Neuropsychology in the Military

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Neuropsychology is the science and study of brain-behavior relationships and the clinical application of that knowledge. Neuropsychology has received a remarkable increase in political and media attention, research funding, and academic interest over the past few decades. Indeed, the 1990s were known as the "Decade of the Brain."

Neuropsychology in the military, in many ways, has been influential in driving the field forward (e.g., History [of DVBIC], 2016). Military neuropsychology has expanded into multiple subspecialties, and a vast literature of peer-reviewed publications, edited and non-edited volumes, list serves, media outlets, and blog posts have been published. The vastness of the available information makes it quite challenging to summarize the history, theory, science, treatment, complex issues, and the future directions of military neuropsychology.

The purpose, therefore, of this chapter is to serve as an introductory primer for learners of all experience levels to be exposed to some of the nuances of neuropsychology and its relationship to the Armed Forces. For those interested in further study, several volumes have been published which expand on many of the topics herein (e.g., Bush, 2012; Kennedy & Moore, 2010).

Neuropsychology in the Armed Forces

The relevance of any topic is an extremely important consideration. It is, therefore, useful to ask, "Is the study of brain-behavior relationships relevant in a military context? And if so, why?" As you will read in the pages below, neuropsychology in the military is not just a good idea whose time has come, but a proven force multiplier useful in many military applications. It does not take much imagination, reading of military histories, or review of military epidemiological studies to appreciate that a potential tragic result of engaging in and preparing for

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armed combat is the possibility of experiencing a neurologic injury (DePalma, 2015). These injuries may lead to a number of sensorial, motoric, emotional, or cognitive difficulties. Indeed, the primary mission and application for neuropsychology in an armed forces context is to help service members (SMs) who have experienced neurologic disorders or injuries by providing assessment, diagnosis, and treatment plans to foster effective recovery (McCrea et al., 2008).

Although traumatic brain injury (TBI) is one of the most commonly occurring neurological conditions (impacting nearly 350,000 SMs; DBVIC, 2016), SMs experience multiple neurologic disorders and injuries. These disorders and injuries can be quite varied (e.g., seizure disorders, cerebral vascular accidents, neoplasms, neurodegenerative conditions, hypoxia, and psychiatric conditions which affect cognitive functioning) and may result in a host of neuropsychiatric (e.g., emotional dysregulation), neurobehavioral (e.g., sleep dysregulation, disinhibition, movement disorders), and neurocognitive sequelae (e.g., deficits in attention/concentration, processing speed, memory, etc. Holster et al., 2016; Raymont, Salazar, Krueger, & Grafman, 2011).

It is within this context that neuropsychologists use standardized assessment measures to evaluate patients' cognitive and emotional functioning in order to provide data to improve the rehabilitation focus of the multidisciplinary medical treatment team and to help optimize health outcomes (Vanderploeg et al., 2008). Understanding the neuropsychological strengths and weaknesses of an individual can provide family members and patients with an important context and narrative to understand various behaviors, guide rehabilitation and treatment planning, facilitate return to duty and vocational placement determinations, and help determine cognitive capacity/decision-making abilities in medicolegal contexts.

Neurocognitive measures have also been used to evaluate pre-deployment cognitive abilities. This "premorbid" assessment provides baseline data in the event an SM experiences a neurologic injury (Vasterling et al., 2012) and can help predict the likelihood that an SM may experience various psychiatric conditions related to deployments to dangerous and austere environments (Sørensen, Anderson, Karstoft, & Madsen, 2016). This process allows neuropsychologists to compare pre-injury cognitive and psychological test scores with post-injury test scores to determine whether any changes in functioning have occurred and facilitate treatment planning and return to duty decisions (Dretsch, Kelly, Coldren, Parish, & Russell, 2015).

Cognitive pre- and post-testing has also been used to assess the utility of treatment interventions to help guide the progression of treatment focus as it evolves over time (Cicerone, et al., 2008; Holleman, Vink, Nijland, & Schmand, 2016). This method can also be used when a patient requires neurosurgical intervention to assess presurgical functioning as well as potential deficits acquired from neurosurgery. Oftentimes, patients who have received neurosurgical intervention will have serial neuropsychological evaluations (e.g., approximately every 12–24 months) to assess recovery and responses to intervention.

In addition to helping predict and measure outcomes, the study of brain-behavior relationships also helps improve our understanding of how to prevent neurologic disorders and injuries (Manoogian, McNeely, Duma, Brolinson, & Greenwald, 2006; Olvey, Knox, & Cohn, 2004). As we learn more about what the limitations and vulnerabilities of the brain are, we can then intervene to prevent neurologic problems through education, training, better equipment, and improved tactical engagement (Kaul et al., 2016). For example, combat helmets have undergone considerable changes from World War I to today and will likely continue to evolve with our understandings of brain-behavior relationships and the improved effectiveness of current equipment (Committee on Review of Test Protocols Used by the DoD to Test Combat Helmets, Board on Army Science and Technology, Division on Engineering and Physical Sciences, & National Research Council, 2014).

A Brief History of Neuropsychology in the Armed Forces

While neuropsychology has existed in its current form for the past several decades, behavioral manifestations of neurological injury have been documented on Egyptian papyrus dating back to 3000 BCE (Kulas & Naugle, 2003). Over the next few millennia, further attempts at identifying brain localization dysfunction were theorized by Hippocrates (believed the brain to be the seat of intelligence), Aristotle (believed that humans had higher cognitive/rational functions separating them from "beasts"), Galen (denied mind-body dualism), Descartes (advocated the most widely accepted conceptualization of mind-body dualism), Gall (phrenology and localization of function), and, finally, by the nineteenth century Paul Broca (localization of expressive language function; Puente, 1992). Most of these historical advances were based on religion, philosophy, gross anatomical observations, and single case studies of brain lesions. With the advances of neurology, neuroscience, psychology, and neuroimaging, modern neuropsychology is vastly different from its early origins in both form and application.

