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Assessing the Comprehensive Soldier Fitness Program: Measuring Startle Response and Prepulse Inhibition

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14. ABSTRACT

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ASSESSING THE COMPREHENSIVE SOLDIER FITNESS PROGRAM: MEASURING STARTLE RESPONSE AND PREPULSE INHIBITION

ABSTRACT

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CONTENTS

Introduction

Military service is arguably among the most dangerous occupations. Historically, direct combat has been viewed as the exclusive source of danger, conflict, and trauma and as the necessary and sufficient cause of post-service mental health problems, such as posttraumatic stress disorder (PTSD) (Maguen, Suvak, & Litz, 2006). Research has shown that in the face of extreme combat conditions most men and women do exceptionally well and are able to grow from their experiences. Even so, there is a substantial percentage of Soldiers who develop post service mental health problems. A large-scale study examining the consequences of combat duty in Iraq and Afghanistan since the events of September 11, 2001 showed that PTSD among Army Soldiers deployed to Afghanistan was 12 percent, while rates among Army Soldiers and Marines deployed to Iraq were 18 percent and 20 percent, respectively (Maguen, Suvak, & Litz, 2006). Stress is a natural human experience and during combat Soldiers respond in a vast number of ways.

Biologic responses immediately after a traumatic event include the release of stress hormones and peripheral catecholamines, resulting in a fight, flight or freeze response (Holloway & Benedek, 1999). In the intermediate phase one week to several months after the event, intrusive symptoms such as recollections of the event with increased autonomic arousal (e.g., startle response, hypervigilance, insomnia, and nightmares) are common. During the long term phase at 1 year or more, some individuals may experience continued posttraumatic psychiatric symptoms for years after the attack, while the majority will rebuild their lives and focus on future challenges (Holloway & Benedek, 1999). A Soldier’s response to combat stress ranges on a spectrum from the best results to the worst. On the worst end of the spectrum there are Soldiers who develop PTSD from combat. The latter group is followed by Soldiers who clinically do not have PTSD but who still have problems with living (e.g., conduct issues, emotional strain, marital or family issues). At the median, there are Soldiers who are unaffected by combat stress, and these Soldiers return home the same as before they deployed, whether good or bad. Towards the positive end of the spectrum we see Soldiers who display resilience and hardiness while in stressful situations. These Soldiers are able to bounce back after a negative situation and persevere through the hardship. Lastly, the most desired outcome on the spectrum is the idea of posttraumatic growth where we see Soldiers who undergo a positive psychological change as a result of combat stress.

PTSD is a psychiatric disorder that is linked to a specific type of life experience. PTSD appears in many forms and there are studies showing that it is often found in conjunction with at least one, if not several other psychiatric disorders (Brady, 1997). Most symptoms of PTSD occur because of an individual's previous exposure to trauma and PTSD can thus lead to subsequent trauma (Breslau, Chilcoat, Kessler, & Davis, 1999). Soldier development of PTSD produces high costs for the military. Increasing rates of PTSD have been found to produce high attrition rates in the military.

Substantial amounts of money are invested in training and developing a Soldier for combat. This investment returns void when a Soldier has to be discharged due to a psychiatric illness. PTSD is associated with greater psychiatric co-morbidity and attempted suicide, increased frequency of bronchial asthma, hypertension, peptic ulcer and impaired social support (Davidson, Hughes, Blazer, & George, 1991). Additionally, studies show that another health factor related to PTSD is the reduction in the size of the hippocampus. This structure in the forebrain plays a major role in short term memory and spatial navigation. Studies show that suffering from major depression and PTSD can reduce an individual's hippocampus size resulting in the patient's inability to recall certain parts of the traumatic event or, alternatively, the memories may be extremely vivid and always present (Bremner, Narayan, Anderson, Staib, Miller, & Charney, 2000). These health conditions require that the military expend money to provide treatment for the Soldier or lose an investment by discharging the Soldier. It has been reported that in 2004, the Veterans Affairs Department (VA) spent $4.3 billion on PTSD disability payments. In 2006, the VA requested $2.2 billion for mental health services (MAPS, 2005). Even though combat is a high producer of PTSD cases, recent researchers have confirmed that pre-military, during military, and post-military variables all have strong influences on who develops PTSD, and these variables likely also influence who maintains PTSD (Green, Grace, and Leonard, 1992). Pre-military, it is important to screen an incoming Soldier because a person's socioeconomic status, parental relationship or even education level could affect one's vulnerability to PTSD. Additionally, post-military social support at home, or upon returning home, could either positively or negatively affect a Soldier. There are several factors which could play a role in the development of PTSD and consequently there are several negative outcomes as a result.

Transitioning across the spectrum, we encounter individuals who do not clinically have PTSD but that have difficulties living a normal life. Diagnostic criteria for PTSD include a history of exposure to a traumatic event and symptoms from each of three symptom clusters: intrusive recollections, avoidant/numbing symptoms, and hyper-arousal symptoms. A fifth criterion concerns duration of symptoms (must be more than 1 month) and a sixth assesses functioning *(Diagnostic Criteria and Characteristics for PTSD*, 2009). Unless a patient meets these criteria, he or she may have significant stress related problems, but will not be treated as if they have PTSD. These Soldiers pose a problem because if they are not given adequate attention these symptoms have the potential of progressing into full-blown PTSD.

