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Long-Term Psychological Outcomes And Awareness Of Deficit In Persons With Traumatic Brain Injury And Their Significant Others: The Role Of Physiological And Neuroendocrine Reactivity To Stress

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LONG-TERM PSYCHOLOGICAL OUTCOMES AND AWARENESS OF DEFICIT IN PERSONS WITH TRAUMATIC BRAIN INJURY AND THEIR SIGNIFICANT OTHERS: THE ROLE OF PHYSIOLOGICAL AND NEUROENDOCRINE REACTIVITY TO STRESS

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DEDICATION

This manuscript is dedicated to my mother and father, Pauline Rose Meachen and Robert Charles Dudley Meachen. Without your encouragement and sacrifice, I would have had neither the courage, nor the confidence, to arrive at this point. I love you both dearly.

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CHAPTER 1

INTRODUCTION

Background and Significance

Long-Term Psychological Outcomes in Persons with Traumatic Brain Injury and Their Significant others

Clinically significant psychological or emotional distress following traumatic brain injury (TBI) is a well-documented phenomenon (Deb, Lyons, Koutzoukis, Ali, & McCarthy, 1999; Dikmen, Bombardier, Machamer, Fann, & Temkin, 2004; Fann, et al., 2004; Grados, 2003; Hanks, Temkin, Machamer, & Dikmen, 1999; Rapoport & Kiss, 2006; Satz, et al., 1998; Seel, et al., 2003). A recent prospective cohort study (Fann, et al., 2004) reported the prevalence of emotional distress in the year following moderate/severe TBI to be 49% (compared to 18% in a control group with no history of head injury). In particular, the reported prevalence rates of *depression* following TBI are variable – ranging from less than 10% in one study (Rutherford, 1977) to 77% in another (Varney, Martzke, & Roberts, 1987) – but generally startlingly high. TBI is associated with increased rates of anxiety disorders as well (Deb, et al., 1999; Fann, et al., 2004).

Clinically significant psychological distress (including depression and anxiety) among *significant others* of persons with TBI is also alarmingly high, with reported prevalence rates ranging from 30% - 50% (Kreutzer, Gervasio, & Camplair, 1994; Marsh, Kersel, Havill, & Sleigh, 1998). Vedhara and colleagues studied psychological, neuroendocrine, and immunological consequences of spouses of patients with dementia (Vedhara et al., 1999; Vedhara, 2002) compared to controls. Mean scores of

emotional distress were significantly higher in significant others at each time point than in controls. Interestingly, the injury severity of the person requiring care has less to do with psychological distress in the significant other (Ergh, Rapport, Coleman, & Hanks, 2002; Hanks, Rapport, & Vangel, 2007; Knight, Devereux, & Godfrey, 1998) than other factors such as level of neurobehavioral dysfunction (Groom, Shaw, O'Connor, Howard, & Pickens, 1998) of the person with TBI.

Awareness of Deficit (AOD)

Individuals with TBI often describe themselves as more capable than do their family members, significant others, and therapists (Prigatano, Borgaro, Baker, & Wethe, 2005; Sherer, Bergloff, Levin, et al., 1998; Sherer, Boake, et al., 1998). Similarly, whereas self-ratings of ability are modestly predictive of vocational status, ratings by medical staff and family members tend to be more so. Together, these data suggest an underlying diminished AOD (clinically referred to as anosagnosia) in a substantial subset of persons with TBI. The consequences of failure to appreciate extent of deficit are multi-fold and complex. On the one hand, limited AOD is an impediment to successful rehabilitation (Prigatano, et al., 1998). On the other hand, persons with TBI who are more aware of their deficits have more symptoms of depression (Malec, Testa, Rush, Brown, & Moessner, 2007) and other cognitive disorders (Ryan, et al., 2007) than those who have diminished awareness of deficits.

The impact of patient AOD on the significant other is less clearly understood. However, there is evidence that underestimation of deficit by the person with TBI has implications for the significant other that are *opposite* to those observed in the patient. Specifically, whereas patient AOD has been shown to correlate positively with

depressive symptoms in the patient, the reverse may be true of significant others. For example, among 60 pairs of persons with TBI and those who provide their care, patient AOD was positively associated with life satisfaction and negatively associated with psychological distress among significant others with low social support (Ergh, Hanks, Rapport, & Coleman, 2003; Ergh, et al., 2002). Despite these important findings, the impact of AOD on the physiological/neuroendocrine stress reactivity of persons with TBI and their significant others remains uninvestigated.

Physiological/Neuroendocrine Reactivity and Stress (PNSR)

Many empirical studies have shown that physiological and neuroendocrine functioning can be adversely affected by acute and chronic life stressors such as surviving a traumatic brain injury or caring for someone who has. For example, one study found that caregiving episodes (as opposed to non-caregiving episodes) were associated with increases in cortisol production and a statistically significant difference between non-caregiving and caregiving cortisol levels in the predicted direction (Davis, et al., 2004). Cacioppo et al. (2000) compared the autonomic and endocrine responses to a public-speaking task among women caring for a spouse with progressive dementia and controls matched for age and family outcome (Cacioppo, et al., 2000). Spouses of those with dementia exhibited shorter pre-ejection periods, higher blood pressures, and higher heart rate than controls. To date, the physiological and neuroendocrine reactivity (and its relationship with potential moderating characteristics) of persons with TBI and their significant others has not been reported.

Consequences of PNSR Reactivity.

The relationship between chronic stress and PNSR reactivity is not merely of academic interest. On the contrary, elevated PNSR is associated with a variety of negative outcomes. In their comprehensive review, Brown and Varghese (2004) concluded that there is substantial empirical evidence supporting a relationship between elevated cortisol and depression, hippocampus atrophy, cognitive impairment, abdominal obesity, and loss of bone density. They also provided compelling evidence of a relationship between elevated cortisol and hypertension, peptic ulcers, and diabetes.

Health and Immunological Outcomes. Substantial evidence indicates that the chronic stress of caregiving in progressive dementia has health and immunological consequences. Specifically, elderly significant others of persons with progressive dementia have increased hypothalamic-pituitary-adrenal axis functioning, and they may be more vulnerable to infectious diseases (such as influenza) than non-caregiving individuals of similar socioeconomic status (Vedhara, et al., 1999). In a series of cross-sectional studies in which significant others were matched to comparison participants based on age, sex, and socioeconomic status, significant others exhibited a poorer antibody response, lower levels of in vitro cytokines, lower percentages of total T lymphocytes, helper T lymphocytes, and suppressor cell ratios, and higher antibody titers to Epstein-Barr virus than matched comparison participants (Kiecolt-Glaser, Glaser, Gravenstein, Malarkey, & Sheridan, 1996) (Kiecolt-Glaser, et al., 1987). Similar evidence is given in several empirical studies (Mills, et al., 2004; Redwine, et al., 2004). A notable exception to these findings is also reported in the literature (Irwin, et al., 1997).

Psychological Outcomes. In non-clinical samples, there is evidence that even minor changes in mood states may alter adrenocortical function (M. van Eck, Berkhof, Nicolson, & Sulon, 1996). Furthermore, the reactivity of the hypothalamic-pituitary-adrenal (HPA) axis has been empirically demonstrated to be related to affective disorders such as depression (Gotlib, Joormann, Minor, & Hallmayer, 2008), social phobia (Condren, O'Neill, Ryan, Barrett, & Thakore, 2002), and posttraumatic stress disorder (Goldfinger, Amdur, & Liberzon, 1998). Approximately 50% of depressed patients appear to have a hyperactive HPA axis as evidenced by increased concentrations of corticosteroid releasing hormone, adrenocorticotropic hormone (ACTH), and diminished plasma cortisol response to dexamethasone challenge (Southwick, Vythilingam, & Charney, 2005). Furthermore, antidepressants have been shown to normalize this excessive activation of the HPA axis in patients with major depression (Nestler et al., 2002).

Research in oncology samples has shown that symptoms of depression are related to stress reactivity, including autonomic and HPA axis function. Among 45 depressed and 45 non-depressed patients with metastatic breast cancer, depression was associated with blunted HPA response to awakening (Giese-Davis, et al., 2006). In addition, depression was associated with alterations in autonomic regulation, particularly reductions in respiratory sinus arrhythmia, at baseline and during the Trier Social Stress Test (TSST). One group of researchers examined the association between depression and 24-hour urinary cortisol in a cross-section of 693 medical outpatients with known chronic heart disease (Otte, et al., 2004). Twenty percent of the sample had current depression. Depressed participants had greater mean cortisol levels

than those without depression. With each increasing quartile of cortisol concentration, the frequency of depression increased significantly. Young et al. (2004) measured baseline and post-TSST challenge blood cortisol and ACTH among individuals with pure major depression, pure anxiety, and comorbid depression and anxiety. The comorbid group showed significantly greater ACTH and cortisol response to the social stressor than did the other two groups.

It remains untested whether a link exists between physiological and neuroendocrine reactivity to stress and psychological outcomes (such as depression, anxiety and life satisfaction) among persons with TBI and their significant others.

Inducing Stress in the Lab

In order to evaluate individual differences in reactivity to acute stress, it is necessary to designate an appropriate stressor. In selecting a paradigm for inducing acute stress in the lab, there are several theoretical, methodological, ethical, and logistical considerations. First, there needs to be empirical precedent suggesting that the paradigm can produce measurable changes in physiology and/or endocrine activity. In addition, it is necessary that the acute stressor be sufficiently related to the underlying chronic stress of disability/dependence/loss of autonomy (for survivors) and caregiver burden (for significant others) that relationships between them could logically be expected to be uncovered. Importantly, the acute stressor needs to be tolerable for the participants, causing no lasting or disproportionate distress, and it must meet all ethical standards of best research practice. There are several approaches to inducing stress in a laboratory setting. Among the most popular are public-speaking paradigms and taxing mental arithmetic tasks. A different approach to inducing stress that has

been used in the caregiving literature involves asking participants to engage in discussion about the most stressful aspects of being a survivor or caregiver (for example, see (Uchino, Kiecolt-Glaser, & Cacioppo, 1992)). This approach has the advantage of being more closely related to the chronic stress of caregiving than is mental arithmetic or public-speaking on a generic topic. In addition, there is evidence that such discussions can lead to measurable changes in physiology (Uchino, et al., 1992). Finally, this approach is likely to be more tolerable to participants than other approaches. A similar approach has been used in HIC approved research from the Wayne State University Dept. of Psychology Marriage and Health Lab (led by Dr. Ann-Marie Cano), where researchers have completed preliminary research showing that skin conductance is greater during emotional discussions than neutral discussions among couples affected by chronic pain (per personal communication with Dr. Annmarie Cano, October 22, 2007).

Neuroendocrine Function

A thorough review of neuroendocrine function is beyond the scope of this paper. Excellent recent synopses are provided elsewhere (Kiecolt-Glaser, McGuire, Robles, & Glaser, 2002b; Kirschbaum & Hellhammer, 1989). The current proposal focuses on the role of the neuroendocrine *stress response*; therefore, a brief overview is warranted. In the typical human stress response, an encountered stressor activates two pathways of physiological response: the hypothalamic-pituitary-adrenal (HPA) axis, and the sympathetic adrenal-medullary (SA) axis. Affective psychological distress is primarily reflected in HPA activation, whereas motor and cognitive efforts to control a stressor are primarily reflected by the SA system. SA activation is indexed by a variety of measures

such as blood pressure, heart rate, and electrodermal activity. HPA activation is indexed by glucocorticoid (e.g., salivary cortisol) activity. The release and suppression of cortisol is regulated by the activity of the pituitary gland, and in turn, the hypothalamus. Specifically, the paraventricular nucleus of the hypothalamus secretes corticotropin releasing factor (CRF), which in turn stimulates the anterior pituitary gland to synthesize and release adrenocorticotropin (ACTH). ACTH stimulates the synthesis and release of adrenal cortical glucocorticoid (Southwick, et al., 2005) – in humans, cortisol.

The current study used salivary cortisol levels as the basis of indices of neuroendocrine functioning (for details of measurement, please see Method section). Cortisol is the primary glucocorticoid produced by the adrenal cortex. Cortisol has both metabolic and immunologic functions. Among its metabolic functions, it promotes gluconeogenesis, liver glycogen deposition, and the reduction of glucose utilization. Immunologically, cortisol is an important anti-inflammatory that is also involved in immuno-suppression and resistance to disease.

Although it is possible to assay cortisol in the blood or urine with increased precision, salivary sampling provides a reliable assay of cortisol that is economical, comparatively non-invasive, and heavily involved in hypothalamic-pituitary-adrenal axis functioning. A number of studies have revealed correlations of $r > 0.90$ between salivary and plasma cortisol levels (Kirschbaum & Hellhammer, 1989). Importantly, there is evidence that engaging in caregiving tasks results in increased cortisol production that is detectable despite the many uncontrolled factors affecting cortisol (Davis, et al., 2004). Moreover, adrenocortical indices such as cortisol are highly reactive to acute and chronic psychosocial stress and are associated with both state and trait factors (e.g.,

affect and personality). Measurable changes in saliva cortisol levels can be expected to occur approximately 15 minutes after exposure to a psychosocial stressor. It is important to consider not only absolute value of salivary cortisol levels, but also analyze change indices, such as the difference between baseline and post-acute stress cortisol levels (reactivity to acute stress), as well as the difference between post-acute stress cortisol samples and ones taken 15 minutes after a rest-period (repair from acute stress) (Burleson, et al., 2003; Kirschbaum & Hellhammer, 1989).