Contemporary (Neuro) Psychological Assessment

One of the first applications of contemporary assessment of behavioral functioning was implemented in the US military during World War I. In 1917 Robert Woodworth implemented a group personality test called the Personal Data Sheet which laid the foundation for modern personality testing including advanced psychometrics. In the same year, the president of the American Psychological Association, Dr. Robert Yerkes, worked with Lewis Terman (publisher of the Stanford-Binet IQ test) and David Wechsler (eventual creator of the Wechsler Adult Intelligence Scale) to create the Army alpha and beta tests, which were used during the screening process for Army recruits to disqualify those with intellectual disabilities (Cardona & Ritchie, 2007). While cognitive testing was a valuable tool in the screening process for potential enlistees, the various psychiatric screening tests developed during subsequent conflicts were overall ineffective in predicting compatibility with military service and were found to be useful only in screening out the most serious mental illnesses.

The Expansion of Military (Neuro) Psychology

Toward the end of World War II and during the postwar period, the role of military psychologists expanded beyond that of military personnel selection adding clinical psychologists who primarily focused on clinical assessment and treatment and with the Army introducing behavioral scientists via the research psychologist (71F) occupational specialty. Currently, there are approximately 30 research psychologists who are engaged in laboratory-based "neuroscience, human performance, sleep management, psychosocial and environmental stressors, personality and social/organizational factors, leadership, and occupational health" (Kennedy & Moore, 2010; U.S. Army Research Psychologist, 2012).

This increase in the breadth of the role of military psychologists, as well as an increase in the number of psychologists employed as service members themselves, began a new era of assessing, treating, and rehabilitating those with psychological wounds. Additionally, as technology continued to advance weaponry, battlefield medicine simultaneously evolved and became increasingly more effective. Thus, injuries that would have led to almost certain death in past conflicts (e.g., polytrauma, penetrating head injuries, etc.) could now often be stabilized in a manner that would preserve life. However, while countless lives have been saved due to the advancement of battlefield medicine, many of these former life-threatening injuries have now expressed themselves as temporary or permanent disabilities. Whether these injuries are acute or chronic in nature, clinical neuropsychologists are uniquely qualified to assess, treat, and aid in the rehabilitation process when involving neurological, cognitive, and/or psychological sequelae.

Military Neuropsychology Training and Functions

Clinical neuropsychology is itself a relatively young specialty given that the formal training requirements for neuropsychologists were not established until 1982 by the newly formed American Board of Clinical Psychology (Puente, 1992). Shortly thereafter, the Air Force and Navy began offering neuropsychology fellowship training to their active duty clinical psychologists at civilian institutions. The Army began offering fellowship training a few years later at Walter Reed Army Medical Center and Tripler Army Medical Center (Kennedy & Moore, 2010). Walter Reed Army Medical Center was also the first military postdoctoral fellowship in neuropsychology to be accredited by the American Psychology Association. In 2008, the Army expanded fellowship training to a third site located at San Antonio Military Medical Center (SAMMC), formerly known as Brooke Army Medical Center. Then, in 2014, the Air Force established SAMMC as its primary fellowship training location (see Parker, 2017, Chap. 5).

Per estimates from the service-respective psychology consultants, of the approximately 600 active duty clinical psychology positions allocated between the three branches, 3–5% of the psychologists have completed fellowship training in clinical neuropsychology and are qualified to provide neuropsychological services. The three branches make a concerted effort to offer post-fellowship follow-on assignments at large military treatment facilities where the new neuropsychologists can apply their unique skillset. In addition to active duty neuropsychologists, a number of civil service and contract neuropsychologists are located at many military treatment facilities. These civilian neuropsychologists play a crucial role in the continuity of the garrison mission, to include overseeing training programs, as they do not typically deploy to combat zones like their active duty colleagues.

Neuropsychologists' contemporary functions within the military health system include assessment and treatment within the traditional mental health clinics, in stand-alone neuropsychology clinics, and in concussion clinics. At facilities with inpatient units, military neuropsychologists often provide initial assessment of mental status and cognitive functioning for acutely injured patients, then make recommendations to the rehabilitation staff. In outpatient settings, military neuropsychologists are often called upon to make fitness for duty recommendations, in addition to clarifying differential diagnoses.

Current DoD Research and Treatment Initiatives Involving Neuropsychology

There is an extensive history of research within the Department of Defense (DoD) involving neuropsychology. Across the past several years, the clinical needs of deployed service members who have experienced TBI have driven many of the research initiatives within the DoD. As mentioned above, nearly 350,000 active duty military service members have experienced a TBI (DVBIC, 2016). The majority of these injuries (82%) have been categorized as mild in severity, and as such, mild TBI (mTBI) has been the focus of several programs of research (DVBIC, 2016). Although a full review of these initiatives is beyond the scope of the current chapter, several will be highlighted.

The Naval Medical Center San Diego involves neuropsychologists in several ongoing research projects including the following: identification of novel assessment methods to track changes in individuals who continue to report concussion-related symptoms in the absence of positive neuroimaging or findings on neuropsychological evaluation, the comparison of different cognitive remediation strategies in a randomized controlled trial, assessment of effects associated with subconcussive blast exposures, evaluation of progressive return to activity interventions, and the study of long-term outcomes from mTBI in a 15-year longitudinal study. Among the broad range of research areas, military neuropsychologists have also been engaged in the evaluation of visual impairment following mTBI (Ettenhofer & Barry, 2016).