At the median we have those Soldiers who are not affected at all by the stress of combat. These individuals, whether in good shape or bad, maintain the status quo upon their return home. Unlike the latter group, there are individuals who have positive results following combat exposure. Reaching the positive end of the spectrum we have Soldiers who demonstrate resilience when faced with the demands of combat. The need for resilience is felt more urgently nowhere more than in military combat, where exposure to extreme and ongoing stress is all but avoidable (Lukey & Tepe, 2008). Resilience stands as an individual's ability to ameliorate stress and continue the mission in extreme environments and situations (APA, 2004). Resilience requires the individual to be strong enough to step forward and deal with his or her problems treating stress as a challenge and not an obstacle. Being resilient does not mean that a person does not experience difficulty or distress. In fact, the road to resilience is likely to involve considerable emotional distress (APA, 2004).

Resilience can be learned by and enhanced in any individual. Several studies have shown that the effects of a deficient environment can be reversed by involvement in a positive environment. In a longitudinal study of nearly 700 children born into poverty on the island of Kauai, findings revealed that one-third of those considered to be at the highest risk for negative developmental outcomes went on to overcome the risk and live fulfilling and successful lives (MacDermid, Shelley, Samper, Schwarz, Nishida, & Nyarong, 2008). These individuals attributed their success to finding positively supportive relationships during childhood, and in some cases, later in life. Teaching resilience is an important concept that the military must incorporate as part of its routine training, because one or more risk factors in a person's life may increase the likelihood that a problem behavior will occur at a later point in time (Kumpfer, 1999).

Incorporated with resilience is the idea of hardiness. Hardiness is an individual's ability to self-enhance in the area of resilience. Hardy individuals have a strong perspective on life having meaning and purpose. Hardiness training in some facets has been reported as better than general relaxation/meditation and a placebo/social support control condition as a method for relieving and combating stress (Maddi, Kahn, & Maddi, 2008). In general, hardy individuals are better able to perform well under stress and are less likely to experience stress-related illnesses (Kobasa, Maddi, & Kahn 1982). The concept of hardiness is much like resilience in that it can be trained as well as enhanced. Adler & Dolan (2006) found that hardiness training protected Army Reserve forces from the effects of war related stress due to disruption of their civilian jobs, separation from family, and other military related stressors.

The most desired outcome of experiencing some form of stress is posttraumatic growth. Research based on Soldier interaction with combat stress tends to focus solely on the negative aspects of this situation. Even so, some studies have shown that overcoming the challenges of life's worst experiences can catalyze new opportunities for individual and social development resulting in posttraumatic growth (Calhoun & Tedeschi, 1998). This concept, although often overlooked, brings a positive light to the transformative power of trauma. There are several factors that may contribute to an individual's ability to gain a positive experience from combat ranging from resilience training to social support structures. Though seeming farfetched, actually having a support group or community capacity can build a Soldier's tolerance for extreme situations. The individual's cognitive engagement with and cognitive processing of trauma may be assisted by the disclosure of that internal process to others in socially supportive environments (Calhoun & Tedeschi, 2000). This type of growth is believed to be developed out of a cognitive process that is initiated to cope with traumatic events that extracts an extreme cognitive and emotional toll. These events that initiate posttraumatic growth have the quality of “seismic events,” but on a psychological level (Tedeschi & Calhoun , 1995). It is important that we do not overlook the potential positive results of studying post traumatic growth. n fact, the Posttraumatic Growth Inventory is a metric used to assess the positive outcomes reported by persons who experience traumatic events. Potentially finding components that enable a person to be positively affected by a negative event can be transferred in training from one individual to the next. Although the PTGI is a general measure of growth suitable for non-trauma studies (Tedeschi & Calhoun , 1996), research on expanding this idea to measuring growth from combat experiences could produce positive gains.

In dealing with Soldiers who experience combat stress, there are several approaches to treating the Soldiers. Of these approaches, one method to increase resilience and enhance performance is the Comprehensive Soldier Fitness (CSF) program. This program moves to aid service members and their families by developing their strengths in the emotional, social, spiritual, and family domains. Though the program has produced some gains in building resilience in Soldiers, additional measures need to be developed to assess the effectiveness of the CSF program or possibly provide components to improve it.

