. Sweet (Eds.), *Neuropsychology of Malingering Handbook* (pp. 386-397). New York: Psychology Press.

Ozen, L. J., & Fernandez, M. A. (2011). Effects of "Diagnosis Threat" on cognitive and affective functioning long after mild head injury. *Journal of the International Neuropsychological Society, 17,* 219-229. doi:10.1017/S135561771000144X

Pitoniak, M. J., & Royer, J. M. (2001). Testing accommodations for examinees with disabilities: A review of psychometric, legal, and social policy issues. *Review of Special Education Research, 71*, 53-104.

Ponsford, J., Willmott, C., Rothwell, A., Cameron, P., Ayton, G.,...Ng, K. (2001). Impact of early intervention on outcome after mild traumatic brain injury in children. *Pediatrics*, *108*, 1297-1303.

Raine, M. (2009). Helping advocates to understand the psychological diagnosis and assessment of malingering. *Psychiatry, Psychology, and Law, 16*, 322-328.

Randolph, C., Millis, S., Barr, W. B., McCrea, M., Guskiewicz, K. M., Hammeke, T. A., & Kelly, J. P. (2009). Concussion Symptom Inventory: An empirically derived scale for monitoring resolution of symptoms following sport-related concussion. *Archives of Clinical Neuropsychology, 24*, 219-229.

Rees, L. M., Tombaugh, T. N., Gansler, D. A., & Moczynski, N. P. (1998). Five validation experiments of the Test of Memory Malingering (TOMM). *Psychological Assessment*, *10,* 10-20.

Rey, A. (1964). *L'examen Clinique ex psychologie.* Paris: Presses Universitaires de France.

Richman, J., Green, P., Gervais, R., Flaro, L., Merten, T., Brockhaus, R., & Ranks, D. (2006). Objective tests of symptom exaggeration in independent medical examinations. *Journal of Occupational and Environmental Medicine, 48*, 303-311.

Rogers, R. (Ed.). (2008). *Clinical Assessment of Malingering and Deception* (3^{rd} Ed.). New York: Guilford Press.

Rogers, R., & Cruise, C. R. (1998). Assessment of malingering with simulation designs: Threats to external validity. *Law and Human Behavior*, *22*, 273-285.

Rogers, R., Sewell, K. W., Martin, M. A., & Vitacco, M. J. (2003). Detection of feigned mental disorders: A meta-analysis of the MMPI-2 and malingering. *Assessment, 10*, 160-177.

Ropper, A. H., & Gorson, K. C. (2007). Clinical practice: Concussion. *The New England Journal of Medicine, 356*, 166-172.

Ruff, R. M., Wylie, T., & Tennant, W. (1993). Malingering and malingering-like aspects of mild closed head injury. *Journal of Head Trauma Rehabilitation*, *8*, 60-73.

Sarmiento, K., Mitchko, J., Klein, C., & Wong, S. (2010). Evaluation of the Centers for Disease Control and Prevention's concussion initiative for high school coaches "Heads Up: Concussion in High School Sports." *Journal of School Health, 80*(3), 112-118. doi: 10.1111/j.1746-1561.2010.00491.x.

Sbordone, R. J., Saul, R. E., & Purisch, A. D. (2007). *Neuropsychology for psychologists, health sare professionals, and attorneys* (3rd Ed.). Boca Raton, FL: CRC Press.

Schatz, P., Pardini, J. E., Lovell, M. R., Collins, M. W., & Podell, K. (2006). Sensitivity and specificity of the ImPACT test battery for concussion in athletes. *Archives of Clinical Neuropsychology, 21*, 91-99.

Shuttleworth-Edwards, A. B. (2009). Convolutions of the silent sports concussion: A neuropsychologists' response to the dark ages of rule-based return-to-play decisions. *Archives of Neurology, 66,* 420-421.

Sigurdardottir, S., Andelic, N., Roe, C., Jerstad, T., & Schanke, A. (2009). Post-concussion symptoms after traumatic brain injury at 3 and 12 months post-injury: A prospective study. *Brain Injury, 23*(6), 489-197. doi: 10.1080/02699050902926309.

Singhal, A., Green, P., Ashaye, K., Shankar, K., & Gill, D. (2009). High specificity of the Medical Symptom Validity Test in patients with very severe memory impairment. *Archives of Clinical Neuropsychology, 24*, 721-728.