Physiological Function

Two measures of physiological function were used in the current investigation: Blood Pressure (BP) and Heart Rate (HR). HR reflects the functioning of both the parasympathetic and sympathetic nervous systems. HR reactivity (as in reaction to acute stressors, for example) has been associated in research with plasma cortisol, and immune responses to stress (Cacioppo, et al., 1995; Sgoutas-Emch, et al., 1994). In healthy individuals, there is parasympathetic regulation of HR that promotes health and may reduce sympathetic reactions to stress (Porges, 1992). Poor parasympathetic control of HR may be related to a host of adverse consequences including hypertension, cardiovascular disease, and death (Singh, et al., 1998). Moreover, chronically low parasympathetic tone and reactivity may predict a person's vulnerability to stress (Porges, 1992). Blood pressure refers to the amount of force that is exerted by circulating blood on the walls of vessels. Like HR, BP is reactive to stress and associated with plasma cortisol levels (Cacioppo, et al., 1995; Sgoutas-Emch, et al., 1994). Chronically high BP is a key indicator of poor cardiovascular health as well as a leading predictor of cardiovascular disease (Seshadri, et al., 2001; The sixth report of

the Joint National Committee on prevention, detection, evaluation, and treatment of high blood pressure," 1997; Stamler, Stamler, & Neaton, 1993)

Limitations of the Extant Literature

To date, there have been no published investigations of physiological or neuroendocrine relationships with long-term psychological outcome among persons with TBI and their significant others, despite precedent in other medical contexts (such as progressive dementia) described above. Even in progressive dementia research, where the role of physiology and neuroendocrine function in long-term outcomes is somewhat established, no published studies have examined the potentially moderating role of AOD on physiological/neuroendocrine indices of chronic stress and acute stress reactivity. Just as emotional distress is moderated by awareness of deficit, the stress response regarding deficits associated with TBI is likely diminished or absent among persons who lack awareness about their deficits. In addition, the outcomes of interest tend to be physical health outcomes, which, while important, may not capture potential links between physiological/neuroendocrine functioning and psychological/psychosocial outcomes. Importantly, in published research that incorporates an acute laboratory stressor, there is often an unclear correspondence between the types of acute stressors used and the types of underlying chronic stress. For example, it is not clear how and to what extent physiological and neuroendocrine responses to generic public-speaking or mental-arithmetic tasks are related the type of stress experienced in the daily lives of survivors and significant others with disability (loss of autonomy, adjustment to disability, etc.). It may be that stronger relationships between chronic and acute reactions to stress in predicting long-term outcomes will emerge when there is a closer

correspondence between the tasks used to measure acute stress reaction, and the chronic stressors experienced by persons with disability and their significant others (Uchino, et al., 1992).

Purpose and Aims of the Current Study

Overview

The current research project was the first to investigate the relationships between physiological/neuroendocrine reactivity to stress among persons with TBI and their significant others, and long-term psychological outcomes. In addition, this study was the first to investigate the potential moderating role of patient AOD in characterizing these relationships. Outcomes of interest included level of psychological distress, subjective life satisfaction, perceived competence in providing care (significant others only), and perceived burden in providing care (significant others only). Importantly, the study addressed many of the limitations of the extant literature. For example, unlike most previous research, the design used an acute stressor that was germane to the underlying chronic stress in this population, as opposed to a generic public speaking or mental arithmetic task.

Objective 1 (PNSR and Long-Term Outcome)

The first objective of the current study was to describe the extent to which physiological/neuroendocrine stress reactivity among persons with TBI and their significant others is related to their psychological distress, satisfaction with life, and (in significant others only) mastery in providing care and perceived burden in providing care.

Hypothesis 1-A: Among survivors, it was hypothesized that physiological/ neuroendocrine stress reactivity would be positively associated with psychological distress, and inversely correlated with life satisfaction, even after accounting for demographic characteristics, perceived social support, and injury severity.

Hypothesis 1-B: Among significant others, it was hypothesized that physiological/ neuroendocrine stress reactivity would be positively associated with psychological distress and burden in providing care, and inversely related to both satisfaction with life and mastery in providing care, even after accounting for demographic characteristics, perceived social support, and injury severity.

Objective 2 (Role of Awareness of Deficit)

A second objective of the current study was to identify differences in physiological/ neuroendocrine stress reactivity, psychological distress, and life satisfaction among persons with TBI and their significant others, as a function of the level of deficit awareness of the person with TBI.

Hypothesis 2-A: It was hypothesized that TBI survivors who are unaware of their deficits would show less psychological distress and higher overall life satisfaction than those characterized by awareness of deficits. By contrast, it was hypothesized that among significant others, subjective life satisfaction and perceived mastery in providing care would be positively correlated with patient AOD, whereas psychological distress, and perceived burden in providing care would show an inverse correlation with patient AOD.

Hypothesis 2-B: It was hypothesized that TBI survivors who are unaware of their deficits would show less PNSR than those characterized by awareness of deficits. The

opposite pattern of relationships was predicted in the SO group. Specifically, among significant others, PNSR would be lower for those who provide support to survivors with intact awareness.

Hypothesis 2-C: It was hypothesized that the relationships in hypothesis 1 would be moderated by level of awareness. Specifically, it was hypothesized that in TBI survivors, relationships between PNSR and psychosocial outcomes would be strongest for survivors with intact awareness of their impairments. Among SOs of those survivors, relationships between PNSR and psychosocial outcome, would be strongest among SOs of survivors with impaired awareness.

CHAPTER 2

METHOD

Participants and Setting

The initial pool of eligible persons with TBI and significant others included individuals who enrolled in the Southeastern Michigan Traumatic Brain Injury System (SEMTBIS) research project between 2001 and 2007 who agreed to be contacted at a later date regarding other research projects. In order to be eligible SEMTBIS participants, persons with TBI were at least 16 years of age at the time of injury, received acute care at a designated model system acute-care site within 24 hours after injury, were directly transferred to a model system inpatient rehabilitation unit, and gave informed consent. Thus, this sample excluded persons with mild or very severe brain injuries who did not receive inpatient rehabilitation. The size of this initial eligibility pool at the time of data collection was 568 survivors, and 177 significant others. Significant others were identified by the TBI survivor as a relative or close friend who was familiar with their daily functioning and who currently or previously provided assistance, care, and/or support for the survivor as part of their recovery from TBI.

Whenever possible, evaluations were conducted at the Rehabilitation Institute of Michigan in Detroit. When this was not possible, evaluations were conducted at the Rehabilitation Institute of Michigan in Novi, Michigan (2 survivor/significant other pairs), or at the participant's home (2 survivor/significant other pairs).

Measures

Stressful Aspects of Recovery Form (SAR)

The Stressful Aspects of Recovery (SAR) Form was developed for this study in order to help participants prepare for the stressful speech task by identifying and quantifying aspects of recovery that were most stressful for them. Nine areas of potential difficulty were rated using a scale of 1 to 10 in which *1 = "Not at All Stressful,"* and *10 = "Extremely Stressful."* Areas of potential difficulty included the following: physical problems, emotional problems, cognitive/thinking problems, functioning problems, behavioural problems, financial problems, social support problems, legal problems, and other problems. Examples were provided for each area for clarification. Note that survivors rated their stress in dealing with their own difficulties in the nine areas. Significant others rated *their own* level of stress in dealing with *the survivor's problems* in the nine areas. The survivor and significant other SAR forms are shown in Appendices 1 and 2, respectively. Following their subjective ratings, the examiner confirmed with the participant the three areas of highest subjective stress, and these were selected as areas to discuss for the videotaped speech described next.

Stressful Speech Task

Acute stress in the current study was elicited via a videotaped speech lasting 3 min in which participants were asked to talk about the most stressful aspect(s) of their recovery as identified on the SAR. Prior to the speech, participants were read the following instructions: *"For this study, we are interested in seeing how you handle stress. In order to find out, we're going to ask you to do something that many people find somewhat stressful: write and deliver a speech. We are going to give you 5 minutes to prepare a 3-minute speech. The topic of the speech should be about…"*

For survivors, *"…the most stressful part of your recovery, as identified on the form you just filled out."* For significant others, *"…the most stressful part about caring for your loved one during his/her recovery, as identified on the form you just filled out."*

The following additional instructions were given:

> *"You should start by talking about the most stressful aspect of recovery, then, if you have time, move to the next aspect, until the 3 minutes have elapsed. Things you could talk about include some of the experiences you had, and why they were stressful, what kinds of emotions you had during that time, what the hardest challenges were, etc. You may use this paper to make notes that will help you organize your thoughts. However, you may not use any notes when you give the speech. If you run out of things to say, please try to keep talking for the entire 3 minutes. The speech will be videotaped so that later I can view the tape and judge the quality and content of your speech, so please make sure to try your best. I will also give you immediate feedback about how well you did your speech. This video will not be viewed by anyone outside the study. The clips will be stored in a secure filing cabinet at the hospital. Do you have any questions?"*

After reading the instructions and answering any questions, the examiner provided the participant with a piece of paper and pencil and left the room during the speech preparation period. Upon returning and completing PNSR measurements, the examiner recorded the participant's 3-min speech. During the speech, the examiner was instructed to stand opposite the seated participant, make direct eye contact, and hold the stopwatch in an obvious fashion. If the participant indicated that he/she could not think of anything else to say, or if he/she stopped speaking for a several seconds prior to the 3-min time limit, the examiner prompted him/her to continue and provided an area of concern as indicated on the participant's SAR form. When the 3-min time limit had elapsed, the examiner thanked the participant for their speech and provided the following generic feedback: "You did a good job of explaining your experience. I have a better understanding about what recovery was like for you." The examiner explained the

speeches would not be rated for quality as part of the current study. Following the speech, participants had a 20-min recovery period, during which they were offered a small selection of magazines to read.

Neuroendocrine/Physiological Predictors of Outcome

Cortisol. Participants were asked to thoroughly rinse their mouths with water at least 10 min prior to collection of cortisol in order to minimize potential contaminants. Participants were asked to refrain from smoking, caffeine and alcohol intake, and vigorous exercise the day of the assessment. Salivary cortisol was collected using the *Salimetrics Oral Swab (SOS)*, which is an inert polymer cylindrical swab (10 mm x 30 mm) that becomes saturated with saliva when placed under the tongue for 1 to 2 min. The SOS was placed within a plastic cryovial tube appropriate for freezing. Tubes were placed within a storage box and frozen immediately. Research shows that salivary samples can be stored for a year or more (at -10 degrees Celsius) without an appreciable effect on cortisol concentration (Kirschbaum & Hellhammer, 1989). Cortisol samples were sent in large batches via overnight courier to Salimetrics Labs in Pennsylvania for analysis. Samples were shipped on dry ice in accordance with Salimetrics' recommended procedure. Salimetrics used an Enzyme-Linked Immunosorbent Assay (ELISA) cortisol kit with a reported sensitivity of 12 micrograms per 100mL (12 µg/dL) and a mean intra-assay coefficient of variation of 4.8% (M. van Eck, et al., 1996). All samples were assayed in duplicate and the mean value was used for the study.

Blood Pressure (BP). Systolic and diastolic BP were measured using a home blood pressure monitor with a standard occluding cuff applied to the participant's left

arm. In accordance with the recommendations of the manufacturer, participants whose arms did not fit comfortably within the standard cuff were provided with a larger cuff.

Heart Rate (HR). HR was estimated by the home blood pressure monitor, simultaneously with BP measurement.

Awareness

Awareness Questionnaire (AQ; (Sherer, Bergloff, Boake, High, & Levin, 1998). The AQ was developed as a measure of self-awareness after traumatic brain injury. The 17-item survey is completed by TBI survivors about their own abilities, and a version of the form is completed by significant others about the survivor. The measure was designed to assess perception of the survivor's functioning in three domains: cognitive, behavioral/affective, and motor sensory. The ability to perform various tasks after the TBI as compared to before the injury are rated on a 5-point scale ranging from "much worse" to "much better." The AQ provides an index of awareness of deficit that is calculated as the discrepancy between survivors' self-report of their cognitive, behavioral, and motor functioning and significant others' perceptions of the survivors' abilities. Internal consistency for the total score was reported at .88 for survivor and significant other samples (Sherer et al., 1998a). The AQ Survivor form is shown in Appendix D. The AQ Significant Other form is shown in Appendix E.

Awareness of Deficit was assessed using the AQ Difference score: The index defined impaired awareness in terms of the discrepancy between survivors' self-reports of their general functional abilities across a variety of domains and the external criterion of significant others' perceptions of the survivors' functional abilities (Survivor AQ – significant other-rated AQ). Discrepancy scores of this nature are a widely-used,

traditional approach of quantifying awareness of deficit among populations with cognitive impairment such as TBI (Prigatano, Altman, & O'Brien, 1990; Prigatano & Fordyce, 1986) and MS (Ryan, et al., 2009; Sherman, Rapport, & Ryan, 2007). Positive scores indicate that survivors rated themselves as more functionally able than did their significant others (i.e., unawareness of deficit). Negative scores indicate that survivors underrated their functional abilities as less functionally able compared to significant other perceptions of the survivors' abilities (i.e., hypervigilance or hyperawareness). Scores approaching zero indicate convergence between survivor self-perceptions and perceptions of them by significant others (awareness).

Outcome Measures

Brief Symptom Inventory-18 (BSI-18) (Derogatis, 2001). The BSI-18 requires respondents to rate their level of distress *over the past 7 days* using a 5-point (ordinal) Likert-type scale, in which 0 = Not at All, 1 = Rarely/Occasionally, 2 = Sometimes, 3 = Often, and 4 = Extremely. The BSI-18 provides scores on three dimensions: "Somatization", "Depression", and "Anxiety". Each of these clinical subscales is comprised of 6 items, such that the range of possible scores for each is 0 – 24. In addition, a composite score, a "Global Severity Index" (GSI) is calculated based on all 18 items such that the range of possible scores is 0 - 72. The internal consistency of the GSI has been shown to be excellent across studies (Derogatis, 2001; Prelaw & Weaver, 2005; Zabora, et al., 2001), whereas internal consistency estimates on the three clinical dimensions are more modest and variable. For the present study, GSI served as a measure of long-term psychological outcome for both survivors and significant others.

Satisfaction with Life Scale (SWLS) (Diener, Emmons, Larsen, & Griffin, 1985). The SWLS requires respondents to rate their level of agreement with five life satisfaction statements using a 7-point scale (*strongly disagree* = 1 to *strongly agree* = 7). The SWLS reflects a global judgment of life satisfaction. Examples of items on the SWLS include "In most ways my life is close to my ideal life" and "If I could live my life over, I would change almost nothing." In the present study, total score on the SWLS served as an outcome measure for survivors and significant others. Internal consistency estimates of the SWLS was adequate (Cronbach's alpha = .72) in a recently published report based on data collected from significant others of persons with TBI (Ergh, et al., 2003). The SWLS is shown in Appendix F.