Startle Response and Prepulse Inhibition

One potential metric we have identified as a method to assess the effectiveness of the Comprehensive Soldier Fitness (CSF) program is a measure of startle response and prepulse inhibition (PPI). The startle response occurs when a startling stimulus, such as a loud noise or skin shock, causes a measurable level of constriction in the orbicularis oculi muscle surrounding the eye (Lukey & Tepe, 2008). Early startle response research used a pistol shot to evoke the startle response while participants were recorded with high-speed cameras for analysis (Landis &

Hunt, 1939). PPI occurs when a mild stimulus precedes a startling stimulus, resulting in suppression of the startle response (Anokhin, Heath, Myers, Ralano, & Wood, 2003). The prepulse must be presented 30-500 ms prior to the startle stimulus (Graham, 1975). Research shows that baseline startle response is elevated in combat veterans with posttraumatic stress disorder (PTSD), while PPI is decreased—i.e., a prepulse stimulus results in less startle response suppression (Butler et al., 1990; Morgan, Grillon, Southwick, Davis, & Charney, 1996). Reduced PPI has also been observed in patients with panic disorder (Ludewig, Ludewig, Geyer, Hell, & Vollenweider, 2002).

A wide variety of stimuli can be used to evoke the startle response, including tactile, acoustic, and vestibular stimuli. Tactile stimuli can incorporate administered shocks or a puff of air in the eye. Acoustic stimuli are the most common, but it is important that the stimuli have a sharp and sudden onset in order to evoke the startle response (<50 ms). Additionally, an acoustic stimulus has a minimum threshold of ~80 dB in order to evoke the startle response, although a reduced threshold may indicate PTSD (Yeomans, Li, Scott, & Frankland, 2002; Braff, Geyer, & Swerdlow, 2001). Presenting the stimuli binaurally increases the magnitude of the response as opposed to presenting it to only one ear. Vestibular stimuli generally try to replicate the feeling of free-fall. Research shows that presenting the startle stimuli in multiple modalities (i.e., acoustic and tactile, acoustic and vestibular, all three, etc.) can greatly increase the magnitude of the startle response (Yeomans et al., 2002). The startle may also be elevated when people are viewing pictures that evoke negative emotions (Lang, Bradley, & Cuthbert, 1990).

Although we are most interested in orbicularis oculi contraction in response to a startle stimulus, a stimulus of sufficient magnitude can result in a whole-body startle response. In humans, in addition to eye blink, the head and neck move forward while the mouth and neck muscles tense up. The shoulders tense and elevate, as well as the back. Abdominal muscles stiffen and the elbows point outward. Presumably, the body assumes this position in response to a startle stimulus in order to protect the body from possible impact related to the stimulus (Yeomans et al., 2002). However, the whole body reflex is more difficult to induce, and thus impractical for the purpose of this assessment. That being said, it may be prudent to note any incidence of whole-body responses in the course of this research, as it may be a gross indication that a participant has PTSD or may be susceptible to it. The startle response also generally occurs in conjunction with an increase in both heart rate and skin conductance; however, heart rate and skin conductance responses to a startle stimulus using sound may decline over the course of tone presentations (Orr, Lasko, Pitman, & Shalev, 1995).

Orbicularis oculi contraction is relatively simple to measure as well. Researchers need only to attach two surface EMG electrodes just below the eye. Surface electrodes have a silver-silver chloride (Ag-AgCl) surface to detect EMG signals. Sizing matters as well—a .25 cm detection surface is preferred for facial EMGs (Fridlund & Cacioppo, 1986). The site must be prepared, usually using an alcohol wipe or alcohol-wetted swabs. Other important factors to consider are electrical noise caused by nearby electrical equipment such as lights and TVs, properly grounding all equipment, the laboratory atmosphere, and the experimenters themselves. Atmosphere and experimenter attitude/sex have the capacity to induce anxiety in participants, which could potentially confound results. For a more thorough review on the effect of these potential experimental biases, see Fridlund & Cacioppo (1986). A more detailed description of the equipment required and the procedure will be offered in the methods section.

A number of studies show that startle response and PPI may be good candidates both for identifying people prone to PTSD and those who are resilient, as well as assess the interventions under the CSF program. In theory, CSF training should result in decreased startle response and increased PPI. One study involving 20 unaffected biological siblings of patients with schizophrenia and 19 healthy controls demonstrates that PPI suppression is at least somewhat genetically mediated. The study found that the unaffected siblings showed reduced PPI compared to the healthy control group (Kumari, Das, Zachariah, Ettinger, & Sharma, 2005). Another study found that PPI shows over 50% heritability (Anokhin et al., 2003). The study involved 40 monozygotic and 31 dizygotic female twins. Since schizophrenia and PTSD are often comorbid, it is possible that the same effect holds true for genetic influence on PPI in unaffected siblings of patients with PTSD. To our knowledge, there are no studies that have sought to demonstrate this effect. The genetic contribution to PTSD is around 30% as shown by True et al. (1993). Since both PTSD and PPI are shown to be hereditary, it is possible that reduced PPI could be indicative of someone who is susceptible to PTSD, not just schizophrenia. Conversely, a robust PPI effect could typify a resilient individual.