Slick, D., Hopp, G., Strauss, E., & Thompson, G. B. (1997). *Victoria Symptom Validity Test, Professional Manual.* Odessa, TX: Psychological Assessment Resources.

Slick, D. J., Tan, J. E., Strauss, E. H., & Hultsch, D. F. (2004). Detecting malingering: A survey of experts' practices. *Archives of Clinical Neuropsychology, 19*, 465-473.

Slobounov, S. M., Zhang, K., Pennell, D., Ray, W., Johnson, B., & Sebastianelli, W. (2010). Functional abnormalities in normally appearing athletes following mild traumatic brain injury: A functional MRI study. *Experimental Brain Research, 202*(2), 341-354. doi: 10.1007/s00221-009-2141-6.

Smith, A. (1982). *Symbol Digits Modalities Test*. Western Psychological Services, Los Angeles.

Snell, F. L., & Halter, M. J. (2010). A signature wound of war: Mild traumatic brain injury. *Journal of Psychosocial Nursing and Mental Health Services, 48*(2), 22-28.

Sterr, A., Herron, K. A., Hayward, C., & Montaldi, D. (2006). Are mild head injuries as mild as we think? Neurobehavioral concomitants of chronic post-concussion syndrome. *BMC Neurology, 6*(7). Retrieved February 10, 2009 from http://www.biomedcentral.com/1471-2377/6/7.

Sullivan, B. K., May, K., & Galbally, L. (2007). Symptom exaggeration by college adults in attention-deficit hyperactivity disorder and learning disorder assessments. *Applied Neuropsychology, 14*, 189-207.

Suhr, J. A. & Gunstad, J. (2002). "Diagnosis threat": The effect of negative expectations on cognitive performance. *Journal of Clinical and Experimental Neuropsychology, 24*, 448– 457.

Swaine, B. R, & Friedman, D. S. (2001). Activity restrictions as part of the discharge management for children with a traumatic head injury. *The Journal of Head Trauma Rehabilitation, 16*, 292-301.

Sweet, J. J., Wolfe, P., Sattleberger, E., Numan, B., Rosenfeld, J. P., Clingerman, S., & Nies, K. J. (2000). Further investigation of traumatic brain injury versus insufficient effort with the California Verbal Learning Test. *Archives of Clinical Neuropsychology, 15*, 105-113.

Tellegen, A., & Ben-Porath, Y. S. (2008). *MMPI-2-RF technical manual*. Minneapolis, MN:University of Minnesota Press.

Thomas, M. L., & Youngjohn, J. R. (2009). Let's not get hysterical: Comparing the MMPI-2 validity, clinical, and RC scales in TBI litigants tested for effort. *The Clinical Neuropsychologist, 23*, 1067-1084.

Tombaugh, T. (1996). *Test of Memory Malingering*. Toronto, Ontario, Canada: Multi-Health Systems.

Tukey, J.W. (1977). *Exploratory Data Analysis.* Reading, MA: Addison-Wesley.

Vallerand, R. J. (2004). Intrinsic and extrinsic motivations in sport. In C. Spielberger (Ed) *Encyclopedia of Applied Psychology: Volume 2* (pp. 427-435). Elsevier Academic Press: New York.

Van Kampen, D. A., Lovell, M. R., Pardini, J. E., Collins, M. W., & Hu, F. H. (2006). The "value added" of neurocognitive testing after sports-related concussion. *American Journal of Sports Medicine, 34*, 1630-1635. doi: 10.1177/0363546506288677.

Weiten, W. (2010). *Psychology Themes and Variations* (8th Ed.). Wadsworth: Belmont, CA.

Yeates, K. O., Luria, J., Bartkowski, H., Rusin, J., Martin, L., & Bigler, E. D. (1999). Postconcussive symptoms in children with mild closed head injuries. *The Journal of Head Trauma Rehabilitiation, 14*, 337-350.

Yeates, K. O., & Taylor, H. G. (2005). Neurobehavioral outcomes of mild head injury in children and adolescents. *Pediatric Rehabilitation, 8*, 5-16.

Zillmer, E. A., Spiers, M. V., & Culbertson, W. C. (2008). *Principles of neuropsychology* (2nd Ed.). Belmont, CA: Thomson Higher Education.

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