Caregiver Appraisal Scale (CAS) (Struchen, Atchison, Roebuck, Caroselli, & Sander, 2002). The CAS is a multidimensional measure of caregiving appraisal that has been validated for use with caregivers of adults with TBI. Respondents indicate their extent of agreement with 41 statements about caregiving using a 5-point scale (*strongly disagree* = 1 to *strongly agree* = 5). Examples of items on the CAS include, "I am very tired as a result of caring for this individual", "It makes me happy to know that this individual is being cared for by his/her family," and, "I have lost control of my life since this individual's injury." Principal components analysis with varimax rotation yielded four factors that were stable across treatment settings: perceived burden, caregiver relationship satisfaction, caregiving ideology, and caregiving mastery. In the present study, perceived burden (CAS PBS) and caregiver mastery (CAS Mastery) served as outcome measures for significant others. These subscales are scored so that high

scores on both are interpreted in the healthy (i.e. greater mastery, less perceived burden) direction. The CAS is shown in Appendix G.

Other Measures

Social Provision Scale (SPS) (Cutrona & Russell, 1987). The 12-item SPS requires respondents to rate their level of perceived social support using a 5-point Likert scale (*strongly disagree = 1* to *strongly agree = 5*). Examples of items include, "There are people I can depend on to help me if I really need it" and "I feel a strong emotional bond with at least one other person." In a published report of SEMTBIS participants (Ergh, et al., 2002), the internal consistency of this measure was adequate for research (*Cronbach's alpha* = .78). The SPS is shown in Appendix H.

Demographic and Health Behavior Predictors of Outcome

In order to account for variance in outcome that is attributable to demographic and health status, information about gender, age, race/ethnicity, years of education, income level, comorbid illnesses, and medication usage were recorded.

Injury Severity

Time to follow commands, which is defined as the number of days that it takes to obtain a score of 6 on the motor subscale of the Glasgow Coma Scale two out of two times within a 24-hour period, was used a index of brain injury severity. To provide secondary information about injury severity, length of post-traumatic amnesia was also recorded.

Procedure

Key personnel contacted eligible participants via phone. During this initial contact, the clinician briefly explained the purpose and procedures of the study,

including risks and benefits of participation. Those individuals who indicated that they were interested in participating were asked to come to RIM to complete the assessment. If the potential participant indicated that was not feasible for him/her to come to RIM in Detroit, the key personnel offered to complete the assessment at RIM in Novi, or, barring that, the participant's home. Key personnel explained that the assessments should ideally take place in the morning (beginning between 8 am and 10 am). If the potential participant indicated that this was prohibitive, the key personnel offered alternative times for the assessment. Potential participants were asked to refrain from caffeine, alcohol, smoking, and vigorous exercise on the morning of the assessment. Individuals who agreed to participate were scheduled for a visit. They received a phone call (1 to 3 days prior to their appointment) to remind them of the date, time, and location of the assessment. In order to minimize the influence of diurnal cortisol changes, survivors were tested, when possible, in the morning, when cortisol values tend to be highest. However, due to availability, 3 pairs of participants were tested in the early afternoon.

The examiner obtained informed consent from each participant according to procedures specified by the Wayne State University Human Investigation Committee (HIC). The examiner explained the scope and limits of confidentiality and participant rights, and answered any questions that were posed.

Timing of Cortisol, BP, and HR Measurement. As much as possible, examiners adhered to the timing of cortisol, heart rate, and blood pressure measurement schedule shown in Appendix 3. In order to acclimate participants to the measurement procedure, BP and HR were taken immediately after obtaining informed consent (at approximately

6 min into the procedure). These measurements were termed “white coat” measurements, because of the known tendency for initial BP/HR readings taken in the presence of a health professional to be higher than those taken some time later. White coat measurements of BP and HR (also known as BPS1, BPD1, and HR1) were not included in any of the analyses.

Baseline Measurements of BP and HR were taken 20 min into the procedure, after allowing the participant to get used to the examiner and setting. BP and HR were measured for a third time immediately prior to speech delivery (following the speech preparation), and for a fourth time immediately after delivery of the speech. The latter measurement point was the *High Stress* measurement of BP and HR (BPS4, BPD4, and HR4). In order to monitor recovery from stress, BP and HR were then measured 5 additional times, at 4-min intervals, throughout the recovery period.

Baseline measurements of cortisol were taken at the same time as baseline measurements of BP and HR. *High Stress* measurements of cortisol were taken 12 min after the speech. *Recovery* measurements of cortisol were taken 22 min following the speech.

All other questionnaires were administered following the recovery period and after all PNSR measurements had been taken. Participants were compensated $20.00 for their time.

Analyses

Objective 1

Hypothesis 1 a & b. These hypotheses were investigated by examining partial correlations between PNSR variables and outcome variables after accounting for injury severity (time to follow commands), SPS scores, age, and education.

Objective 2

Hypothesis 2a. Four univariate ANOVAs were run, one for each outcome variable. For the outcome variables BSI-18 GSI and SWLS, ANOVAS included two between-group factors: group membership (survivor vs. significant other) and awareness status (intact vs. impaired). For the outcome variables CAS PBS and CAS Mastery, ANOVAs included only one between-group factor: awareness status. All four ANOVA models were conducted with age, education, injury severity (time to follow commands), and SPS score as covariates.

Hypothesis 2b. Four repeated-measures general linear models were run. In the first model, cortisol at times 1, 2, and 3 was the within-subject factor, and awareness status and group (survivor vs. significant other) were the between-groups factors. In the second model, systolic blood pressure at times, 2-9 (“white coat” measurement excluded) was the was the within-subject factor, and awareness status and group (survivor vs. significant other) were the between-groups factors. In the third model, diastolic blood pressure at times, 2-9 was the was the within-subject factor, and awareness status and group (survivor vs. significant other) were the between-groups factors. In the fourth and final model, heart rate at times, 2-9 was the within-subject factor, and awareness status and group (survivor vs. significant other) were the between-groups factors.

Hypothesis 2C: Split-plot correlations were used to test the hypothesis that awareness of deficit moderates any relationships between PNSR and psychosocial outcome that were previously found in hypothesis 1.

CHAPTER 3

RESULTS

Preliminary Analyses

Prior to analysis, the data were screened for violations of the assumptions associated with univariate and multivariate tests. Variables with non-normal distributions were transformed to improve normality and linearity when possible. Results of this evaluation led to square root transformations of all absolute systolic and diastolic BP variables, as well as all absolute cortisol variables (change BP and cortisol variables remained untransformed). Also, to reduce the disproportionate influence of outliers, cortisol values were winsorized (Tabachnick & Fidell, 2006). For the purposes of interpretation, the untransformed values are included in tables, whereas the transformed variables were used in the statistical analyses.

Description of Sample

Seventy-nine individuals with a history of moderate or severe TBI from the SEMTBIS research pool and 65 of their significant others participated in the present study. This sample excludes 4 survivors and 8 significant others who had missing or invalid cortisol data due to insufficient quantity of saliva (1 case), implausible values suggesting a contaminated sample (9 cases), or because the participant completed only the questionnaire portion of the study (2 cases). Four additional significant others were excluded due to outlying values on age ($\geq$ 75 years). Finally, five pairs were excluded because of missing or incomplete AQ data. Of these, three pairs had missing AQ data because the survivor's cognitive impairments were too severe for them to understand

the task instructions; two pairs had missing AQ data because the identified significant other had not known the survivor prior to his/her injury.

Demographic Characteristics

Descriptive statistics for TBI survivors and significant others are summarized in Table 1. The sample ranged in age from 20 to 72 years (M = 46.3, SD = 13.0) and ranged in education from 8 to 18 years (M = 12.0, SD = 2.0). The majority of the sample identified themselves as African American (73.6%), whereas 22.9% identified as white, and 2.1% other. Significant others (27.7%) were significantly less likely than TBI survivors (72.3%) to be men (χ^2 (1) = 39.26, p < .001). However, as shown in Table 2, gender was generally not related to any of the outcome variables of interest, with the exception of a small positive correlation with baseline cortisol in the TBI survivor sample (Eta = .32), as well as a small positive correlation with CAS Mastery in the significant other sample (Eta = .27). On average, significant others had more years of education than survivors (F (1,142) = 9.0, p = .003). As shown in Table 2, education was not related to any of the outcome variables of interest in the TBI survivor sample. In the significant other sample, there was a moderate inverse correlation between education and psychological distress assessed via BSI-18 (r = -.52) as well as small positive correlations between education and significant other mastery (r = .33) and significant other perceived burden (r = .27) assessed via CAS significant other mastery subscale. TBI survivors and significant others did not differ significantly in terms of age (F (1, 142) = 2.31, p = .131).

Injury Characteristics

TBI survivors took an average of 7.1 days (*SD* = 8.8, *range* = 0.5 – 40.0) to obtain a motor score of 6 on the Glasgow Motor Scale (i.e., obey commands for movement) and 26.4 days (*SD* = 19.8, range = 0 – 76) to clear post-traumatic confusion based on the Orientation Log or Galveston Orientation and Amnesia Test. They were an average of 121.7 months (*SD* = 67.1) post injury at the time of evaluation. As shown in Table 2, injury characteristics were generally unrelated to predictor and outcome variables of interest, with the following exceptions. Impaired awareness (AQ difference) was moderately correlated with injury severity as assessed by days of post-traumatic confusion (*r* = .36); and, in the survivor sample, days to follow commands was inversely correlated with psychological distress as assessed by BSI-18 GSI T scores (*r* = -.33), and positively correlated with perceived social support as assessed by SPS scores (*r* = .24). Among significant others, sense of caregiving mastery as assessed by the CAS Mastery subscale was positively correlated with perceived social support as assessed by SPS score (*r* = .31).

Severity of TBI was defined based on days of post-traumatic confusion and days to follow commands (essentially days of unconsciousness). Severe cases (83.5%) were those individuals with either > 24 hours to follow commands or > 7 days of post-traumatic confusion. Moderate cases (8.9%) were those in which either 1 to 24 hours to follow commands or 1 to 7 days of post-traumatic confusion elapsed. Mild complicated cases (7.6%) were those in which time to follow commands was less than 1 hour and post-traumatic confusion was less than 1 day, but acute intracranial pathology was identified on neuroimaging. The majority of the brain injuries were caused by blunt assault (31.6%), gunshot wound (12.7%), or other violence (2.5%), followed by motor

vehicle accident (27.8%); other injuries were caused by falls (10.1%), struck as pedestrian (6.3%), motorcycle accident (6.3%), all-terrain vehicles (1.3%), and hit by flying/falling object (1.3%).

Predictor and Outcome Variables

Descriptive statistics for predictor and outcome variables as a function of group membership (survivors vs. significant others) are summarized in Table 1. Correlations between predictor/outcome variables and demographic/injury severity variables are summarized in Table 2.

Psychological Distress (BSI-18). In the present study, the internal consistency of the BSI-18 Global Severity Index (GSI) was excellent (*Cronbach's α* = .91). TBI survivors had an average gender-corrected GSI T score on the BSI-18 of 55.8 (*SD* = 10.7) compared with an average raw score of 53.1 (*SD* = 11.4) in the significant other group, F (1,142) = 2.10, p = .150. Participants also were classified for *caseness* (presence of significant psychological distress) as per standard scoring: Global Severity Index T Score > 62, two subscale T Scores > 60, or any endorsement of Item 17 (thoughts of ending one's life). Using these criteria, 31 (39.2%) of TBI survivors were classified as distressed, compared with 18 (27.7%) of significant others, $\chi 2$ (1) = 2.12, p = .146.

Subjective Life Satisfaction (SWLS). In the present study, the internal consistency of the SWLS was adequate for research purposes (*Cronbach's α* = .81). The TBI survivor group (*M* = 17.5, *SD* = 7.8), endorsed significantly lower satisfaction with life on the SWLS than did the significant other group (*M* = 20.2, *SD* = 6.6), F (1,142) = 4.92, p = .028. *Cohen's d* for this group difference was -0.37, which indicates

a small to medium effect. Mean SWLS scores among TBI survivors was meaningfully lower than mean SWLS scores of a sample of 244 American college students (*M* = 23.7, *SD* = 6.4; Pavot & Diener, 1993) and a sample of 25 nurses and health workers (*M* = 23.6, *SD* = 6.1; Judge, 1990). The mean SWLS item endorsement within the TBI group (3.4) corresponds to “slightly disagree” (i.e., less than satisfied with one's life) whereas the mean SWLS item endorsement within the significant other group corresponds to “neutral.” Using interpretative guidelines for the SWLS (Diener et al., 2002), 57.1% of the survivors were slightly dissatisfied with their life and 27.4% were very dissatisfied with their life; among significant others, 35.7% were slightly dissatisfied with their life and 12.9% were very dissatisfied with their life.

Perceived Social Support (SPS). On the SPS, the TBI survivor group (*M* = 38.7, *SD* = 4.0) did not differ significantly from the significant other group (*M* = 37.7, *SD* = 2.8), *F* (1,142) = 2.78, *p* = .098). The mean item score (after reverse scoring) across all items of the SPS was 3.2 (*SD* = .29), which corresponds roughly to “neutral/uncertain.”

Awareness Questionnaire (AQ). In the present study, the internal consistency of the AQ patient report was excellent (*Cronbach’s α* = .95) as was the internal consistency of the AQ significant other report (*Cronbach’s α* = .95). On the AQ, TBI survivors (*M* = 43.9, *SD* = 13.7) rated themselves significantly more functional than did their significant others, (*M* = 38.9, *SD* = 13.4), *t* (144) = 2.24, *p* = .013. *Cohen’s d* for this difference was 0.36, which indicates a small to medium effect.

Caregiver Appraisal Scale – Perceived Burden Subscale (CAS PBS). The average score on the CAS PBS was 53.2 (*SD* = 12.6). This mean CAS PBS score was similar to the mean CAS PBS score of 241 caregivers of persons with TBI in a different

study (Struchen et al, 2002; *M* = 52.7, *SD* = 12.9). In the present study, the mean item score (after reverse scoring) across all 15 items of the CAS PBS was 3.7 *(SD* = 0.8*),* where a mean of 1 reflects maximal perceived burden and a mean of 5 reflects minimal perceived burden.

Caregiver Appraisal Scale – Caregiving Mastery Subscale (CAS Mastery). The average score on CAS Mastery was 13.5 (*SD* = 3.1). This mean CAS Mastery score was similar to the mean CAS Mastery score of 241 caregivers of persons with TBI in a different study (Struchen et al, 2002; *M* = 13.9, *SD* = 3.0). In the present study, the mean item score across all four items of the CAS Mastery scale was 3.4 (*SD* = 0.78), where a mean of 5 reflects maximal perceived mastery of caregiving.