Womack Army Medical Center at Fort Bragg provides another example of extensive neuropsychological involvement in research. This program focuses on a wide range of concussion-related issues, including response patterns on symptom questionnaires and traditional neuropsychological test batteries (Belanger et al., 2016), computerized assessment of neurocognitive functioning after concussion (Cole et al., 2013; Cole Arrieux, Dennison, & Ivins, 2017), diagnosis and treatment of posttraumatic headache (Finkel et al., 2016; Yerry, Kuehn, & Finkel, 2015), manualized treatment for problems related to concussion sustained on deployment (Bell et al., 2015, 2016), oculomotor functioning as a biomarker for concussion (Walsh et al., 2016), and the effectiveness of clinical recommendations for how to safely return service members to duty after concussion.

Past studies have also collected data, including various symptom questionnaires and computerized neurocognitive testing, on over 17,000 army paratroopers (Ivins et al., 2003, 2015; Bailie et al., 2015) and have included an epidemiological study of soldier health after deployment. Current dissemination efforts are focused on clarifying the nature of cognitive functions being measured by computerized neurocognitive tests and the clinical utility of such tools. Future studies will investigate a novel dietary-based intervention for chronic posttraumatic headache, a prototype for assessing multiple oculomotor functions in one device as a potential postconcussion assessment tool, and cardiac functioning as an objective biomarker for concussion.

Validity Testing

Neuropsychologists across the DoD have also been heavily involved in the study of validity testing in service members with a history of mTBI from a variety of independent samples (Armistead-Jehle & Buican, 2012; Grills & Armistead-Jehle, 2016; Jones, 2013; Jones, Ingram, & Ben-Porath, 2012; Lange, Brickell, & French, 2015; Lange, Brickell, Lippa, et al., 2015). Additional work has been done on the neuropsychological correlates of posttraumatic stress disorder (for a review, see Vasterling, MacDonald, Ulloa, & Rodier, 2010), cognitive sequelae of sustained combat operations (for a review, see Holster et al., 2016), factors associated with neurocognitive performance in service members with a history of concussion (Armistead-Jehle, Cooper, & Vanderploeg, 2016; Cooper, Chau, Armistead-Jehle, Vanderploeg, & Bowles, 2012; Cooper, Vanderploeg, Armistead-Jehle, Lewis, & Bowles, 2014), and medically unexplained symptoms (Graver, in press; Graver & Bieliauskas, 2009).

Treatment Outcomes

In regard to treatment outcomes research, a recent prospective study at SAMMC evaluated response to cognitive rehabilitation (CR) in service members with a history of mTBI (Cooper et al., 2016). This randomized clinical trial demonstrated that therapist-directed CR and integrated CR with psychotherapy groups reduced participant's self-reported cognitive symptoms with greater efficacy than psychoeducation alone. Research from SAMMC involving neuropsychology has also demonstrated the benefit of multidisciplinary treatment (i.e., cognitive rehabilitation, vestibular therapy, headache management, and behavioral healthcare) in active duty military patients with a history of concussion (Janak et al., 2017).

Beyond these current trends in research activity, neuropsychology has played an integral role with regard to treatment within the DoD. Although neuropsychology is engaged across the spectrum of neurologic and psychiatric diagnoses, given the heightened demands of TBI-related care, much of the recent focus has been on this condition. Branches of the DoD require concussion specific clinics within military treatment facilities (MTF). As a function of the size of the MTF, different levels of care are mandated and resourced. Across the DoD, several of these clinics are managed by neuropsychologists, with these individuals running point on the direction and administration of TBI-related treatment.

Beyond MTF-based concussion clinics, a 4-week intensive outpatient program has been developed at the National Intrepid Center of Excellence (NICoE) at the Walter Reed National Military Medical Center (WRNMMC), Bethesda. This model of care utilizes neuropsychological services as an aspect of comprehensive interdisciplinary care. As an extension of the original

NICoE, five Intrepid Spirit Centers have been opened at major military installations across the continental United States (with four more planned in the upcoming years). These centers extend the NICoE interdisciplinary model of care with a focus on diagnosis and treatment (NICoE, 2016).

Complex Issues in Military Neuropsychology

As is true for most fields involved with novel research and treatment modalities, neuropsychology in the military is not without its debates. Given the limitations of this chapter, a brief review of some of the most salient issues will be summarized including concussion outcomes, blast wave vs. blunt force trauma, performance/symptom validity, Integrated Disability Evaluation System (IDES) evaluations and the diagnosis of malingering, and medically unexplained symptoms (i.e., somatoform disorders). Although the debates discussed herein do not exhaustively cover the debates in the field and are generally associated with neuropsychology as a science (that is, they are not uniquely associated with neuropsychology in the military), these issues are nevertheless germane to neuropsychology in the military for several reasons including the high number of SMs who experience neuropsychological concerns, their political- and media-related consequences, and potential disability- and/or disciplinary-related issues.

Concussion Outcomes

Concussion or mTBI has, perhaps erroneously, been called the "signature injury" of our current military engagements. That is, approximately 80% of concussions occur in garrison calling into question whether it is truly a deployment-related problem that has a higher representation than other battle-related injuries. However, this is not the only concern concussion researchers have encountered. There continues to be a vibrant debate in the literature regarding whether a small subset of individuals continue to experience symptoms that are directly related to the concussion after 3 months of recovery (Vasterling et al., 2012; Shenton et al., 2012). Generally speaking, there are two views on whether these persistent postconcussive symptoms (PPCS) such as headache, photophobia, phonophobia, sleep difficulties, dizziness, and psychiatric conditions, are caused by neurobiological sequelae from the concussion.