Due to the close relationship between PPI and startle response, it is reasonable to believe that genetics may also have an influence on the startle response. The research supports this. A study of 66 pairs of monozygotic twins and 57 pairs of dizygotic twins shows about 60% heritability in startle response magnitude when viewing positive, negative, and neutral pictures (Anokhin, Gologsheykin, & Heath, 2006). An earlier study showed similar results, suggesting that baseline startle magnitude is about 70% heritable (Anokhin et al., 2003). Exaggerated startle response is already a clinical symptom that is specific to PTSD (Morgan et al., 1996). Thus, exaggerated startle response, similar to reduced PPI, may signify someone who is susceptible to PTSD. Indeed, one study showed that children of patients with anxiety disorders also exhibit an exaggerated startle response. This study suggests that elevated startle response could be a predictor of vulnerability to developing clinical anxiety (Grillon, Dierker, & Merikangas, 1998). Minimal or no startle response, on the other hand, could identify resilient personnel. Some studies did have incidents with participants who showed virtually no startle response (Morgan et al., 1996; Grillon & Morgan, 1999). These patients were subsequently excluded from data analysis.

One significant benefit to using startle response and PPI as an assessment metric is that the Army already has the majority of the structure in place required to support the assessment. Experiments need to be carried out in sound-attenuated rooms with controlled temperature and lighting. These facilities already exist at Soldier Readiness Processing (SRP) centers on every Army post. As part of the processing, Soldiers undergo a hearing test in a soundproof room. The rooms are already equipped with the equipment necessary—headphones and a way to administer acoustics. At this point, it would be relatively simple to add the EMG recording equipment in order to measure startle response and PPI as part of their normal readiness processing. Large numbers of participants could be run simultaneously as well. The difficulty would lay with the trainers. Critical to collecting good data is correct and consistent placement of the surface EMG electrodes on the face. Proper training would be necessary to ensure meaningful data. This is especially important in this scenario, as different researchers will run the experiments at every post. Although startle response and PPI are both potentially good measures to assess the CSF program, there are a few methodological problems associated with each that are inherent in the target population.

One factor that may exclude participants is hearing loss resulting from combat or other reasons. Hearing loss is a significant problem in the Army, especially among those coming back from deployments. In all startle response and PPI studies reviewed above, hearing loss was grounds for exclusion from the experiments. Since hearing loss could potentially be correlated with level of combat exposure, we may be inadvertently leaving out a significant portion of the population that we want to look at most—i.e., those who have had the heaviest combat exposure. One possible way to work around this problem would be to use a tactile stimulus rather than an acoustic. However, this would require new facilities or equipment rather than being able to use the sound rooms and hardware that already exist.

One other common reason for exclusion could be drug use, whether illegal, over-the-counter, or prescribed. Studies show that there is a pharmacological effect on startle response and PPI, such as that observed with alcohol and prescribed anxiolytic (anxiety-reducing) drugs, which can artificially increase PPI and decrease startle response (Braff et al., 2001). Nicotine can increase PPI, but dopamine agonists can have the opposite effect by reducing PPI. Fortunately, caffeine appears to have no significant effect on PPI. Since anxiolytic drugs are commonly prescribed to patients with anxiety disorders or PTSD, we may once again be excluding an important segment of the military population from the study. Taking Soldiers off of their medications would not be a viable option.

Another potential issue is that race seems to be a factor in startle response and PPI. A study of 174 males of both Caucasian- and Asian-American participants showed that Caucasians tend to have a greater startle response and lower PPI compared to their Asian counterparts (Swerdlow, Talledo, & Braff, 2005). With the Army today as diverse as it is, it may be difficult to account for this data. Normative data across several races may need to be obtained before reliable data can be collected. There is conflict, however, over whether sex has any effect on startle response magnitude or PPI (Ludewig et al., 2003; Braff et al., 2001).

The Army also has a wide range of age groups. Research shows that startle response magnitude steadily decreases with age, with a marked decline between the ages of 50 and 60 (Ludewig et al., 2003). However, since this is not our target population, we do not believe it will be a significant issue. Data analysis will need to take age into consideration to account for variations in test results. Current environment and emotional state may also mediate startle magnitude and PPI (Grillon, Morgan, Davis, & Southwick, 1998; Grillon & Baas, 2003). Since viewing positive, neutral, and negative scenes has been shown to affect startle magnitude and PPI, measurements may be largely dependent a participant's current emotional state. If a participant recently had a significantly positive or negative experience, results could be skewed. This is all the more likely considering the longitudinal nature of the CSF assessment phase.

Although startle response and PPI are possibilities for assessing the CSF program, it is clear from the problems identified above the experiments must be tightly controlled in order to collect valuable data. However, limiting the experiment to a somewhat unrepresentative sample (no medication, single race, similar ages, and with no hearing loss) may inhibit the experiment's external validity. Yet it may be possible to assume that if the CSF assessment program *does* have an effect on PTSD rates and other objective and subjective measures within a particular group, then it should be affecting other groups in the same way. Thus, startle response and PPI could be valuable metrics to use in assessing the CSF program. The next step is to design a longitudinal study that can determine the CSF program's effectiveness.