PNSR Variables. Tables 3 to 6 provide the means and standard deviations for absolute and change values of cortisol, systolic blood pressure, diastolic blood pressure, and heart rate, as a function of group membership (TBI vs. significant other). Group differences between TBI survivors and significant others on PNSR variables were explored as part of analyses for Hypothesis 2b.

Objective 1 – PNSR and Psychological Outcomes

Hypothesis 1-A (Survivors). The results of these analyses are summarized in a series of four correlation tables (Tables 7 – 10), which show both the zero-order correlations (below the diagonal), as well as the partial correlations (above the diagonal), the latter adjusting for injury severity, perceive social support (SPS total), age, and education.

In terms of covariates, time to follow commands (*r* = -.31, *p* = .004) and SPS total (r = -.24, *p* = .019) accounted for significant variance in BSI-18 GSI T scores within the

survivor group. Specifically, less severe injury and lower perceived social support (SPS total) were associated with higher reported psychological distress (BSI-18) among survivors. Neither injury severity nor SPS total was associated with significant variance in SWLS within the survivor sample. Neither age nor education was associated with significant variance in BSI-18 GSI or SWLS within the TBI survivor sample.

As shown in Table 7, within the TBI survivor group, there was a trend toward baseline cortisol accounting for a small proportion of variance in BSI-18 GSI, even after accounting for age, education, injury severity (time to follow commands) and SPS total, partial correlation = .20, $p = .052$. In other words, consistent with the hypothesis, higher baseline cortisol was associated with slightly higher self-reported psychological distress in the survivor sample. Contrary to the hypothesis, neither high stress cortisol (time 2), recovery cortisol (time 3), nor cortisol change indices, were associated with BSI-18 GSI in the TBI survivor sample. None of the cortisol variables was associated with significant variance in SWLS within the TBI survivor sample.

As shown in Table 8, within the survivor group, baseline systolic blood pressure (BPS) accounted for a small but significant amount of unique variance in SWLS (partial correlation = .20, $p < .05$), but not BSI-18 GSI. This result was in the opposite direction as expected. Although neither BPS Change 1 (Baseline – High Stress) nor BPS Change 3 (Baseline – Recovery) was associated with unique variance in either outcome variable, BPS Change 2 (High Stress – Recovery) was associated with both. Specifically, and in keeping with the hypothesis, there was a small but significant inverse correlation between BPS Change 2 and BSI-18 GSI after accounting for injury severity (time to follow commands), SPS total, age, and education (partial correlation = -

.21, $p < .05$). In addition, there was a positive association between BPS Change 2 and SWLS, partial correlation = .27, $p < .05$.

Because BPS Change 2 is calculated by subtracting BPS Time 9 (recovery) from BPS Time 4 (high stress), higher positive scores reflect the expected pattern of lower BPS at recovery than at high stress. Thus, the present finding suggests that within the TBI survivor sample, greater BPS recovery from stress (BPS change 2) was associated with lower self-reported psychological distress and higher self-reported satisfaction with life.

Table 9 shows the zero-order and partial correlations between diastolic blood pressure (BPD) variables and outcome variables of interest in the survivor sample. Contrary to the hypothesis, neither baseline BPD, nor any of the BPD change variables, accounted for significant variance in either BSI-18 GSI or SWLS in the survivor sample, after accounting for age, education, injury severity (time to follow commands), and SPS total.

Table 10 shows the zero-order and partial correlations between heart rate variables and outcome variables of interest in the survivor sample. Providing mixed support for the hypothesis, there was a small but significant inverse relationship between HR Change 1 (Baseline – High Stress) and SWLS, (partial correlation = -.24, $p < .05$), which was not observed between HR Change 1 and BSI-18 GSI. Because HR Change 1 is calculated by subtracting HR Time 4 (High Stress) from HR Time 2 (Baseline), highly reactive HR (large increases from baseline to high stress) are reflected in increasingly negative scores for HR Change 1. Thus, the present finding suggests that greater reactivity to the stress task (negative values for HR Change 1)

was associated with lower subjective life satisfaction. In addition, HR Change 3 (Baseline – Recovery) accounted for a small but significant proportion of unique variance in SWLS (partial correlation = -.21, $p < .05$) but not BSI-18 GSI. For HR Change 3, increasingly positive scores reflect greater decreases in HR from Baseline to Recovery. Thus, the current finding suggests that decreases in HR from Baseline to Recovery are associated with lower subjective life satisfaction. Contrary to expectation, within the TBI sample, neither baseline heart rate, nor HR Change 1 (Baseline – High Stress) was associated with significant unique variance in BSI-18 GSI scores or SWLS scores.

Hypothesis 1-B (Significant others). The results of these analyses are summarized in a series of three correlation tables (Tables 11 - 14), which show both the zero-order correlations (below the diagonal), as well as the partial correlations (above the diagonal), the latter adjusting for injury severity, SPS total, age, and education.

In terms of covariates within the significant other sample, education was correlated with BSI-18 GSI ($r = -.52$, $p < .001$) and CAS Mastery ($r = .33$, $p < .01$). There was a small but significant inverse correlation between age and CAS PBS ($r = -.21$, $p < .05$), as well as between age and BSI-18 GSI ($r = .27$, $p < .05$). Injury severity (time to follow commands) was positively associated with both CAS PBS ($r = .20$, $p < .01$) and CAS Mastery ($r = .29$, $p < .01$). SPS scores within the significant other sample were not significantly correlated with any of the outcome variables of interest.

As shown in Table 11, there were significant inverse partial correlations between significant other BSI-18 GSI and both significant other high stress cortisol ($r = -.25$, $p < .05$) and significant other recovery cortisol ($r = -.34$, $p < .01$), as well as a trend toward

an inverse partial correlation between significant other BSI-18 GSI and significant other baseline cortisol (r = -.20, p = .06). This was counter to expectation in that, as was the case in the TBI group, cortisol was predicted to be positively associated with psychological distress. In general, SWLS scores were not associated with cortisol variables in the significant other sample, aside from a trend toward a positive partial correlation between SWLS scores and recovery cortisol (r = .21, p = .054). There were significant positive partial correlations between CAS PBS and baseline cortisol (r = .23, p < .05), and recovery cortisol (r = .32, p < .01). As was the case with BSI-18 as an outcome, these relationships are contrary to the hypothesis, because as baseline and recovery cortisol values increased, significant other perception of burden decreased. There were also trends (in the counter-intuitive direction) toward positive partial correlations between CAS PBS and high stress cortisol (r = .21, p < .10), as well as cortisol change 1 (baseline – high stress, r = .20, p < .10). Caregiving mastery as assessed by the CAS Mastery subscale was not significantly associated with baseline or change cortisol indices in the significant other sample.

As shown in Table 12, systolic blood pressure (BPS) at Time 2 (baseline) was inversely related to SWLS in the significant other sample, as hypothesized, even after accounting for age, education, injury severity (time to follow commands), and SPS total (partial correlation = -.28, p < .05). However, baseline systolic blood pressure was not related to other outcomes of interest in the significant other sample (BSI-18 GSI, CAS PBS, or CAS Mastery). In keeping with the hypothesis, BPS Change 2 (high stress – recovery), was inversely related to BSI-18 GSI (partial correlation = -.22, p < .05) and positively related to CAS Mastery (partial correlation = .24, p < .05) after accounting for

covariates. Similarly, there was a trend toward a positive partial correlation between BPS Change 2 (high stress – recovery) and CAS PBS (partial correlation = .22, $p < .10$). Increasingly positive scores on BPS Change 2 reflect greater decreases in BPS from Time 4 (High Stress) to Time 9 (Recovery). Thus, the present finding suggests that, consistent with the hypothesis, reductions in SBP from high stress to recovery were associated with increase in subjective life satisfaction, as well as increases in CAS Mastery reduced perceived burden. BPS Change 2 was not associated with the SWLS in the significant other sample. BPS Change 3 (baseline – recovery) accounted for significant variance in BSI-18 GSI, even after accounting for covariates. Specifically, and in keeping with the hypothesis, reductions in SBP from Time 2 (Baseline) to Time 9 (Recovery) (positive values of BPS Change 3), were associated with decreases in BSI-18 GSI scores (partial correlation = -.28, $p < .05$). There were also trends toward BPS Change 3 (baseline – recovery) having positive partial correlations with SWLS (partial correlation = .21, $p < .10$), CAS PBS (partial correlation = .20, $p < .10$), and CAS Mastery (partial correlation = .17, $p < .10$), all of which are in the expected direction. Contrary to prediction, BPS Change 1 (Baseline – High Stress) was not associated was any outcomes of interest in the significant other sample.

As shown in Table 13, baseline BPD (Time 2) showed the expected trend towards an inverse partial correlation with SWLS scores in the significant other sample (partial correlation = -.22, $p = .053$). BPD Change 2 (High Stress – Recovery) accounted for significant variance in SWLS (partial correlation = .27, $p < .05$) and CAS PBS (partial correlation = .29, $p < .05$), but not BSI-18 GSI or CAS Mastery. BPD Change 3 (Baseline – Recovery) accounted for significant variance in CAS PBS only (partial

correlation = .32, $p < .01$). Neither baseline BPD nor BPD Change 1 (Baseline – High Stress) was associated with significant variance in any of the outcomes of interest in the significant other sample.

As shown in Table 14, there was a trend toward Baseline HR accounting for significant variance in CAS PBS scores (but not BSI-18 GSI, SWLS, or CAS Mastery), even after accounting for covariates (partial correlation = .21, $p < .10$). This result is contrary to expectation because high scores on CAS PBS indicate lower perceive burden, thus it was expected to correlate negatively with baseline heart rate. Contrary to hypothesis, however, none of the HR Change variables accounted for significant variance in outcome variables of interest for the significant other group.

Objective 2 – Role of Awareness of Deficit.

Awareness Status. Using the procedure described in the method section, survivors were classified as "intact awareness" (i.e., aware/hypervigilant) or "impaired awareness" based on the difference between their responses to the Awareness Questionnaire and those of their significant other. Within the survivor group ($n = 79$), 48 participants (60.8%) were classified as intact awareness; 40 significant others of those survivors were available. The remaining 31 survivors (39.2%) were classified as having impaired awareness; 25 significant others of those survivors were available to these analyses.

Approximately equal proportions of the intact awareness (77.1%) and impaired awareness (83.9%) survivors were men, $\chi^2(1) = .537$, $p = .464$. Ethnic composition of the intact and impaired survivors was equivalent between the two groups ($\chi^2(1) = .012$,

p = .914) and consistent with the composition of the overall sample. There were no significant differences between the survivors with impaired awareness and those survivors with intact awareness in terms of age (*F* (1, 77) = 0.75, *p* = .388), years of completed education (*F* (1, 77) = 2.84, *p* = .096), or injury severity (F (1, 73) = 0.14, *p* = .740). Similarly, there were no significant differences between significant others of survivors with impaired versus intact awareness in terms of age (*F* (1, 63) = 2.92, *p* = .092), years of education (*F* (1, 63) = 0.06, *p* = .803), or injury severity (*F* (1, 60) = 0.18, *p* = .672). Descriptive statistics summarizing demographic and injury characteristics as a function of awareness status and group membership (survivor vs. significant other) are shown in Table 15.

Objective 2-A.

Descriptive statistics summarizing psychosocial outcome variables as a function of awareness status and group membership (survivor vs. significant other) are summarized in Table 15. Contrary to expectation, there were no main effects or interactions across all four outcome variables of interest. However, the results for the interactions were in the predicted directions for SWLS, *F*(1, 140) = 1.97, *p* = .162, eta^2 = .02, and for BSI, *F*(1, 140) = 1.97, *p* = .162, eta^2 = .02. Education *F*(1, 140) = 4.23, *p* = .043, eta^2 = .03, but not age, *F*(1, 140) = 0.94, *p* = .760, eta^2 = .00 was a significant covariate. With education included, *F*(1, 140) = 2.63, *p* = .107, eta^2 = .02. As shown in Table 15, the means show the predicted pattern, in which SWLS is higher among survivors with impaired awareness of their deficits than among those with intact awareness of their deficits; in contrast, significant others of survivors with intact awareness of their deficits show higher mean SWLS than do those of survivors with

impaired awareness of their deficits. Conversely, distress is lower among survivors with impaired awareness as compared to intact, but it is higher among significant others of survivors with impaired awareness as compared to intact.

Objective 2-B – Awareness Status, Group Membership, and PNSR Variables.

Cortisol. Mean cortisol values as a function of awareness status and group membership (survivor vs. significant other) are shown in Table 16. A repeated-measures general linear model with cortisol at times 1, 2, and 3 as the within-subject factor, and awareness status and group (survivor vs. significant other) as between-groups factors was run. The within-subject factor was significant (*Greenhouse-Geisser Adjusted F* (1.6, 211.2) = 13.27, $p < .001$, $eta^2 = .09$). Post hoc analyses revealed that cortisol at Time 1 was significantly greater than cortisol at Time 2 (F (1, 136) = 6.37, $p = .013$, $eta^2 = .05$) and that cortisol at Time 2 was significantly greater than cortisol at Time 3 (F (1, 136) = 12.43, $p = .001$, $eta^2 = .08$). In other words, when considered independently of group membership and awareness status, cortisol tended to decline across the three time points, rather than increase in response to the stressful task, as expected.

Tests of between-subject main effects showed that TBI survivors had higher cortisol than significant others, F (1, 136) = 5.91, $p = .016$, $eta^2 = .04$. The interaction term between group membership (TBI survivor vs. significant other) and cortisol time (1, 2, and 3) was nonsignificant, *Greenhouse-Geisser Adjusted F* (1.5, 211.2) = 0.29, $p = .689$, $eta^2 = .00$. As shown in Figure 1, there was a similar difference between TBI survivor and significant other cortisol across all three time points and both groups showed decreases of a similar magnitude between adjacent time points.