Proponents of the first view suggest that concussions are fundamentally different from more serious moderate or severe TBIs such that concussions should not be considered on the same continuum as the potentially more pernicious TBIs. They further suggest that, if symptoms following a concussion continue past 90 days (i.e., PPCS), these symptoms are not attributable to the concussion but to various other "non-specific" factors including sleep difficulties, psychosocial stressors, psychiatric disorders, and malingering and may perhaps be psychogenic in nature.

Proponents of the second view suggest that all severities of TBI occur on a spectrum from mild to severe and that there is a small but meaningful subset of individuals (often referred to as the "miserable minority") who continue to experience PPCS associated with neurobiological changes from the concussion. Many estimates of what percentage of individuals experience PPCS have been proffered and they vary considerably from study to study (e.g., from 0-15; for example see McCrea et al., 2013). Research in this area continues and will likely help clarify the nuances between these two views.

Blast Wave Versus Blunt Force Trauma

A related issue in the literature concerns the relationship between blunt-force traumatic brain injuries and blast-exposure brain injuries. Researchers have tried to identify whether mechanisms of injury are distinct from blunt-force injuries (e.g., MacDonald et al., 2014). Clarifying whether the mechanisms and potential neurobiological sequelae are similar in the two types of injuries is essential for developing and testing candidate therapies for rehabilitation purposes as well as for developing improved protective equipment to address each of the causes of injury (Courtney & Courtney, 2015). Interestingly, although recent research has suggested that the clinical outcomes of these two populations are similar (Dretsch et al., 2015), some have called into question the use of group inferential statistics in identifying group differences given the possibility that these statistical methods may mask individual differences (see Han et al., 2014; Iverson, 2010). Research is continuing in this area and is taking advantage of advanced technologies including multimodal neuroimaging and other biomarkers to help identify the potential differences in these two types of injuries.

Performance Validity

Another relevant debate is related to how SMs score on performance and symptom validity measures (PVT and SVT, respectively). These measures have skewed distributions such that the vast majority of individuals should be able to score above assigned cutoffs, suggesting that if a patient does not perform above the cutoff then it is more likely that factors not related purely to cognitive ability attenuated their performance (e.g., behavioral factors; it should be noted however that individuals with neurodegenerative processes or other neurological injuries may perform more poorly on these measures and that is taken into consideration when interpreting these measures).

Interestingly, there is ongoing research whether PVTs and SVTs perform in the way in which they are purported and whether cut scores adequately allow clinicians to interpret level of effort, motivation, and engagement in the tasks (for a comprehensive review, see Bigler, 2014). PVTs and SVTs are frequently included in neuropsychological test batteries to help determine whether the neurocognitive and psychological data are valid and SMs tend to not "pass" these measures at a higher rate even if they are not in a compensation and pension evaluation (approximately 25–35%; Armistead-Jehle & Buican, 2012; McCormick, Yoash-Gantz, McDonald, Campbell, & Tupler, 2013) compared to civilians (approximately 3–6%; Gfeller & Roskos, 2013).

Whether test data are valid is extremely important for data interpretation, diagnosis, and treatment planning. Data that are considered invalid, for example, may need to be interpreted with certain caveats (e.g., only intact scores are interpreted and may actually underestimate the patient's abilities and scores in the impaired range are not interpreted because they may overestimate the impairment). Interestingly, there are many reasons a patient's PVT and SVT data may be invalid including lacking motivation/energy, neurobiological underpinnings (e.g., seizure during testing, moderate to severe dementia, and active psychotic disorder), and feigning/exaggerating cognitive impairment to name a few.

Although the exact mechanism driving data invalidity in any given patient is often very difficult to discern, and may be contextually dependent (e.g., PVT and SVT failure in those in compensation and pension evaluations can be as high as 54–71%; Armistead-Jehle & Buican, 2012; Nelson et al., 2010; McCormick et al., 2013; Young, Kearns, & Roper, 2011), there are possible military disciplinary consequences. Specifically, if an individual is found to be feigning symptoms, they are potentially subject to the Uniform Code of Military Justice (UCMJ) given that Article 115 of the Manual for Courts-Martial (Joint Service Committee on Military Justice, 2012) states that "Any person subject to this chapter who for the purpose of avoiding work, duty, or service - (1) feigns illness, physical disablement, mental lapse or derangement; or (2) intentionally inflicts self-injury; shall be punished as a court-martial may direct" (IV-59 and IV 60). Although diagnosing malingering in a neuropsychological context is infrequent partly due to its politically charged nature, it is important to note that a malingering diagnosis may lead to punishment under the UCMJ.

Malingering

PVTs and SVTs are also closely related to another debate that involves IDES evaluations and the diagnosis of malingering. Neuropsychologists in the military and the Department of Veterans

Affairs (VA) healthcare systems are often asked to conduct evaluations to determine SMs' fitness for duty or level of disability. Interestingly, there is an inherent incentive for SMs and veterans to exaggerate or malinger symptoms in order to gain access to disability moneys, medical treatment, and other benefits. Individuals who exaggerate or malinger symptoms may be more likely to fail PVTs and SVTs and therefore may be candidates for a diagnosis of malingering if certain criteria are met.