Proposed Study Method

Participants

Participants will be 100 military personnel from each of the eight brigade combat teams (BCT) participating in the CSF program. Participants should be a representative sample of both men and women. The sample should also include personnel with and without PTSD to determine how the CSF interventions affect each group. However, those with PTSD taking medications, such as anxiolytic drugs, should be excluded. Smokers and personnel with a history of alcohol abuse should also be excluded, as these can affect startle response and PPI results. Due to racial/ethnic differences in startle response and PPI identified in the literature review, this study should potentially over-sample minority populations for which normative does not exist. Hearing loss should also be an exclusionary criterion. Participants should be of similar age and have a similar level of combat exposure. Level of education should also be controlled, or at least taken into account, as level of education has been shown to affect susceptibility to PTSD.

Apparatus and Materials

Fridlund and Cacioppo (1986) offer some general guidelines for EMG research which serves as a reference for the proposed study. As already discussed, the facilities for research are already in place. Sound rooms for hearing tests at SRP centers have much of the needed equipment to run the experiment, such as the headphones and a way to administer acoustic startle stimuli. The noise generator should be capable of delivering a signal at greater than 80 dB with an immediate onset (i.e., signal does increase gradually) and over the course of <50 ms. The only necessary equipment would be the EMG monitoring system itself. Surface electrodes should have an Ag-AgCl surface with a .25 cm detection surface. Complete systems specifically designed to measure startle response are commercially available from companies like San Diego Instruments, Inc. and Coulbourn Instruments.

Design

This experiment will be a between-subjects design. The independent variable will be the group treatment under the CSF program. Eight brigade combat teams (BCT) will be participating in the initial CSF evaluation. First and 3rd BDE, 4th ID at Fort Carson will be labeled the “interaction group” and will receive both online training via the Comprehensive Resilience Modules (CRM) and the 10-day Master Resilience Training (MRT) course aimed at senior NCOs. First Brigade, 25th ID in Alaska and 2nd BDE, 1st ID at Fort Riley will be labeled the MRT group, as they will only receive the MRT training. Third Brigade, 1st ID at Fort Knox and the 170th Heavy BCT will be labeled the CRM group, as they will only receive the CRM training. The control groups will be 2nd Brigade, 4th ID at Fort Carson and the 11th Armored Cavalry Regiment (ACR) at Fort Irwin and will not receive training.

The dependent variables will be the magnitude of the startle response in pulse-alone trials and the percent reduction in startle magnitude in PPI trials compared to the magnitude of response in the pulse-alone trials.

Procedure

In addition to the Global Assessment Tool (GAT), Soldiers will also take the startle response and PPI test every six months. This will be used to assess the longitudinal effectiveness of the CSF program. The procedure should be similar to that presented in Kumari et al. (2005) and Ludewig et al. (2002). At each session, participants should be seated comfortably. EMG electrodes should be placed below either the left or right eye. According to Fridlund and Cacioppo (1986), the first electrode should be placed 1 cm below the outside corner of the eye, and the second should be placed 1 cm medial to, and slightly inferior to, the first (see Figure 1 below).

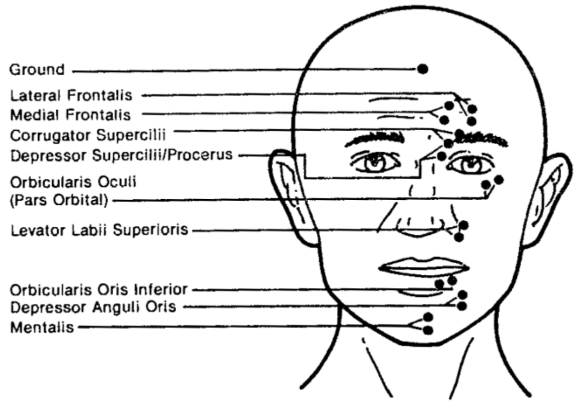

Figure 1. Proper placement of the surface electrodes on the orbicularis oculi muscle (Fridlund & Cacioppo, 1986).

As in Kumari et al. (2005), participants should be told that the experiment is to measure their response to a number of noise bursts, but no specific instruction should be given as to attend or ignore the noises. Participants should be told to keep their eyes open during the experiment. A background noise, such as white noise, of sufficient volume should be used. The prepulse stimuli should be easily distinguishable from the background noise, but not so loud as to elicit the startle response. Five minutes should be devoted at the beginning of the experiment to acclimatize participants to the background noise and establish baseline EMG activity (Kumari et al., 2005). The experiment should be a mix of pulse-alone and prepulse trials, presented either randomly or semi-randomly. The first trial should be analyzed separately, as studies show the startle response from the first trial is of significantly greater magnitude than subsequent trials (Morgan et al., 1996). Pulse-alone trials should assess multiple stimuli intensities (i.e., 100, 110, and 120 dB startle noises), and prepulse trials should assess multiple time intervals between the prepulse and the startle stimuli. EMG recording should begin before presentation of the startle stimuli and continue for up to two seconds after. The measures examined should be the magnitude of the startle response in the pulse-alone trials and the percent reduction in startle magnitude in the PPI trials compared to the magnitude of response in the pulse-alone trials (Ludewig et al., 2002).