The main effect of awareness status was not significant (F (1, 136) = 1.57, p = .212, eta^2 = .01). There was a significant interaction between cortisol time (1, 2, and 3) and awareness status (*Greenhouse-Geisser Adjusted F* (1.6, 211.2) = 5.73, p = .007, eta^2 = .04). As depicted in Figure 1, post hoc analyses indicated that across group, participants associated with impaired awareness (survivors and SOs) had initially higher baseline cortisol levels than did the participants associated with intact awareness, (F(1, 136) = 4.87, p = .029, eta^2 = .04); furthermore, post hoc tests comparing adjacent cortisol values showed that Time 1 cortisol was significantly greater than Time 2 cortisol in the impaired awareness group but not in the intact awareness group, F (1, 136) = 5.30 p = .023, eta^2 = .02. In the intact awareness group there was no significant change in cortisol across the three time points. However, when the groups were divided into those whose cortisol increased in response to the task versus those whose cortisol decreased in response to the task, a significantly greater proportion of significant others of survivors with *intact* awareness (55.0%) showed cortisol increases to the stressful task than the proportion of impaired awareness survivors (35.4%) and their significant others (32.0%) who showed such increases, X^2(3, N = 144) = 8.58, p = .035, phi = .24.

The two-way between-group interaction term (group by awareness status) was nonsignificant (F (1, 136) = 1.13, p = .288, eta^2 = .01). From Figure 1 it appears that the effect may be driven most by the SOs of survivors of impaired awareness; however, the three-way interaction (time by group by awareness status was not significant; *Greenhouse-Geisser Adjusted F* (1.5, 211.2) = 1.77, p = .181, eta^2 = .01). Groups associated with impaired awareness (survivors and SOs) showed higher baseline

cortisol and greater drop in cortisol from baseline through recovery than did those associated with intact awareness of deficit.

Systolic Blood Pressure. Systolic blood pressure (BPS) values as a function of awareness status and group membership (survivor vs. significant other) are shown in Table 17. A repeated-measures general linear model with SBP at Times 2 through 9 (the Time 1 "white coat" measurement was excluded as explained in the method section) as the within-subject factor, and awareness status and group (survivor vs. significant other) as between-group factors was conducted.

The within-subject factor (systolic BP Time 2–9) was significant (*Greenhouse Geisser Adjusted F* (5.6, 675.1) = 22.89, $p < .001$, $eta^2 = .16$). Post hoc analyses comparing BPS values at adjacent time points showed that SBP was reactive to the speech task. Specifically, BPS at Time 3 (immediately following speech preparation) was significantly higher than BPS at Time 2 (baseline), F (1, 119) = 11.12, $p = .001$, $eta^2 = .09$. Similarly, BPS at Time 4 (immediately following speech delivery) was significantly higher than BPS at Time 3, F (1, 119) = 16.20 $p < .001$, $eta^2 = .12$. At that point, BPS began to fall, such that SBP at Time 5 was significantly lower than BPS at Time 4, F (1, 120) = 60.84 $p < .001$, $eta^2 = .34$. Thereafter, BPS remained relatively stable.

The main effect of group (survivor vs. significant other) was nonsignificant F (1, 119) = 0.68, $p = .412$, $eta^2 = .01$. However, there was a significant interaction between BP time and group (survivor vs. significant other), *Greenhouse-Geisser Adjusted F* (5.7, 675.6) = 5.34, $p < .001$, $eta^2 = .04$. As shown in Figure 2, post-hoc analyses showed that BPS increased from Time 2 (Baseline) to Time 3 (immediately following speech preparation), but only in significant others (F (1, 119) = 8.59 $p = .004$, $eta^2 = .07$). In

addition, there was a greater reduction in BPS from Time 4 (immediately following the speech) to Time 5 (taken 5 minutes after Time 4) in the significant other sample, than in the survivor sample (F (1, 119) = 12.82, p < .001, eta^2 = .10). Figure 2 shows visually how BPS is more reactive in the significant other group than the survivor group, and that despite increasing to a greater extent in response to the stress task, BPS in significant others recovered to levels equivalent to that of survivors, by the immediate measurement point.

The main effect of awareness status was nonsignificant (F (1, 119) = 1.11, p = .295, eta^2 = .01), as was the time by awareness status interaction (*Greenhouse-Geisser Adjusted F* (5.7, 675.6) = 1.38, p = .223, eta^2 = .01). However, there was a significant three-way interaction between BPS time, group (TBI survivor vs. significant other) and awareness (*Greenhouse-Geisser Adjusted F* (5.7, 675.6) = 2.87, p = .011, eta^2 = .02). Examination of the plotted estimated marginal means for BPS in Figure 2 helps to elucidate the nature of this interaction. Specifically, and as predicted, among survivors, the aware group was more reactive to the stress task, whereas among the significant other group, the significant others of survivors with impaired awareness were more reactive to the stress task.

Diastolic Blood Pressure (BPD) BPD values as a function of awareness status and group membership (survivor vs. significant other) are shown in Table 18. A repeated-measures general linear model with BPD at Times 2 through 9 as the within-subject factor, and awareness status and group (survivor vs. significant other) as between-group factors was conducted.

The within-subject factor (BPD Time 2-9) term was significant (*Greenhouse-Geisser Adjusted F* (6, 709.7) = 9.10, $p < .001$, $eta^2 = .07$). Post hoc analyses revealed that BPD at Time 4 (high stress) was significantly greater than diastolic BP at Time 5 (*F* (1, 119) = 19.93, $p < .001$, $eta^2 = .14$). No other adjacent BPD time points were significantly different.

The main effect of group (survivor vs. significant other) was nonsignificant, *F* (1, 119) = 0.04, $p = .844$, $eta^2 = .00$. However, there was a significant interaction between Group (TBI survivor vs. significant other) and BPD Time (*Greenhouse-Geisser Adjusted F* (6, 709.7) = 4.59, $p < .001$, $eta^2 = .04$). As shown in Figure 3, BPD at Time 5 reduced significantly more from BPD at Time 4 (immediately following delivery of speech) among significant others than was the case among TBI survivors, *F* (1, 119) = 4.06, $p = .046$, $eta^2 = .03$. In other words, significant others showed a greater BPD recovery from the task than did TBI survivors, just as was the case for BPS.

The main effect of awareness status was nonsignificant (*F* (1, 119) = 1.02 $p = .314$, $eta^2 = .01$), as was the interaction between awareness status and BPD Time (*Greenhouse-Geisser Adjusted F* (6.0, 709.7) = 1.72, $p = .115$, $eta^2 = .01$), and the three-way interaction between awareness status, group (TBI survivor vs. significant other) and BPD Time (*Greenhouse-Geisser Adjusted F* (6, 709.7) = 0.61, $p = .724$, $eta^2 = .01$).

Heart Rate (HR). HR values as a function of awareness status and group membership (survivor vs. significant other) are shown in Table 19. A repeated-measures general linear model with HR at Times 2 through 9 as the within-subject

factor, and awareness status and group (survivor vs. significant other) as between-group factors was conducted.

The within-subject factor (HR Time 2–9) term was significant (*Greenhouse-Geisser Adjusted F* (5.3, 671.7) = 22.40, $p < .001$, $eta^2 = .15$), indicating that mean HR differed significantly among the eight time points. Post hoc analyses revealed that HR was reactive to the task. Specifically, HR at Time 3 (immediately following speech preparation) was significantly higher than HR at Time 2 (baseline), F (1, 126) = 5.55, $p = .020$, $eta^2 = .04$. HR at Time 4 (immediately following speech delivery) was significantly *lower* than HR at Time 3 (immediately following speech preparation), F (1, 126) = 19.62, $p < .001$, $eta^2 = .14$. HR then continued to drop, with HR at Time 5 being significantly lower than HR at Time 4, F (1, 126) = 7.54, $p = .007$, $eta^2 = .06$. As shown in Figure 4, thereafter, HR remained stable.

The main effect of group (survivor vs. significant other) was significant (F (1, 126) = 5.09, $p = .026$, $eta^2 = .04$), showing that significant others had higher HR than the TBI group. As depicted in Figure 4, post hoc analyses showed that HR at Time 3 (immediately following speech preparation) increased to a greater extent in the significant other group than it did in the TBI group, F (1, 126) = 5.14, $p = .025$, $eta^2 = .04$.

The main effect of awareness status (intact vs. impaired) was nonsignificant, (F (1, 126) = 0.75, $p = .387$, $eta^2 = .01$), as was the interaction between awareness status and the within-subject factor (HR Time 2 to 9), *Greenhouse Geisser Adjusted F* (5.3, 671.7) = 0.47, $p = .811$, $eta^2 = .00$.

The three-way interaction term of HR Time by group (TBI survivor vs. significant other) by awareness status (intact vs. impaired) was nonsignificant, *Greenhouse-Geisser Adjusted F* (5.3, 671.7) = .83, p = .827, eta^2 = .00.

Objective 3-C.

Split-plot correlations were used to test the hypothesis that awareness of deficit moderates the relationship between PNSR and psychosocial outcome. As shown in Table 20, among significant others of survivors with impaired awareness of their deficits, the correlations between PNSR variables and psychosocial outcomes are stronger than those observed among significant others of survivors with intact awareness of their deficits.

As was the case with Hypothesis 1A, counterintuitive relationships are observed between absolute cortisol values and psychosocial outcome in the SO group only. However, Table 20 illustrates that only the SOs of survivors with *impaired* awareness specifically show the counterintuitive pattern. This pattern is observed in three of the four outcomes (BSI-18, SWLS, and PBS; no relationship for mastery). Overall, the relationships between PNSR and psychosocial outcomes seem stronger in SOs of survivors with impaired awareness than in any other group. For example, the mean magnitude (absolute value) of correlation between BSI distress and each of the PNSR variables is .30 for SOs of survivors with impaired awareness; in contrast, for the three other groups (survivors with intact and impaired awareness, and SOs of survivors with intact awareness) the mean magnitude of correlations is .11 to .16. For SWLS, SOs average magnitude of correlation with PNSR is .28, whereas SOs of survivors with intact awareness average .13, survivors with impaired awareness average .23,

survivors with intact awareness average .13. For caregiver perceived burden, among SOs of survivors with impaired awareness, the average correlation is .28, whereas for SO of survivors with intact awareness the average correlation is .15. SOs of survivors with intact awareness of deficits more frequently were stressed by the task (55.0%) versus SOs of survivors with impaired awareness (32.0%) and TBI survivors with impaired (22.6%) and intact awareness of deficits (35.4%), $X^2(3, N = 144) = 8.58$, $p = .035$, phi = .24.

For BPS, all of the relationships are in the intuitive direction except one. Just as was the case in Hypothesis 1a, a counterintuitive relationship was observed between baseline BPS and SWLS in the TBI group only ($r = .36$; increase in BPS is associated with increase in SWLS). As seen in Table 20, it is only the impaired-awareness group that shows this pattern. By contrast, the correlation between SWLS and baseline BPS in SOs was inverse ($r = -.41$; increases in BPS associated with descreases in SWLS). Fisher's r-to-z transformation was calculated to assess the significance of the difference between these two correlation coefficients. The resulting value ($z = 2.89$, $p < .004$) suggested a large and clinically meaningful difference in the correlations between SWLS and BPS for survivors with impaired awareness and SOs of those survivors.

Examination of the patterns of correlations in Table 20 show that significant others of survivors with intact versus impaired awareness show correlations between systolic blood pressure and psychosocial functioning that are in opposite directions. For example, whereas significant others of intact survivors showed the expected positive correlation between BPS and distress (.39), those of SOs of impaired survivors showed the opposite, negative pattern ($r = -.23$), in which higher blood pressure was associated

with less subjective distress. Using Fisher's r-to-z transformation, the difference between these two correlations was statistically significant and of a large magnitude, z = 2.4, p = .016. A similar dissociation between significant others of survivors with intact vs. impaired awareness was found when caregiver mastery was the outcome of interest. In significant others of survivors with intact awareness, a sense of caregiving mastery was negatively correlated with reactivity to the speech task (i.e. higher mastery was associated with less reactivity), r = -.48. By contrast, in significant others of survivors with impaired awareness, a sense of caregiving mastery was positively correlated with reactivity (i.e. higher mastery correlated with greater reactivity), r = .38. Using Fisher's r-to-z transformation, the difference between these two correlations was statistically significant and of a large magnitude, z = -3.43, p < .001.

DISCUSSION

The present findings indicate that physiological stress reactivity predicts poor psychosocial functioning in survivors of TBI and their significant others. Chronic stress (reflected in high baseline values) and stress reactivity were generally *adversely* associated with psychological distress and life satisfaction. Among significant others of TBI survivors, this pattern was also observed for sense of caregiving mastery and burden. However, there were some counterintuitive relationships that emerged as well. For instance, among TBI survivors, poor cardiovascular health and/or a higher level of chronic stress (reflected in baseline systolic blood pressure) was *favourably* associated with life satisfaction. Similarly, among significant others, chronic cortisol level was *favourably* associated with life satisfaction, psychological distress, and perceived caregiving burden. The construct of survivor awareness of deficits helped to elucidate this intriguing pattern of results. In general, and as predicted, stress responses were larger among survivors with intact awareness of their deficits and significant others of survivors with impaired awareness of their deficits than among survivors with impaired awareness and significant others of survivors with intact awareness of deficits. Moreover, counterintuitive findings were only observed among survivors with impaired awareness of deficits and their significant others. In the following discussion, specific findings will be presented and discussed in the context of the growing body of literature highlighting the myriad adverse psychological and health outcomes associated with chronic stress and stress reactivity, and the special moderating role awareness of deficit appears to play.

With regard to the first hypothesis, the findings of this study generally support a relationship between stress reactivity and psychosocial outcome in persons with TBI and significant others involved in their care Poor psychosocial outcome was associated with adverse physiologic stress reactivity: Among TBI survivors, psychological distress was associated with chronic stress as evidenced in elevations of baseline cortisol, as well as poorer physiological adjustment in response to acute stress (i.e., less recovery of systolic blood pressure toward baseline).. Similarly, low life satisfaction was associated with larger acute response to stress as evidenced in heart rate reactivity as well as poorer recovery from stress in terms of blood pressure recovery. Similarly, among significant others, psychological distress was adversely associated with physiological adjustment to acute stress (i.e., less recovery of systolic blood pressure toward baseline). In addition, low life satisfaction was associated with chronic stress and/or poor cardiovascular health as well as poor recovery following acute stress as demonstrated in baseline and reactivity blood pressures. High caregiving mastery and low caregiving burden were associated with better adjustment to acute stress (i.e., recovery of systolic blood pressure to baseline following acute stress) compared to low caregiving mastery and high caregiving burden.