The Army Office of the Surgeon General (OTSG) has given guidance on diagnosing malingering (OTSG/MEDCOM Policy 14-094, 2014) and stated the following:

> Although the influence of secondary gain is an important clinical consideration in the differential diagnosis, the diagnosis of malingering should not be made unless there is substantial and definitive evidence from collateral and/or objective sources that false or grossly exaggerated symptoms are intentionally produced for external incentives. Poor effort on psychological/neuropsychological tests does not equate to malingering, which requires proof of intent… (pg. 6).

Often included in discussions of this nature is guidance from the OTSG to give the "benefit of the doubt" to SMs when they are reporting symptoms even when the symptoms appear to be noncredible. Interestingly, some have interpreted the necessity for requiring "proof of intent" as a near impossibility and giving the benefit of the doubt as unethical. For example, Poyner (2010) pointed out that giving the benefit of the doubt makes conducting objective, ethically responsible assessments difficult given that empirical data may otherwise have to be ignored.

Medically Unexplained Symptoms

The final debate discussed herein relates to what is sometimes called medically unexplained symptoms. Neuropsychologists in the military are often referred patients who report cognitive difficulties but have no clear medical etiology that accounts for these problems. These patients frequently perform in the normal range of functioning on neurocognitive measures despite subjective complaints for cognitive inefficiencies or difficulties. They are then often described as not "demonstrating" the feared medical condition or are diagnosed with a somatoform disorder.

Somatoform disorders are principally conceptualized as involving medically unexplained symptoms, represent "sickness behaviors" (not biological sickness), and are therefore traditionally thought to be better explained by psychological processes (i.e., are psychogenic). That is, if the symptoms are not proven to be biologically driven, then there may be a psychological explanation. Notably, not only are somatoform disorders thought by some to have a psychological etiology, but most psychiatric disorders as defined in the DSM-5 (American Psychiatric Association, 2013) have no clear biological etiology and may therefore be characterized as psychogenic in nature, although they are rarely discussed as such in the current zeitgeist. For example, depression, as pointed out by Dantzer and his colleagues (2011), is not classified as a disease in the strict sense given that its causal mechanisms are poorly understood and there is no sine qua non neuroanatomical marker, metabolic biomarker, or other identifiable biological cause. In other words, depression would also be considered psychogenic and may well be "all in one's head."

Contrary to the psychogenic hypothesis, some suggest that medically unexplained symptoms can actually be caused and therefore explained by biological processes. For example, Irwin (2011) suggests that somatic sensitivity related to pain, sleep disturbance, and fatigue (all of which can affect neurocognitive functioning and all of which get frequently reported by SMs) may be accounted for by inflammatory processes associated with the proinflammatory cytokine network.

Interestingly, many researchers have noted the Cartesian, mind-body dualism inherent in this debate and have challenged the false dichotomy by offering alternative frameworks from which conceptualization of these patients can begin. Sharpe (2013) offered a practical way to arrest the dualistic nature of the debate. He suggests viewing all somatic symptoms as both "medically explained" and "medically unexplained" to varying degrees given that they are "neither mere reflections of bodily pathology, nor simple manifestations of mental processes" (pg. 320). From this non-dualistic framework, he recommends using "symptom burden" or how much patients are bothered by their symptoms (e.g., how many symptoms they report, the severity of symptoms they report, and their psychological reaction to them) to determine diagnosis. He further points out that the DSM-5 (American Psychiatric Association, 2013) diagnosis of Somatic Symptom Disorder has provided a means by which both "medically explained" and "medically unexplained" symptoms can be addressed without falsely dichotomizing patients into those with biological disease and those with psychogenic disease, such that even individuals with cancer can be diagnosed with Somatic Symptom Disorder if they meet the symptom burden criteria.

Applications to Civilian Neuropsychology

As suggested above, much of neuropsychological sciences, treatments, and debates are not exclusive to the military and its applications of neuropsychology. This section, however, will suggest ways in which military neuropsychology can particularly aid the advance of civilian applications. For example, some military neuropsychologists are adept at working within large-scale, well-funded, interdisciplinary neuro-rehabilitation teams (e.g., NICoE) which may offer generalizability to civilian contexts. Although neuropsychologists working with civilian sports-related concussion were among the first to advance research in this area including diagnosis and management, military neuropsychologists frequently diagnose and treat concussion and may be able to offer additional insights to sports teams with regard to evaluation of and recovery from sports-related head injury. Furthermore, military neuropsychologists have considerable experience working with individuals seeking disability due to occupational impairment which, in our highly litigious culture, is an ever expanding area of expertise for civilian neuropsychologists. Finally, military neuropsychologists are commonly asked to make personnel decisions based on cognitive and personality characteristics. Strategies used by military neuropsychologists for selection of troops for Special Operations, Military Training Instructors (MTI), and pilots may be useful for selection of individuals for civilian occupations including high-level positions (e.g., CEOs), police and other security professions, and commercial airline pilots.

Treatment and Rehabilitation

Due to the large-scale TBI challenges faced during OIF, OEF, and Operation New Dawn (OND), the Department of Defense (DoD), in collaboration with neuropsychologists and numerous other healthcare professionals, has developed large-scale rehabilitation facilities aimed at helping troops overcome cognitive and psychiatric deficits.