CONCLUSION

Measuring startle response and PPI in Soldiers could potentially be a strong metric for assessing CSF effectiveness. A significant body of research already exists on startle response and PPI that supports its use in identifying PTSD and susceptibility to other psychiatric disorders. If the CSF program does in fact work, then there should be a reduction in startle response magnitude and an increase in PPI among those who receive CSF training. We would expect to see greater results in the groups who receive both CRM and MRT treatments compared to the groups who only receive one or the other. All three of these groups should show greater results than the control brigades. Although some methodological problems have been identified, these may be overcome by tightly controlling for variables such as age, sex, and drug use. Although this may somewhat limit external validity, we do not believe there will be a significant difference in how other groups react to the CSF training. Future research could potentially identify resilient Soldiers and target them as candidates for MRT, as having someone who is resilient as an instructor may be more beneficial. Startle response and PPI could also be used to assess a variety of other interventions, not just CSF.

Annotated References

Adler, A. & Dolan, C. (2006). Military hardiness as a buffer of psychological health on return from deployment. *Military Medicine, 171,* 93-98.

Research reporting that hardiness training protected Army Reserve forces from the effects of war related stress due to disruption of their civilian jobs and separation from family, among other factors.

Anokhin, A. P., Golosheykin, S., & Heath, A. C. (2006). Genetic and environmental influences on emotion-modulated startle reflex: A twin study. *Pyschophysiology, 44*, 106-112.

Study of 66 pairs of monozygotic and 57 pairs of dizygotic twins. The study shows that startle response magnitude is approximately 60% heritable when viewing positive, neutral, and negative stimuli.

Anokhin, A. P., Heath, A. C., Myers, E., Ralan, A., & Wood, S. (2003). Genetic influences on prepulse inhibition of startle reflex in humans. *Neruroscience Letters, 353,* 45-48.

Another twin study using 40 monozygotic and 31 dizygotic female pairs. Results show that PPI is approximately 50% heritable, with startle response magnitude approximately 70% heritable.

American Psychological Association (2004). The Road to Resilience. Washington, D.C.: The American Psychological Association. http://helping.apa.org.

This brochure is intended to help readers with taking their own road to resilience. The information within describes resilience and some factors that affect how people deal with hardship. Much of the brochure focuses on developing and using a personal strategy for enhancing resilience.

Brady, Kathleen T. (1997). Posttraumatic stress disorder and comorbidity: Recognizing the many faces of PTSD. *Journal of Clinical Psychiatry, 58,* 12-15.

Study showing that PTSD is often found in conjunction with at least one, if not several, other psychiatric disorders.

Braff, D.L., Geyer, M.A. & Swerdlow, N.R. (2001). Human studies of prepulse inhibition of startle: Normal subjects, patient groups, and pharmacological studies. *Psychopharmacology (Berl)*, 156, 234-258.

This article observes three areas of interest in human PPI studies. First, it reviews the normal influences on PPI related to the underlying construct of sensori- (prepulse) motor (startle reflex) gating. Second, it reviews PPI studies in psychopathological disorders that form a family of gating disorders. Third, it reviews the relatively limited but interesting and rapidly expanding literature on pharmacological influences on PPI in humans.

Bremner, J.D., Narayan, M., Anderson, E.R., Staib, L.H., Miller, H.L. & Charney, D.S. (2000). Hippocampal volume reduction in major depression. *American Journal of Psychiatry, 157*, 115-118.

Imaging study of the hippocampus showing reduced hippocampus size in those suffering from major depression and PTSD.

Breslau, N., Chilcoat, H. D., Kessler, Ronald C., & Davis, Glenn C. (1999). Previous exposure to trauma and PTSD effects of subsequent trauma: Results from the Detroit Area Survey of Trauma. *American Journal of Psychiatry, 156*, 902-907.

Study determining the effects of previous trauma on subsequent trauma response.

Butler, R.W., Braff, D.L., Rausch, J.L., Jenkins, M.A., Sprock, J. & Geyer, M.A. (1990). Physiological evidence of exaggerated startle response in a subgroup of Vietnam veterans with combat-related PTSD. *Am. J. Psychiatr*, *147*, 1308-1312.

This article shows a comparison between Vietnam combat veterans with PTSD and combat veterans without PTSD on the eyeblink reflex electromyographic response of the startle reaction. Results showed that participants with PTSD generally had a higher startle response than those without PTSD.

Calhoun L.G., Tedeschi R.G. (1998). Posttraumatic growth: Future directions. In R.G. Tedeschi, C.L. Park, & L.G.Calhoun (Eds). *Posttraumatic Growth: Positive Changes in the Aftermath of Crisis* (pp. 215-238). Mahwah, N.J.: Lawrence Erlbaum Associates Publishers.

This article suggests the reality and pervasive importance of post traumatic growth and provides an overview of how to overcome the challenges of life’s worst experiences.