These findings are consistent with prior research showing a robust adverse association between stress reactivity and well-being in several populations, including mood disorders (Gotlib, et al., 2008; M. M. van Eck, Nicolson, Berkhof, & Sulon, 1996), cancer (Giese-Davis, et al., 2006), and heart disease (Otte, et al., 2004). In addition, it complements existing literature showing that caregivers are more chronically stressed and show greater reactivity to acute stress than non-caregivers (Cacioppo, et al., 2000;

Davis, et al., 2004). This pattern of results should raise major concerns given the substantial empirical evidence that a number of adverse health outcomes are associated with chronic stress (Kiecolt-Glaser, et al., 1996; Kiecolt-Glaser, et al., 1987), heightened reactivity to stressors (Kiecolt-Glaser, McGuire, Robles, & Glaser, 2002a) and higher levels of circulating cortisol (Brown, Varghese, & McEwen, 2004), including cognitive dysfunction, reduced immune response to illness, hippocampal atrophy, and obesity. In addition, individuals with greater physiological stress and stress reactivity are more likely to be clinically depressed and have other psychiatric conditions (Condren, et al., 2002; Goldfinger, et al., 1998; Gotlib, et al., 2008).

Although most of the relationships observed in this study were as predicted, there were also some counterintuitive relationships that emerged between acute stress reactivity and psychosocial outcome. For example, within the TBI group, baseline systolic blood pressure had a counterintuitive relationship with subjective life satisfaction, one which was not observed in their significant others: Survivors with higher baseline systolic blood pressure (which is generally correlated with high stress and chronic poor health) reported *greater* satisfaction with life, whereas significant others with higher baseline systolic blood pressure reported *less* satisfaction with life. Another unexpected finding was observed in the significant other group. Specifically, significant others with *higher* cortisol reported greater life satisfaction, less psychological distress, and less perceived caregiving burden than those with low cortisol. This was not the case in the survivor group, where the relationship between cortisol and psychosocial outcome was in the expected direction (i.e. survivors with higher baseline cortisol had worse psychosocial outcome).

In the current study, as with prior research, survivor awareness of deficits was an important construct in characterizing the nature of the relationships between physiological stress reactivity and psychosocial outcome. A growing research literature has drawn attention to the double-edged sword of impaired awareness for cognitively impaired individuals and individuals involved in their care. For *survivors*, prior findings (Malec, et al., 2007; Ryan, et al., 2009) indicate that those with impaired awareness report greater life satisfaction than those with intact awareness ("ignorance is bliss"). For *significant others*, the reverse appears to be true; that is, significant others of survivors with impaired awareness report more symptoms of depression than significant others of survivors with intact awareness (Malec, et al., 2007). In the current study, the pattern of relationships between awareness status and psychosocial outcome were consistent with these prior findings. That is, TBI survivors with intact awareness had worse psychosocial outcome than TBI survivors with impaired awareness, whereas among significant others, the reverse was true: Significant others of survivors with impaired awareness had poorer psychosocial outcome than significant others of survivors with intact awareness. Perhaps due to inclusion of significant others providing only very minimal support to the survivor in conjunction with the specific cut-point used to define awareness status, these relationships did not reach significance in the statistical sense. However, the relationships were clinically meaningful and in the expected directions.

The construct of awareness also appeared to be an important factor in determining reactivity to stress. Firstly, relationships between physiological stress and psychosocial outcome were stronger among significant others of survivors with impaired

awareness than among any other subgroup. In many cases, the relationships between physiological stress and psychosocial outcome were *opposite,* depending on awareness status. Moreover, and as predicted, survivors with intact awareness were more reactive to stress (in terms of systolic blood pressure) than survivors with impaired awareness (for whom “ignorance is bliss”), whereas significant others of survivors with intact awareness were less reactive to stress than significant others of survivors with impaired awareness.

This general pattern of results (in which the reactivity of TBI survivors and their significant others showed opposite patterns depending on the awareness status of the survivor) held for all stress markers used in this study with the exception of cortisol, which appeared to act somewhat differently. For cortisol, *both* groups associated with impaired awareness (survivors *and* significant others) showed a similar pattern of higher baseline cortisol (thought to reflect chronic stress) and a greater drop in cortisol from baseline through recovery in response to acute stress than did those associated with intact awareness of deficit. When taken as a whole, TBI survivors with *intact* awareness and their caregivers showed no appreciable change in cortisol across the measurement period. However, a greater *proportion* of significant others of survivors with intact awareness had *increases* in cortisol in response to stress than TBI survivors with impaired awareness and significant others of survivors with impaired awareness. In sum, impaired awareness of deficits appears to be adversely associated with physical health among both survivors of TBI and their significant others.

Awareness of deficits was also important in understanding seemingly counterintuitive relationships between physiological stress reactivity and psychosocial

outcome that were observed. For instance, although baseline systolic blood pressure was unrelated to life satisfaction in survivors with intact awareness, it had a positive association with life satisfaction in survivors with impaired awareness. In other words, a sign of chronic physiological stress (heightened baseline blood pressure) was associated with greater life satisfaction among TBI survivors with impaired awareness, but not among survivors with intact awareness of their deficits. More than the other physiological markers examined in this study, baseline systolic blood pressure is indicative of cardiovascular health (Vasan, et al., 2001). The initial hypothesis was based on the intuitive notion that negative appraisal of emotional well-being and life satisfaction would adversely affect physiological health via chronic elevation of blood pressure. The fact that the *opposite* pattern was observed in survivors with impaired awareness is intriguing.

One potential explanation to account for this finding is that impaired awareness of deficits reflects impaired awareness in a broader sense – that is, beyond impaired awareness for cognitive and functional impairments related to injury or illness. Perhaps TBI survivors with anosagnosia also lack awareness of chronic health problems or awareness of poor lifestyle choices that may be causing such problems. If true, this phenomenon once again underscores the paradox of awareness. Though ignorance may be bliss in terms of experienced life satisfaction or distress, the adverse health consequences of this ignorance may be severe. Many researchers in this area have pointed out the potential downside of impaired awareness for the survivor. Prigitano and colleagues, for instance, discussed how impaired awareness of deficit can be an impediment to successful rehabilitation (Prigatano, et al., 1990). In fact, impaired

awareness in survivors of TBI may be an impediment to engagement in health care in general. One is not likely to be motivated to improve one's cardiovascular health if one is not aware of having poor cardiovascular health to begin with.

Future studies could help to test this hypothesis directly by asking TBI survivors to estimate aspects of their cardiovascular health (e.g., body mass, blood pressure, etc.) in comparison to their peers and then comparing their estimates to objective measurements of the same. Then, using the magnitude of the discrepancy as an index of lack of awareness, researchers could investigate whether poor awareness of cardiovascular health is related with impaired awareness of cognitive/functional impairments, and in turn, whether these are related to service utilization and adherence, lifestyle adjustments, cardiovascular outcomes, etc.

The unexpected positive association between cortisol and favourable psychosocial outcomes in significant others appeared to be moderated by survivors' awareness of deficit. Among significant others of survivors with impaired awareness *only*, cortisol elevations were *favourably* associated with psychological distress as well as perceived caregiving burden and mastery. In accounting for this unforeseen relationship, a few potential explanations were considered. To begin with, there is some evidence that chronic (background) stress may diminish one's capacity to cope with acute stress (Keltikangas-Jarvinen & Heponiemi, 2004), possibly by blunting normal cortisol activity. For instance, depressed outpatients with a history of experiencing childhood abuse tended to have reduced basal cortisol levels compared to depressed outpatients with no history of abuse (Heim et al., 2001). Significant others involved in the care of persons with impaired awareness may have higher levels of chronic or

background stress than those caring for persons with intact awareness. This extended stress may have an overall blunting effect on their absolute levels of circulating cortisol but not on the reactions of their cortisol to stress. If true, this has implications for interventions, because individuals who show this pattern of lower HPA activity tend to respond poorly to treatment (Hikichi, et al., 2007).

Another possibility is that the finding that elevated cortisol is associated with better self-reported psychosocial wellness in significant others of survivors with impaired awareness reflects the physiological cost of denial, suppression of stress, and/or social desirability. In other words, there may be a group of individuals in the current study who are actively repressing the negative aspects of their experiences in order to avoid confronting them, but they do so at considerable cost to their capacity to cope with stress physiologically. Many researchers have hypothesized that excessive avoidance and/or repression of negative experiences or emotions may cause chronic physiological arousal and over time lead to physical problems, poor response to illness, and even disease (Kelley, Lumley, & Leisen, 1997; Pennebaker, 1993). In support of this hypothesis, researchers have also found that bringing these negative experiences and/or emotions into awareness (e.g. through expressive writing or other psychotherapy in general) initially leads to measurable increases in negative mood but eventually leads to better psychological and health outcomes.

Regardless of what may be driving the positive association between cortisol and self-reported psychosocial wellness in significant others of survivors with impaired awareness, this finding draws attention to the fact that there appears to be a dissociation between subjective well-being and objective physiological well-being for

which survivor awareness of deficits appears to be a major contributing factor. Indeed, in the present study, significant others of survivors with intact awareness versus impaired awareness often show relationships between physiological stress reactivity and psychosocial outcome that are in *opposite* directions. For example, significant others of survivors with intact awareness show the expected positive relationship between blood pressure and distress, whereas significant others of survivors with impaired awareness showed the opposite pattern, in which higher systolic blood pressure was associated with less psychological distress. Similarly, among significant others of survivors with intact awareness, a sense of caregiving mastery predicted low reactivity to the challenge of acute stress (i.e., higher mastery was associated with less reactivity). By contrast, in significant others of survivors with impaired awareness, a sense of caregiving mastery predicted heightened reactivity to acute stress (i.e. higher mastery was associated with with greater reactivity).

Limitations

Inclusion of significant others not providing regular care to the respective survivor may have diluted the observed relationship between physiological stress and psychosocial outcome for this group. However, to the extent that this was a problem in the current study, this would likely mean that the present results *underestimate* the relationships that may exist when significant others not providing regular care to the survivor are excluded. Although the results are not reported here due to insufficient power, the magnitude of the relationships observed in this study appear to be more robust when the significant other sample is trimmed to include only first-degree relatives providing regular support and care.

The current survivor sample comprised primarily (but not exclusively) urban dwelling African American men. A large proportion of these participants had limited educational attainment and financial means. Moreover, this population has a heightened risk of cardiovascular morbidity, and in many instances it is underserved in terms of access to comprehensive medical care. As such, the results of the current study may not generalize well in rural samples or those with greater affluence and educational attainment. Nonetheless, they are an important contribution to understanding relationships between physiological stress and psychosocial outcomes in a population that is especially vulnerable to TBI and adverse psychosocial and health outcomes.

The TBI sample in the current study was disproportionately men, with a ratio of men to women nearly 3 to 1. This ratio is within the expected range for TBI studies recruiting in impoverished urban areas with high levels of interpersonal violence (Bruns & Hauser, 2003). Because survivors of TBI are more likely to be men than women, the primary significant other identified by a survivor is more likely to be a woman than a man. This was the case in the present study. These ratios are similar to those seen in many studies of dementia and in other studies of TBI. This issue raises the question of whether group differences may have been in part driven by different gender composition of those groups. However, despite the fact that non-human animal females tend to have higher circulating levels of glucocorticoids in response to challenge than non-human males, evidence examining gender differences in HPA sensitivity in humans is much more equivocal. Most psychological stress studies have shown either no significant stress differences or higher cortisol responses in young men than women in response to acute real-life or controlled laboratory stressors (Kudielka & Kirschbaum, 2005). In one

study (Kelly, Tyrka, Anderson, Price, & Carpenter, 2008) neither cortisol nor heart rate reactivity to an acute stressor reliably discriminated between women and men.

Conclusions and Future Directions

In conclusion, the current study provides support for the hypothesis that stress and stress reactivity are adversely associated with psychosocial outcome, and moreover, that these relationships are moderated by survivor awareness of deficits in very different ways for TBI survivors compared to those involved in their care. The study also resulted in two unexpected findings. First, awareness among survivors may be impaired more broadly than first thought, to include impaired awareness of poor cardiovascular health or lifestyle choices leading to poor health. Secondly, the unexpected favourable relationship between elevated cortisol and psychosocial outcome among significant others may suggest either that chronic stress blunts responses to acute stress in this population or that some caregivers are actively repressing negative events or emotions but at the expense of chronic physiological stress.

The findings of the current study should be replicated in larger samples in different contexts. Given the apparent dissociation between psychosocial and physiological well-being, future studies are needed to examine the scope of adverse consequences arising from impaired awareness – both for the survivor and significant others involved in their care. For instance, it would be helpful to increase our understanding about whether and to what extent impaired awareness is related to cardiovascular health problems, medical adherence, and poor lifestyle choices that result in health morbidities. In this regard, future research regarding the role of

awareness of deficit in predicting psychosocial outcome, could be informed by research in health psychology focused on the effects of emotional repression or avoidance on psychological and health outcomes (Hsu, et al., 2010; van Middendorp, et al., 2008).

The current study supplements growing data suggesting that impaired awareness may be an appropriate target for intervention. That said, in some ways, the suggestion of increasing awareness of deficits in persons with cognitive impairments may seem counterintuitive. If persons with impaired awareness are less distressed and more satisfied with their lives, why would one want to target awareness in interventions? However, the increasing evidence of the negative consequences of impaired awareness for survivors of TBI and those involved with their care warrant closer attention. In other populations, therapeutic approaches aimed at raising awareness (or reducing avoidance) of negative life events or emotions may initially lead to increased distress but appear to have benefits on psychological and physical well being long term (Kelley, et al., 1997; Pennebaker, 1993).

TABLES

Table 1.

Sample Characteristics of Traumatic Brain Injury (TBI) Survivors and Significant others

	Survivors (*n* = 79)	Significant others (*n* = 65)	
	M (*SD*)	*M* (*SD*)	*Range*
Age	44.9 (12.9)	48.1 (13.0)	20 – 72
Years of Education	11.6 (1.8)	12.6 (2.2)	8 – 18
Brief Symptom Inventory-18 (BSI-GSI)	55.8 (10.7)	53.1 (11.4)	33 – 81
Satisfaction with Life Scale (SWLS)	17.5 (7.8)	20.2 (6.6)	5 – 35
Social Provision Scale (SPS)	38.7 (4.0)	37.7 (2.8)	29 – 53

Note. BSI-GSI = Brief Symptom Inventory-18 Global Severity Index (T score).