In addition to the Defense and Veterans Brain Injury Center (DVBIC) supporting 11 MTFs and 5 Department of Veterans Affairs (VA) healthcare facilities, a 4-week intensive outpatient program has been developed at the National Intrepid Center of Excellence (NICoE) at the Walter Reed National Military Medical Center (WRNMMC), Bethesda. This model of care utilizes neuropsychological services as an aspect of comprehensive state-of-the-art, interdisciplinary care. As an extension of the original NICoE, five Intrepid Spirit Centers have been opened at major military installations across the continental United States (with four more planned in the upcoming years). These centers extend the NICoE interdisciplinary model of care with a focus on diagnosis and treatment (NICoE, 2016). These centers can serve as a useful model for management of TBI in civilian populations where patients who have sustained a brain injury struggle with numerous referrals to multiple specialties in different locations, lack of insurance, potentially limited insight, and other barriers to rehabilitative care (Langlois, Rutland-Brown, & Wald, 2006). Due to the interdisciplinary approach and colocated offices of brain injury centers, patients are rapidly assessed and diagnosed using a combination of neuropsychological assessment, neuroimaging, and behavioral monitoring. Next, evidence-based treatment recommendations are implemented by occupational therapists, physical therapists, speech pathologists, and behavioral health specialists. Outcomes in brain injury centers may be improved due to the cutting-edge services available to patients, the immediate access to early intervention, and the convenience of patients having the majority of their appointments in a centralized location. Civilian healthcare facilities may be able to improve brain injury outcomes by forming multidisciplinary, assessment, and treatment-focused teams modeled after those in the DoD healthcare system.

Additionally, given the frequency with which a military neuropsychologist encounters patients who have sustained a concussion, they may be in a unique position to collaborate with civilian sports neuropsychologists and physicians in diagnosing and preventing concussion during play of organized sports. Estimates of the incidence of concussion in the United States are around 128 per 100,000 people (Ropper & Gorson, 2007). Military neuropsychologists have contributed to understanding the factors that contribute to the susceptibility of sustaining a concussion as well as treatment and recovery issues. Furthermore, the DoD has implemented highly specific guidelines for the medical management of troops that have sustained a concussion with important return to duty considerations (see Traumatic Brain Injury Resources for Providers, Defense Centers of Excellence, 2016). Finally, as referenced above, the DoD utilizes a premorbid assessment tool for the screening of cognitive functioning for all deploying SMs as a baseline assessment, and various professional sporting leagues and the National Collegiate Athletic Association (NCAA) have enacted similar screening and monitoring programs. However, the adoption of a universal, nation-wide screening program for all "at-risk" student athletes has yet to come to fruition. A broad, nation-wide program modeled after the DoD's concussion management protocol may be useful so that all athletes can receive high-quality, standard of care in the event of a sport-related concussion.

Forensic Neuropsychological Applications

Further military neuropsychological applications that are generalizable to a civilian context can be seen in forensic and disability assessments. These types of cases are increasing in frequency for civilian neuropsychologists as disability benefits are becoming more readily available for neurocognitive and neuropsychiatric issues (Leonard, 2015). In contrast, the DoD has recognized neurocognitive and neuropsychiatric problems associated with military service as legitimately compensable since the Civil War (VA, 2010). Military neuropsychologists get unique training during residency and fellowships to help them participate in medical evaluation board (MEB) evaluations to help determine initial disability ratings based on the nature and extent of the injuries in question. Such training is not readily available at many civilian training sites and is highly supervisor dependent when it is available. A military neuropsychologist may be able to offer insights into civilian training programs and independent practitioners with regard to strategies to implement during the initial interview, battery selection, assessments of malingering, and determinations of occupational impairment as such evaluations are commonplace in the military.

Given that nearly every neuropsychological evaluation administered throughout the DoD may be associated with monetary benefits for the patient, assessments of performance and symptom validity are frequently administered by military neuropsychologists. This practice is also common in civilian evaluations as more academic accommodations, occupational services, and monetary compensations have been made available to individuals with neurocognitive disorders (Slick, Tan, Strauss, & Hultsch, 2004). Thus, civilian neuropsychologists may need additional preparation/training to perform this service competently and to efficiently utilize the most current strategies to assess effort and malingering.

Assessment and Selection

Selection of personnel for unique jobs is another area that military neuropsychologists have a great deal of experience and which can generalize to and enhance civilian applications. For instance, military neuropsychologists may assess the cognitive ability of pilots, special operators, MTIs, individuals working closely with nuclear weapons, and individuals working near the President of the United States. More specifically, pilots are selected in part based on general intelligence and other cognitive factors including processing speed, working memory, and executive functioning (Carretta & Ree, 1996; Ree & Carretta, 1996).

Generally speaking, requirements for special duty selection mandate that the individual possesses the basic faculties to perform the required duties and that there are no significant personality features that would preclude an individual from a high-level special service mission. Such selection procedures are aimed at curbing the frequency of inappropriate behavior and abuses of power between MTIs and the recruits they train and lead. Moreover, due to the presence of cell phones, constant surveillance, and rapid access to social media, individual's privacy appears to be ever shrinking. When behavioral conduct of employees is critical such as in law enforcement, teaching, medicine, and other fields, it may be useful to implement more rigorous neuropsychological and psychological testing similar to military programs in order to screen out candidates with data suggestive of undesirable traits which may lead to inappropriate behavior and abuses of power.

Future of Neuropsychology in the Military

Up to this point, we have discussed the many roles in which military neuropsychologists enhance mission readiness and work to preserve the fighting strength. In the last section, we will consider future developments in military psychology that warrant consideration for neuropsychology to remain a force-multiplying service to the US military. This section will address the need for further development of ecological validity for neuropsychological tests administered to military members, the development of neuropsychological screening paradigms based on advanced structural equation modeling to predict resistance and susceptibility to neuropsychological trauma, the development of improved and definitive biological markers useful for diagnosing brain injuries that present with only subtle neuroanatomical and neurochemical changes, and the development of neuropsychological treatments that can improve cognitive ability beyond that of traditional rehabilitative and occupational strategies.