Calhoun L.G., Tedeschi R.G. (2000). Early posttraumatic interventions: facilitating possibilities for growth. In J.M. Violanti , D. Paton, & C. Dunning (Eds). *Posttraumatic Stress Intervention: Challenges, Issues, and Perspectives* (pp. 135-152). Springfield, Ill.: Charles C. Thomas Publishers.

Explains the role of the clinician and the patient in facilitating growth after a tragedy.

Diagnostic Criteria and Characteristics for PTSD (2009, November 9). Retrieved May 3, 2010, from http://www.ptsd.va.gov/professional/pages/dsm-iv-tr-ptsd.asp.

Provides a guideline on the criteria that is used to diagnose a patient with PTSD.

Davidson, J.R., Hughes, D., Blazer, D.G. & George, L.K. (1991). Post-traumatic stress disorder in the community: An epidemiological study. *Psychol. Med.*, *21*, 713-721.

In comparison to non-PTSD subjects, those with PTSD had significantly greater job instability, family history of psychiatric illness, parental poverty, child abuse, and separation or divorce of parents prior to age 10. PTSD was associated with greater psychiatric comorbidity and attempted suicide, increased frequency of bronchial asthma, hypertension, peptic ulcer and impaired social support.

Fridlund, A. J., & Cacioppo, J. T. (1986). Guidelines for human electromyographic research. *Psychophysiology*, *23*, 567-589.

Research guidelines regarding how to conduct EMG research. Includes discussions on the equipment required, proper placement of electrodes, and sources of error/factors to consider when doing EMG research.

Graham, F.K. (1975). The more or less startling effects of weak pre-stimuli. *Psychophysiology, 12,* 238-248.

Green, B.L., Grace, M.C. & Leonard, A.C. (1992). Risk Factors for PTSD and other diagnoses in a general sample of Vietnam veterans. *Am. J. Psychiatr.*, 147, 729-733.

This study examined the contribution of premilitary, military, and postmilitary risk factors to posttraumatic stress disorder (PTSD) and other postwar diagnoses in a sample of Vietnam veterans. PTSD was explained primarily by war stressors, including threat to life and exposure to grotesque death, but premilitary and postmilitary factors also contributed to the likelihood of a current diagnosis of PTSD.

Grillon, C. & Baas, J. (2003). A review of the modulation of the startle reflex by affective states and its application in psychiatry. *Clin. Neurophysiol., 114*, 1557-1579.

A general overview of startle response research and its applications, particularly in trauma-related disorders and fear learning.

Grillon, C., Dierker, L., & Merikangas, K.R. (1998). Fear-potentiated startle in adolescent offspring of parents with anxiety disorders. *Biological Psychiatry, 44*, 990-997.

Study assessing the vulnerability of children to developing anxiety disorders whose parents also had anxiety disorders. Results showed that startle response can discriminate between low-risk and high-risk children for developing anxiety disorders.

Grillon, C. & Morgan, C.A. (1999). Fear-potentiated startle conditioning to explicit and contextual cues in Gulf War veterans with posttraumatic stress disorder. *J. Abnorm. Psychol., 108*, 134-142.

Startle response study showing that Gulf War veterans with PTSD have a differentiated startle response and become sensitized to stress.

Grillon, C., Morgan, C.A., Davis, M. & Southwick, S.M. (1998). Effects of experimental context and explicit threat cues on acoustic startle in Vietnam veterans with posttaumatic stress disorder. *Psychiatr. Res*., *64*, 169-178.

Article on the differentiated response to acoustic startle between Vietnam veterans with PTSD and combat veterans/civilians without PTSD.

Holloway, H. & Benedek, D.M. (1999). The changing face of terrorism and military psychiatry. *Psychiatric Annals*, *29*(6), 364-375.

This article describes the many facets and levels of PTSD. Additionally it addresses how military psychiatry is advancing as the environment changes on the combat stage.

Kobasa, S., Maddi, S. & Kahn, S. (1982). Hardiness and health: A prospective study. *Journal of Personality and Social Psychology*, *42*, 168-177.

Addresses how hardiness can be beneficial and not only increases physical capacity but mental capacity as well.

Kumari, V., Das, M., Zachariah, E., Ettinger, U. & Sharma, T. (2005). Reduced prepulse inhibition in unaffected siblings of schizophrenia patients. *Psychophysiology, 42*, 588-594.

Article suggesting that there may be a genetic influence on schizophrenia identified by reduced PPI.

Kumpfer, K.L. (1999). Factors and processes contributing to resilience: The resilience framework. In M. Glantz & J. Johnson (Eds.), *Resilience and Development: Positive Life Adaptations* (pp. 179-224). New York: Plenum Press.

This chapter discusses three models of resilience—the compensatory, protective, and challenge models—and describes how resilience differs from related concepts. The author describes issues and limitations related to resilience and provides an overview of recent resilience research related to adolescent substance use, violent behavior, and sexual risk behavior.

Landis, C., & Hunt, W.A. (1939). *The Startle Pattern*. New York: Farrar.