Table 2.

Correlations: Demographic and injury-related characteristics with psychosocial and physiologic characteristics

	Age	Education	Gender[a]	Injury Severity (PTC)	Injury Severity (GCS)	Months since injury
Survivors (*n* = 79)						
Awareness (AQ Difference)	.08	-.17	.21	.36**	.06	.05
Distress (BSI-18 GSI)	-.01	-.12	.05	-.18	-.33**	-.03
Life Satisfaction (SWLS)	.04	-.02	.08	.21	.17	.00
Social Support (SPS)	-.16	.22	.18	.25	.24*	-.19
Cortisol (Baseline)[1]	-.23*	-.05	.32**	.05	.02	-.13
Systolic BP (Baseline)[1]	.22	.08	.08	-.20	-.05	.22
Diastolic BP (Baseline)[1]	.14	-.06	.02	-.13	.17	.31**
Heart Rate (Baseline)	.13	-.08	.05	-.18	-.18	.19
Significant others (*n* = 65)						
Distress (BSI-18 GSI)	.27*	-.52***	.00	-.16	-.05	.04
Life Satisfaction (SWLS)	-.09	.36**	.20	.11	-.04	.10
Social Support (SPS)	.10	-.01	.13	-.11	-.08	-.07
Perceived Burden (CAS)	-.21	.29*	.10	.13	.18	.23
Caregiving Mastery (CAS)	-.13	.33**	.27*	.07	.31*	-.13
Cortisol (Baseline)	-.13	-.02	.05	.02	.00	.12
Systolic BP (Baseline)	.41**	-.18	.21	.03	.08	.04
Diastolic BP (Baseline)	.22	-.21	.20	.09	.02	.09
Heart Rate (Baseline)	.15	.08	.02	-.08	-.02	-.05

Note. PTC = post-traumatic confusion (days); GCS = Glasgow Coma Scale, days to follow command; AQ = Awareness Questionnaire; BSI-18 = Brief Symptom Inventory-18; SWLS = Satisfaction with Life Scale; SPS = Social Provision Scale; CAS = Caregiver Appraisal Scale.
[1]Square-root transformation.
[a]Eta correlations.
* $p < .05$, ** $p < .01$, *** $p < .001$.

Table 3.

Mean Cortisol in Survivors Versus Significant Others

	Survivors (*n* = 79)	Significant others (*n* = 65)	*Range*
Time 1 (Baseline)	0.28 (0.15)	0.23 (0.15)	0.01 - 0.77
Time 2 (High Stress)	0.25 (0.13)	0.21 (0.13)	0.01 - 0.72
Time 3 (Recovery)	0.23 (0.12)	0.20 (0.12)	0.01 - 0.70
Change 1	0.02 (0.11)	0.02 (0.08)	-0.38 - 0.31
Change 2	0.02 (0.08)	0.01 (0.06)	-0.48 - 0.19
Change 3	0.05 (0.11)	0.03 (0.10)	-0.26 - 0.35

Note. Standard deviations in parentheses; Change 1 = Baseline – High Stress; Change 2 = High Stress – Recovery; Change 3 = Baseline – Recovery.

Table 4.

Mean Systolic Blood Pressure In Survivors versus Significant Others

	Survivors (*n* = 79)	Significant others (*n* = 65)	*Range*
Time 2 (Baseline)	124.8 (18.0)	127.4 (23.0)	88 – 188
Time 3	124.8 (18.2)	130.1 (23.9)	85 – 193
Time 4 (High Stress)	128.2 (20.4)	135.3 (24.4)	85 – 195
Time 5	125.1 (19.5)	126.4 (21.1)	84 – 181
Time 6	124.2 (17.4)	124.0 (23.4)	90 – 214
Time 7	122.8 (16.9)	125.2 (22.4)	91 – 207
Time 8	123.4 (16.5)	124.5 (22.5)	88 – 202
Time 9 (Recovery)	123.5 (16.7)	124.2 (22.1)	88 – 199
Change 1	-3.8 (10.0)	-8.6 (11.3)	-37 – 23
Change 2	4.7 (9.8)	11.0 (12.1)	-21 – 53
Change 3	1.0 (8.7)	2.6 (10.3)	-20 – 29

Note. Standard deviations in parentheses; Change 1 = Baseline – High Stress; Change 2 = High Stress – Recovery; Change 3 = Baseline – Recovery.

Table 5.

Mean Diastolic Blood Pressure In Survivors versus Significant Others

	Survivors (*n* = 79)	Significant others (*n* = 65)	*Range*
Time 2 (Baseline)	82.0 (13.1)	82.8 (13.9)	54 – 120
Time 3	82.8 (13.4)	85.0 (14.4)	54 – 131
Time 4 (High Stress)	84.0 (12.9)	85.9 (14.6)	56 – 130
Time 5	83.3 (12.0)	82.6 (14.1)	47 – 120
Time 6	83.1 (12.2)	81.0 (13.7)	53 – 119
Time 7	81.8 (12.4)	81.4 (12.7)	53 – 113
Time 8	83.2 (13.0)	80.3 (13.6)	50 – 124
Time 9 (Recovery)	82.4 (12.3)	81.2 (13.5)	54 – 122
Change 1	-2.1 (6.1)	-2.5 (5.4)	-23 – 18
Change 2*	1.6 (6.8)	4.6 (7.5)	-14 – 18
Change 3**	-0.4 (7.0)	2.1 (6.5)	-16 – 18

Note. Standard deviations in parentheses; Change 1 = Baseline – High Stress; Change 2 = High Stress – Recovery; Change 3 = Baseline – Recovery.

Table 6.

Mean Heart Rate In Survivors versus Significant Others

	Survivors (*n* = 75)	Significant others (*n* = 65)	*Range*
Time 2 (Baseline) †	71.5 (11.0)	75.3 (12.4)	42 – 108
Time 3*	71.4 (11.0)	76.5 (13.6)	42 – 111
Time 4 (High Stress)**	69.9 (10.3)	74.6 (12.8)	41 – 111
Time 5†	69.5 (10.5)	73.1 (12.5)	41 – 107
Time 6†	68.8 (10.6)	72.4 (12.2)	42 – 104
Time 7***	68.4 (10.3)	73.0 (12.7)	39 – 102
Time 8†	68.5 (10.5)	72.1 (12.8)	41 – 108
Time 9 (Recovery) †	68.3 (11.1)	71.5 (11.9)	41 – 107
Change 1	1.4 (4.8)	0.5 (4.5)	-12 – 14
Change 2	1.6 (6.9)	3.0 (5.3)	-46 – 19
Change 3	3.1 (7.3)	3.5 (4.5)	-48 – 16

Note. Standard deviations in parentheses; Change 1 = Baseline – High Stress; Change 2 = High Stress – Recovery; Change 3 = Baseline – Recovery.

Table 7.

Survivors Psychosocial and Cortisol Stress Indices: Zero-Order Correlations (Below Diagonal) and Partial Correlations Controlling For Age, Education, Injury Severity and Social Support (Above Diagonal).

	1	2	3	4	5	6	7	8	9	10	11
1. Distress (BSI-18 GSI)	--	-.40***	.20†	.12	.16	.10	-.12	.04	--	--	--
2. Life Satisfaction (SWLS)	-.45***	--	.11	.18	.17	-.02	-.10	.03	--	--	--
3. Cortisol (Baseline)	.14	.13	--	.69***	.64***	.51***	.16	.64***	--	--	--
4. Cortisol (Stress)	.09	.18	.69***	--	.91***	-.27*	-.02	-.03	--	--	--
5. Cortisol (Recovery)	.12	.18	.65***	.90***	--	-.24*	-.33**	-.19	--	--	--
6. Cortisol (Change 1)	.08	-.02	.53***	-.24*	-.20*	--	.22*	.89***	--	--	--
7. Cortisol (Change 2)	-.08	-.09	.12	.02	-.31**	.14	--	.51***	--	--	--
8. Cortisol (Change 3)	.02	.04	.66***	.01	-.14	.88***	.44***	--	--	--	--
9. Age	-.01	.04	-.22*	-.05	-.12	-.24*	.21*	-.20*	--	--	--
10. Education	-.12	-.02	-.05	-.01	.01	-.09	.02	-.09	.15	--	--
11. Injury Severity	-.31**	.18	.07	-.06	.04	.11	-.22*	.06	-.17	-.01	--
12. SPS Total	-.24*	.15	.22*	.19*	.15	.03	.10	.13	-.16	.22*	.15

Note. Change 1 = Baseline to High Stress; Change 2 = High Stress to Recovery; Change 3 = Baseline to Recovery; Injury Severity = Days to follow commands.
† $p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$.

Table 8.

Survivors Psychosocial and Systolic Blood Pressure Stress Indices: Zero-Order Correlations (Below Diagonal) and Partial Correlations Controlling For Age, Education, Injury Severity and Social Support (Above Diagonal).

	1	2	3	4	5	6	7	8	9
1. Distress (BSI-18 GSI)	--	-.40***	-.04	.19	-.21*	-.02	--	--	--
2. Life Satisfaction (SWLS)	-.45***	--	.20*	-.09	.27*	.18	--	--	--
3. Systolic (Baseline)[1]	.00	.16	--	.04	.34**	.44***	--	--	--
4. Systolic (Change 1)	.18	-.09	.02	--	-.61***	.46***	--	--	--
5. Systolic (Change 2)	-.25*	.29**	.33**	-.62***	--	.42***	--	--	--
6. Systolic (Change 3)	-.08	.22*	.40***	.46	.42***	--	--	--	--
7. Age	-.01	.04	.22*	-.13	.17	.04	--	--	--
8. Education	-.12	-.02	.08	-.14	.10	-.06	.15	--	--
9. Injury Severity	-.31**	.18	-.08	.13	.05	.22*	-.17	-.01	--
10. SPS Total	-.24*	.15	-.21*	-.12	.12	.01	-.16	.22*	.15

Notes. Change 1 = Baseline to High Stress; Change 2 = High Stress to Recovery; Change 3 = Baseline to Recovery; Injury Severity = Days to follow commands.

1. Square-root transformation.
*p < .05, **p < .01, ***p < .001.

Table 9.

Survivors Psychosocial and Diastolic Blood Pressure Stress Indices: Zero-Order Correlations (Below Diagonal) and Partial Correlations Controlling For Age, Education, Injury Severity and Social Support (Above Diagonal).

	1	2	3	4	5	6	7	8	9
1. Distress (BSI-18 GSI)	--	-.40***	-.04	.07	-.01	.05	--	--	--
2. Life Satisfaction (SWLS)	-.45***	--	.03	-.11	.08	-.03	--	--	--
3. Diastolic (Baseline)[1]	-.06	.05	--	.27*	.11	.34**	--	--	--
4. Diastolic (Change 1)	-.00	-.08	.25*	--	-.44***	.46***	--	--	--
5. Diastolic (Change 2)	-.05	.12	.16	-.41***	--	.60***	--	--	--
6. Diastolic (Change 3)	-.06	.04	.36**	.47***	.61***	--	--	--	--
7. Age	-.01	.04	.14	-.08	.09	.03	--	--	--
8. Education	-.12	-.02	-.06	.09	-.11	-.01	.15	--	--
9. Injury Severity	-.31**	.18	.14	.14	.17	.30**	-.17	-.01	--
10. SPS Total	-.24*	.15	-.14	.11	-.03	.05	-.16	.22*	.15

Note. Change 1 = Baseline to High Stress; Change 2 = High Stress to Recovery; Change 3 = Baseline to Recovery; Injury Severity = Days to follow commands.
1. Square-root transformation.
*p < .05, **p < .01, ***p < .001.

Table 10.

Survivors Psychosocial and Heart Rate Stress Indices: Zero-Order Correlations (Below Diagonal) and Partial Correlations Controlling For Age, Education, Injury Severity and Social Support (Above Diagonal).

	1	2	3	4	5	6	7	8	9
1. Distress (BSI-18 GSI)	--	-.40***	-.16	-.16	.18	.06	--	--	--
2. Life Satisfaction (SWLS)	-.45***	--	.03	-.24*	-.06	-.21*	--	--	--
3. Heart Rate (Baseline)[1]	-.05	-.02	--	.43***	.03	.31**	--	--	--
4. Heart Rate (Change 1)	-.19*	-.20*	.37***	--	-.24*	.44***	--	--	--
5. Heart Rate (Change 2)	.22*	-.08	.08	-.27**	--	.77***	--	--	--
6. Heart Rate (Change 3)	.08	-.21*	.32**	.40***	.77***	--	--	--	--
7. Age	-.01	.04	.13	-.10	.21*	.14	--	--	--
8. Education	-.12	-.02	-.08	-.05	.02	-.02	.15	--	--
9. Injury Severity	-.31**	.18	-.18	.13	-.22*	-.12	-.17	-.01	--
10. SPS Total	-.24*	.15	-.23*	.10	-.06	.01	-.16	.22	.15

Note. Change 1 = Baseline to High Stress; Change 2 = High Stress to Recovery; Change 3 = Baseline to Recovery; Injury Severity = Days to follow commands;
1. Square-root transformation.
*$p < .05$, **$p < .01$, *** $p < .001$.

Table 11.

Significant Others' Psychosocial and Cortisol Stress Indices: Zero-Order Correlations (Below Diagonal) and Partial Correlations Controlling For Age, Education, Injury Severity and Social Support (Above Diagonal).