Ecological Validity

Ecological validity, which is the applicability of a measure to the "real world," is a considerable issue when using neuropsychological assessment tools used to evaluate SMs. Although the problem is not unique to military neuropsychology, given that the ecological validity and relevance of neuropsychological tests to performance in real-world situations have also been criticized in civilian populations (Chaytor & Schmitter-Edgecombe, 2003; Spooner & Pachana, 2006), it has particular relevance in military contexts given that SMs are asked to perform in battlefield environments that may stress an individual's cognitive abilities in ways that are quite different than their civilian counterparts.

Limitations on ecological validity are due to both test construction and testing environment but the most salient issue with regard to ecological validity of neuropsychological tests in military populations is the testing environment. The testing environment, to a large degree, is contrived and suited to the standardization of administration (Manchester, Priestley, & Jackson, 2004). Many patients complain of difficulties in attention and executive functioning but perform within normal limits during testing due to the artificial testing environment which is often described as a "prosthetic frontal lobe" that provides structure, limits distractions and interruptions, and allows for few outside influences. This is in stark contrast with a real-world environment filled with unpredictable stimuli that can result in distractions and interruptions (e.g., phone calls, emails, text messages, etc.). As suggested above, the military operational environment is even more complex with regard to environmental factors that may impact cognitive functioning. For example, decisions that require calculated risks to human life need to be made rapidly during the chaos and threats associated with a quickly changing battlefield landscape. Even minor fluctuations in executive function may cause delays in decision making that can negatively impact the mission or lead to casualties. It is possible that such minor changes would not be observed during traditional neuropsychological testing methods, but may result in considerable consequences if they are present.

To improve ecological validity, several changes in current testing paradigms need to occur. For example, military neuropsychologists need to develop and utilize tests that have stronger associations with actual job performance or outcome. Such tests place a higher emphasis on the concept of verisimilitude (Chaytor & Schmitter-Edgecombe, 2003). Verisimilitude yokes the neuropsychological performance with the outcome of a particular task. It is because of the unique occupations of SMs in the Armed Forces and the tasks they are required to perform that it is important neuropsychologists working with this population consider the ecological strength or weaknesses of the tests they administer.

Additionally, advancements in technology may be helpful in improving the ecological validity of neuropsychological evaluations. For example, virtual reality is becoming more mainstream, affordable, and computer programs for specific virtual reality tasks are becoming easier to write (Parsons & Rizzo, 2008). Though few neuropsychologists are currently using virtual reality technology, it is possible that this will become a useful tool to enhance the ecological validity of neuropsychological tests without the significant time constraints associated with field observations. Moreover, programs could be written for assessment of specific job duties as opposed to generalized cognitive functioning.

Predicting Performance and Attrition

In addition to ecological validity, future military neuropsychologists need to focus on predicting performance based on neuropsychological test results. As funds and resources become scarce during lean fiscal periods, proper selection of SMs who are aptly suited for their particular jobs becomes paramount. TBI in the battlefield offers an analogy of how the predictive ability of neuropsychological testing can improve mission readiness, help maintain the fighting strength, and potentially reduce the number of TBI-related injuries SMs experience.

More specifically, given the relative success of asymmetrical warfare, it is likely that enemy combatants will continue to use Improvised Explosive Devices (IEDs). This places troops at considerable risk for TBI. Although such injuries can be successfully treated particularly in the case of concussion, in some instances, SMs require significant intervention, experience long-term disability, develop comorbid psychological issues, and may be separated from the military. Given operational demands and strategic necessity, preventing all TBIs in military populations is not possible. However, by utilizing data sets collected over the last 15 years and applying advanced statistical techniques from structural equation modeling (SEM) such as confirmatory factor analysis, path analysis, partial least squares path analysis, and latent growth modeling, it may be possible to determine which soldiers are most vulnerable to prolonged symptoms which complicate TBI recovery, subsequently reduce the fighting strength, and elevate health costs. For example, individuals with a previous mental health diagnosis, tendency to somaticize, prior history of TBI, and a constellation of other factors may be vulnerable to experiencing PPCS which may lead to discharge and/or medical disability (Katz, Cohen, & Alexander, 2015). By using advanced prediction models to reduce the risk of exposure of certain individuals to TBI, the military may be able to preserve fighting strength and reduce long-term healthcare costs.

Occupational selection and prevention of attrition are also important factors when attempting to minimize costs. The average SM costs upwards of $30,000 to train (e.g., Klesges, Haddock, Chang, Talcott, & Lando, 2001). Attrition occurs for numerous reasons including maladjustment, medical problems, psychological problems, academic/technical training failure, and disciplinary problems. In order to reduce the likelihood that these concerns will manifest, there are cursory medical and psychological screenings that occur prior to enlistment (Jones, Hyams, & Wessely, 2003). Such screening has been shown to be cost effective but incomplete as attrition can occur at various points throughout the stages of training and career progression. Development and application of effective and efficient neuropsychological screeners with high predictive value that can match a SM's neurocognitive strengths and weakness with job selection can be an important future development in reducing attrition, selecting members with increased resilience, helping to ensure SMs' job satisfaction, and help preserve resources.