An example of early research on startle response. The study used a pistol shot to evoke the startle response, and participant reaction was measured with high-speed cameras.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1990). Emotion, attention, and the startle reflex. *Psychological Review, 97*, 377-395.

Overview of research in the field of startle response measurement. Identifies trends in data, methodological problems, and shows how current emotional state can affect startle response results.

Ludewig, S., Ludewig, K., Geyer, M.A., Hell, D. & Vollenweider. F.X. (2002). Prepulse inhibition deficits in patients with panic disorder. *Depress. Anxiety, 15*, 55-60.

Participants with high state and trait anxiety exhibited diminished PPI compared to participants with low state and trait anxiety.

Lukey, B. J., & Tepe, V. (2008). *Biobehavioral Resilience to Stress* (pp. xv-xvi). Boca Raton, FL: CRC Press.

This book presents a compilation of work describing the predictive understanding of resilience to stress. It also provides a discussion of the stress of military life.

MacDermid, S.M., Samper, R., Schwarz, R., Nishida, J. & Nyaronga, D. (2008). Understanding and promoting resilience in military families. *Military family Research Institute at Purdue*. (pp.1-21).

This article provides insight on military families in dealing with stress and mechanisms to use in order to achieve resilience.

Maddi, S.R., Kahn, S. & Maddi, L.K. (1998). The effectiveness of hardiness training. *Journal of Consulting Psychology*, 50, 78-86.

This study evaluated the effectiveness of a hardiness training program. With 54 managers as participants, the hardiness training condition was compared with a relaxation/meditation condition and a placebo/social support control. The hardiness training condition was more effective than the other 2 conditions in increasing self-reported hardiness, job satisfaction, and social support while decreasing self-reported strain and illness severity.

Maguen, S., Suvak, M. & Litz, B.T. (2006). Predictors and prevalence of posttraumatic stress disorder among military veterans. In T.W. Britt, A.B. Adler & C.A. Castro (Eds.), *Military Life: The Psychology of Serving in Peace and Combat: Vol 2. Operational Stress* (pp. 141-169). Westport, CT: Praeger Security International.

This chapter provides outlines possible predictors of posttraumatic stress and the trends of this disease in those who have participated in combat.

Morgan, C.A., Grillon, C., Southwick, S.M., Davis, M. & Charney, D.S. (1996). Exaggerated acoustic startle reflex in Gulf War veterans with posttraumatic stress disorder. *Am. J. Psychiatr., 153,* 64-68.

An article focusing on a study that assessed the magnitude of the acoustic startle reflex in Gulf War veterans with PTSD.

Mutlidisciplinary Association for Psychedelic Studies (MAPS) (2005, November 8). Retrieved May 4, 2010, from http://www.maps.org/mdma/.

A membership–based, IRS–approved nonprofit research and educational organization. This organization has a mission to treat conditions for which conventional medicines provide limited relief—such as posttraumatic stress disorder (PTSD).

Orr, S. P., Lasko, N. B., Pitman, R. K., & Shalev, A. Y. (1995). Physiologic responses to loud tones in Vietnam veterans with posttraumatic stress disorder. *Journal of Abnormal Psychology*, *104*, 75-82.

Study of Vietnam veterans with and without PTSD. Measurements of EMG, skin conductance, and heart rate were taken. Veterans with PTSD showed high EMG and HR response and prolonged elevated skin conductance.

Swerdlow, N.R., Telledo, J.A. & Braff, D.L. (2005). Startle modulation in Caucasian-Americans and Asian-Americans: A prelude to genetic/endophenotypic studies across the 'Pacific Rim'. *Psychiatr. Genet., 15*, 61-65.

Study showing the difference in PPI response between Caucasian- and Asian-Americans.

Tedeschi R.G., Calhoun L.G. (1995), *Trauma & Transformation: Growing in the Aftermath of Suffering*. Thousand Oaks, Calif.: Sage Publications.

This book highlights an individual's ability to achieve personal positive growth. The authors provide a thoughtful and creative analysis of the process by which survivors of trauma experience personal growth.

Tedeschi R.G., Calhoun L.G. (1996), The Posttraumatic Growth Inventory (PTGI): Measuring the positive legacy of trauma. *Journal of Traumatic Stress 9*(3):455-471.

This article describes an instrument for assessing positive outcomes reported by persons who have experienced traumatic events.

True, W.W., Rice, J., Eisen, S.A., Heath, A.C., Goldberg, J., Lyons, M.J., et al. (1993) A twin study of genetic and environmental contributions to liability for posttraumatic stress symptoms. *Archives of General Psychiatry, 50*, 257-264.

Another twin study showing that PTSD is partially heritable.

Yeomans, J.S., Li, L., Scott, B.W. & Frankland, P.W. (2002). Tactile, acoustic and vestibular systems sum to elicit the startle reflex. *Neurosci. Biobehav. Rev., 26*, 1-11.

Describes how the startle reflex is elicited by intense tactile, acoustic or vestibular stimuli. Results show that combining stimuli from multiple modalities increases the magnitude of the startle response.