Biomarkers and the Role of Neuropsychologists

Another future role of neuropsychologists in the military will be assisting geneticists, neurologists, and neuroradiologists in the development of biomarkers associated with various psychological and neuropsychiatric disorders. Advanced imaging techniques such as diffusion tensor imaging (DTI), magnetoencephalography (MEG), and quantitative electroencephalography (QEEG) have made it possible to view subtle changes in structure and function of the brain which may correlate with cognitive performance and behavioral output (Alhourani et al., 2016; Haneef, Levin, Frost, & Mizrahi, 2013; Shenton et al., 2012). By using advanced imaging methods and correlating them with neuropsychological assessments, it may be possible to develop biological markers which can help with more definitive diagnosis and treatment of various neurological insults.

Furthermore, a combination of advanced imaging techniques with neuropsychological performance can contribute to more accurate return to duty and dispositional determinations by neuropsychologists following neurological insults. For example, neuropsychologists are often asked to evaluate a patient's ability to return to special duty tasks such as aviation or Special Operations following a neurological insult. These individuals can be highly motivated to return to full duty status and therefore have a tendency to underestimate any impairment they are experiencing. Current neuropsychological tests alone may not be sensitive enough to capture subtle changes in cognitive functioning that may have an impact on high-level duty performance. By combining neuropsychological tests with more advanced imaging methods, subtle deficits may be identified and improved treatment and dispositional recommendations can then be made.

Neurocognitive Enhancement

Finally, in addition to being able to more definitively diagnose and assess neuropsychological problems, military neuropsychologists will need to invest in the development and research of interventions that can enhance and support cognition. For example, battlefield commanders must rapidly process a large amount of data from numerous sources. They must simultaneously process what is in their immediate environment, they must process information being related to them from a central command, and they must process information from other intelligence sources. The amount of real-time data being made available to battlefield commanders is so prodigious that data filters were developed to control the flow and rate of information presented. In other words, commanders must be able to rapidly compile vast amounts of information in order to make efficient, effective decisions in the battlefield. Neuropsychologists should play a role in the military's development of effective cognitive training programs that can improve rapid information processing and decision making.

There are several compounds, procedures, and instruments that are purporting to promote cognitive enhancement (Bostrom & Sandberg, 2009). For example, ampakines are endogenous compounds that have been shown to improve long-term potentiation and encoding of information in animal models and in some human trials through the induction of neurotrophic factors (Lynch & Gall, 2006). Additionally, transcranial magnetic stimulation (TMS) has been shown to enhance human cognition in the domains of perceptual, motor, and executive processing (Luber & Lisanby, 2014). To date, most neuro-rehabilitative programs in the military have focused primarily on recovery, but as the scientific literature on human performance and cognitive enhancement continues to grow, the military will no doubt have an interest in applying the principles to gain a tactical advantage on the battlefield. Neuropsychologists will play an important role in assessing the efficacy, outcomes, and cost-benefit analysis of any cognitive enhancement trials forwarded by the military.

Conclusion

Neuropsychology in the military is a multifaceted force multiplier. Its applications include assessment, treatment planning, and follow-up care for individuals who have sustained neurologic injury; pre- and post-test testing; selection and assessment; and helping to improve equipment through the understanding of brain-behavior relationships.

Neuropsychology in the military has been influenced by a history dating back to ancient Egypt where the first documented theories regarding brain-behavior relationships were proffered. Enormous strides have been made with advances in both science and technology over the past two centuries allowing us to greatly expand our understanding of the central nervous system and the behavioral manifestations that occur upon its compromise.

Clinical psychology found its initial niche within the military during World War I when cognitive and personality assessment were first used to aid in personnel selection. Beginning in World War II and continuing to this day, much of the cognitive and psychological assessment applications have turned to a more clinical neuropsychological focus by means of evaluating and treating service members with neurological injury or disease. Our twenty-first-century conflicts in Iraq and Afghanistan have resulted in neuropsychologists being forward deploying to combat zones to perform clinical evaluations and standing up TBI clinics to intervene more quickly near the time of injury and in making critical fitness for duty determinations.

To aid in the DoD mission for readiness, neuropsychologists in the DoD have engaged in multiple research and treatment initiatives. These efforts include improving TBI and concussion diagnosis and management; cognitive rehabilitation; validity testing; and various levels of care including acute concussion care to chronic severe TBI care. Brain-behavior research in the DoD will likely be an ongoing field of enquiry for many decades to come and will likely continue the tradition of enhancing our understanding of the functioning of the central nervous system.

Military neuropsychology has benefited from advances in the civilian sector. Military neuropsychology can also impact civilian neuropsychology through continued collaboration. The development of large-scale neuro-trauma centers throughout the DoD has allowed neuropsychologists in the military the opportunity to be an important member of an inter-disciplinary team and implement standardized assessment and management guidelines for SMs that have sustained a neurological injury. Due to the military's use of standardized concussion protocols and its ability to implement universal policies, the DoD has been able to screen all active duty members who will be deploying in order to have baseline data so that return to duty determinations can be made in the battlefield if an assessment for TBI is necessary. Such a practice may be useful in high school and primary school sports to promote proper identification and management of concussion in at-risk youth populations. Military neuropsychologists are adept at making dispositions with regard to disability and ability to return to work and have experience with disability evaluations. Lastly, military neuropsychologists have considerable experience with developing selection criteria for unique occupations. As job performance and behavioral conduct move from the office into the public domain, high profile organizations may consider implementing additional selection criteria based on neuropsychological and psychological measures.

The future of military neuropsychology will likely be diverse and multifaceted. It is likely that neuropsychologists will be called on to improve ecological validity of their measures for specific military jobs, make special duty and dispositional recommendations on SMs using prediction models based on more advanced statistical methodologies such as SEM, aid in the development of biological markers that can more accurately detect the presence of subtle brain injuries, and evaluate cognitive enhancement paradigms that facilitate rapid information processing and decision making.

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