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Distress (BSI-18 GSI)	--	-.38**	-.43***	-.17	-.20†	-.25*	-.34**	.02	.13	.09	--	--	--
2. Life Satisfaction (SWLS)	-.50***	--	.42**	-.14	.14	.17	.21†	-.02	-.05	-.04	--	--	--
3. Perceived Burden (CAS)	-.50***	.48***	--	.10	.23*	.21†	.32**	.10	-.15	-.00	--	--	--
4. Caregiving Mastery (CAS)	-.31**	.01	.25*	--	.06	.04	.08	.04	-.05	.00	--	--	--
5. Cortisol (Baseline)	-.19	.14	.24*	.08	--	.82***	.74***	.54***	.27*	.63***	--	--	--
6. Cortisol (Stress)	-.20	.16	.23*	.07	.82***	--	.87***	-.03	.39**	.22*	--	--	--
7. Cortisol (Recovery)	-.27*	.19	.33**	.09	.74***	.87***	--	.02	-.12	-.06	--	--	--
8. Cortisol (Change 1)	-.04	.01	.08	.03	.53***	-.05	.01	--	-.09	.78***	--	--	--
9. Cortisol (Change 2)	.11	-.04	-.11	-.02	.26*	.39**	-.12	-.12	--	.55***	--	--	--
10. Cortisol (Change 3)	.04	-.02	.01	.02	.62***	.20	-.07	.78***	.53***	--	--	--	--
11. Age	.27*	-.09	-.21†	-.13	-.10	-.04	-.10	-.11	.11	-.03	--	--	--
12. Education	-.52***	.36**	.29*	.33**	.01	-.02	-.05	.04	.05	.06	-.02	--	--
13. Injury Severity	-.11	.12	.30*	.29**	.06	.17	.11	-.15	.14	-.04	.07	.30**	--
14. SPS Total	-.10	.10	-.06	-.06	.01	.00	.03	.02	-.06	-.02	.10	-.01	-.14

Note. Change 1 = Baseline to High Stress; Change 2 = High Stress to Recovery; Change 3 = Baseline to Recovery; Injury Severity = Days to follow commands.
† $p < .10$, *$p < .05$, **$p < .01$, *** $p < .001$.

Table 12.

Significant Others' Psychosocial and Systolic Blood Pressure Stress Indices: Zero-order correlations (below diagonal) and partial correlations controlling for age, education, injury severity and social support (above diagonal).

	1	2	3	4	5	6	7	8	9	10	11
1. Distress (BSI-18 GSI)	--	-.38**	-.43***	-.17	-.07	-.01	-.22*	-.28*	--	--	--
2. Life Satisfaction (SWLS)	-.50***	--	.42**	-.14	-.28*	.02	.16	.21†	--	--	--
3. Perceived Burden (CAS)	-.50***	.48***	--	.10	-.03	-.06	.22†	.20†	--	--	--
4. Caregiving Mastery (CAS)	-.31**	.01	.25*	--	.10	-.10	.24*	.17	--	--	--
5. Systolic (Baseline)[1]	.15	-.33**	-.14	-.01	--	.08	.19	.29*	--	--	--
6. Systolic (Change 1)	.01	-.01	-.05	-.10	.03	--	-.59***	.42**	--	--	--
7. Systolic (Change 2)	-.26*	.22*	.21	.25*	.19	-.61***	--	.49***	--	--	--
8. Systolic (Change 3)	-.30*	.25*	.20	.19	.24*	.37**	.52***	--	--	--	--
9. Age	.27*	-.09	-.21*	-.13	.41**	-.15	.19	.06	--	--	--
10. Education	-.52***	.36**	.29*	.33**	-.18	-.13	.27*	.17	-.02	--	--
11. Injury Severity	-.11	.12	.30**	.29*	.06	-.01	.04	.01	.07	.30**	--
12. SPS Total	-.10	.10	-.06	-.06	-.06	.03	.01	.03	.10	-.01	-.14

Note. Change 1 = Baseline to High Stress; Change 2 = High Stress to Recovery; Change 3 = Baseline to Recovery; Injury Severity = Days to follow commands.
1. Square-root transformation.

† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 13.

Significant Others' Psychosocial and Diastolic Blood Pressure Stress Indices: Zero-order correlations (below diagonal) and partial correlations controlling for age, education, injury severity and social support (above diagonal).

	1	2	3	4	5	6	7	8	9	10	11
1. Distress (BSI-18 GSI)	--	-.38**	-.43***	-.17	-.09	.10	-.14	-.07	--	--	--
2. Life Satisfaction (SWLS)	-.50***	--	.42**	-.14	-.22†	-.14	.27*	.18	--	--	--
3. Perceived Burden (CAS)	-.50***	.48***	--	.10	-.06	-.01	.29*	.32**	--	--	--
4. Caregiving Mastery (CAS)	-.31**	.01	.25*	--	.02	.01	.11	.13	--	--	--
5. Diastolic (Baseline)[1]	.10	-.29*	-.15	-.07	--	.06	.25*	.33**	--	--	--
6. Diastolic (Change 1)	.07	-.12	.06	.05	.03	--	-.49***	.26*	--	--	--
7. Diastolic (Change 2)	-.18	.29*	.24*	.11	.21	-.54***	--	.71***	--	--	--
8. Diastolic (Change 3)	-.15	.23*	.33**	.17	.27	.22*	.71***	--	--	--	--
9. Age	.27*	-.09	-.21*	-.13	.22	-.16	.13	.01	--	--	--
10. Education	-.52***	.36**	.29*	.33**	-.21	-.07	.22*	.20	-.02	--	--
11. Injury Severity	-.11	.12	.30**	.29*	-.02	.21	-.11	.02	.07	.30**	--
12. SPS Total	-.10	.10	-.06	-.06	-.06	.03	-.03	-.04	.10	-.01	-.14

Note. Change 1 = Baseline to High Stress; Change 2 = High Stress to Recovery; Change 3 = Baseline to Recovery; Injury Severity = Days to follow commands;
1. Square-root transformation.
† $p < .10$, *$p < .05$, **$p < .01$, *** $p < .001$.

Table 14.

Significant Others' Psychosocial and Heart Rate Indices: Zero-Order Correlations (Below Diagonal) and Partial Correlations Controlling For Age, Education, Injury Severity and Social Support (Above Diagonal).

	1	2	3	4	5	6	7	8	9	10	11
1. Distress (BSI-18 GSI)	--	-.38**	-.43***	-.17	-.13	.01	.09	.12	--	--	--
2. Life Satisfaction (SWLS)	-.50***	--	.42**	-.14	.15	-.03	.08	.07	--	--	--
3. Perceived Burden (CAS)	-.50***	.48***	--	.10	.21†	-.03	.00	-.03	--	--	--
4. Caregiving Mastery (CAS)	-.31**	.01	.25*	--	.05	.10	-.01	.08	--	--	--
5. Heart Rate (Baseline)[1]	-.07	.11	.16	.04	--	.07	.20	.32**	--	--	--
6. Heart Rate (Baseline - Stress)	.01	-.04	-.09	.03	.08	--	-.59***	.29*	--	--	--
7. Heart Rate (Stress - Recovery)	.06	.09	.03	.02	.18	-.60***	--	.60***	--	--	--
8. Heart Rate (Baseline - Recovery)	.07	.07	-.06	.05	.29*	.31**	.58***	--	--	--	--
9. Age	.27*	-.09	-.21*	-.13	.15	-.04	.03	-.01	--	--	--
10. Education	-.52***	.36**	.29*	.33**	.08	-.02	.03	.01	-.02	--	--
11. Injury Severity	-.11	.12	.30**	.29*	-.03	-.26*	.11	-.13	.07	.30**	--
12. SPS Total	-.10	.10	-.06	-.06	-.26*	.04	.03	.08	.10	-.01	-.14

Note. Change 1 = Baseline to High Stress; Change 2 = High Stress to Recovery; Change 3 = Baseline to Recovery; Injury Severity = Days to follow commands.
1. Square-root transformation.
† $p < .10$, *$p < .05$, **$p < .01$, *** $p < .001$.

Table 15.

Demographic and Psychosocial Characteristics: Survivors with intact (n = 48) and impaired (n = 31) awareness of deficits and Significant others of those Survivors with intact (n = 40) and impaired (n = 25) awareness of deficits.

	Awareness Group					
	Intact Awareness	Impaired Awareness				
	M (*SD*)	*M* (*SD*)	*F*	*df*	*p*	Eta^2
TBI Survivors (*n* = 79)						
Age	43.8 (11.9)	46.4 (14.4)	0.75	1,77	.39	.01
Education	11.8 (1.9)	11.1 (1.4)	2.83	1,77	.10	.04
Injury Severity	6.3 (8.1)	8.3 (9.9)	0.15	1,73	.70	.00
Distress (BSI-GSI)	56.6 (10.7)	54.5 (10.7)	0.76	1,77	.39	.01
Satisfaction with Life (SWLS)	16.6 (7.9)	18.8 (7.5)	1.62	1,77	.21	.02
Social Support (SPS)	38.1 (3.6)	39.5 (4.5)	2.32	1,77	.13	.03
Significant others (*n* = 65)						
Age	46.0 (15.1)	51.6 (7.6)	2.91	1,63	.10	.04
Education	12.5 (2.0)	12.6 (2.5)	0.06	1,63	.80	.00
Injury Severity of Survivor	6.9 (8.6)	9.0 (10.3)	0.18	1,60	.67	.00
BSI GSI	52.4 (10.8)	54.3 (12.3)	0.42	1,63	.52	.01
SWLS	20.6 (6.6)	19.4 (6.6)	0.53	1,63	.47	.01
SPS	38.0 (2.6)	37.2 (3.1)	1.23	1,63	.27	.02
Perceived Burden (CAS)	53.1 (11.9)	53.2 (13.7)	0.00	1,62	.97	.00
Caregiving Mastery (CAS)	13.3 (3.2)	13.8 (3.1)	0.28	1,62	.60	.01

Note. BSI-GSI = Brief Symptom Inventory-18 Global Severity Index (T score); SWLS = Satisfaction with Life Scale; SPS = Social Provisions Scale; CAS = Caregiver Appraisal Scale.

Table 16.

Mean Cortisol as a Function of Group (TBI vs. Significant other) and Awareness Status (Intact vs. Impaired Awareness)

	Survivors		Significant others	
	Aware (n = 48)	Impaired Awareness (n = 31)	Aware (n = 40)	Impaired Awareness (n = 25)
Baseline	0.252 (0.150)	0.319 (0.141)	0.213 (0.153)	0.248 (0.137)
High Stress	0.236 (0.131)	0.269 (0.130)	0.216 (0.140)	0.201 (0.100)
Recovery	0.211 (0.104)	0.247 (0.131)	0.212 (0.125)	0.179 (0.100)
Change 1	0.012 (0.113)	0.041 (0.108)	-0.000 (0.078)	0.047 (0.087)
Change 2	0.026 (0.058)	0.006 (0.104)	0.004 (0.068)	0.023 (0.051)
Change 3	0.039 (0.112)	0.061 (0.116)	0.001 (0.093)	0.070 (0.094)

Note. Standard deviations in parentheses; Change 1 = Baseline to High Stress; Change 2 = High Stress to Recovery; Change 3 = Baseline to Recovery.

Table 17.

Mean Systolic Blood Pressure as a Function of Group (TBI vs. Significant others) and Awareness Status (Intact vs. Impaired Awareness).

	Survivors		Significant others	
	Aware (*n* = 48)	Impaired Awareness (*n* = 31)	Aware (*n* = 40)	Impaired Awareness (*n* = 25)
Time 2 (Baseline)	125.9 (18.2)	123.2 (18.0)	121.5 (21.2)	137.0 (23.1)
Time 3	124.9 (18.4)	124.6 (18.1)	124.0 (22.4)	141.8 (22.5)
Time 4 (High Stress)	129.0 (21.0)	127.0 (19.9)	129.3 (22.9)	144.9 (23.9)
Time 5	126.0 (20.1)	123.7 (18.8)	122.8 (20.9)	132.0 (20.8)
Time 6	125.0 (17.4)	123.0 (17.5)	120.6 (24.0)	129.8 (21.6)
Time 7	122.7 (16.9)	122.9 (17.2)	122.2 (23.5)	130.0 (19.9)
Time 8	124.3 (16.1)	121.9 (17.4)	120.8 (23.1)	130.6 (20.4)
Time 9 (Recovery)	124.6 (17.2)	121.7 (16.0)	120.6 (23.7)	129.9 (18.3)
Change 1	-3.8 (9.8)	-3.8 (10.6)	-7.8 (9.9)	-9.9 (13.4)
Change 2	4.4 (10.7)	5.3 (8.2)	8.5 (9.3)	15.0 (14.9)
Change 3	4.4 (10.7)	5.3 (8.2)	1.2 (10.0)	5.0 (10.7)

Note. Standard deviations in parentheses; Change 1 = Baseline to High Stress; Change 2 = High Stress to Recovery; Change 3 = Baseline to Recovery.

Table 18.

Mean Diastolic Blood Pressure as a Function of Group (TBI vs. Significant others) and Awareness Status (Intact vs. Impaired Awareness).

	Survivors		Significant others	
	Aware (*n* = 48)	Impaired Awareness (*n* = 31)	Aware (*n* = 40)	Impaired Awareness (*n* = 25)
Time 2 (Baseline)	82.0 (12.4)	82.1 (14.4)	80.3 (12.2)	86.8 (15.7)
Time 3	83.0 (12.2)	82.4 (15.3)	81.6 (13.0)	90.6 (15.0)
Time 4 (High Stress)	84.2 (11.7)	83.7 14.8)	82.7 (12.9)	91.0 (15.9)
Time 5	83.1 (12.3)	83.5 (14.1)	80.0 (13.1)	86.6 (14.9)
Time 6	83.8 (10.2)	81.9 (14.8)	78.3 (13.7)	85.3 (12.8)
Time 7	82.6 (11.3)	80.4 (14.1)	79.4 (12.3)	84.5 (13.0)
Time 8	84.0 (12.3)	81.9 (14.1)	78.0 (12.9)	84.0 (14.3)
Time 9 (Recovery)	83.6 (11.1)	80.6 (14.1)	78.9 (13.5)	85.0 (12.9)
Change 1	-2.5 (6.1)	-1.6 (6.0)	-2.5 (5.9)	-2.5 (4.6)
Change 2	0.6 (7.0)	3.1 (6.1)	3.7 (7.5)	6.0 (7.5)
Change 3	0.7 (8.1)	1.5 (9.7)	1.3 (6.6)	3.3 (6.4)

Note. Standard deviations in parentheses; Change 1 = Baseline to High Stress; Change 2 = High Stress to Recovery; Change 3 = Baseline to Recovery.

Table 19.

Mean Heart Rate as a Function of Group (TBI vs. Significant others) and Awareness Status (Intact vs. Impaired Awareness).

	Survivors		Significant others	
	Aware (*n* = 48)	Impaired Awareness (*n* = 31)	Aware (*n* = 40)	Impaired Awareness (*n* = 25)
Time 2 (Baseline)	71.8 (10.6)	71.0 (11.7)	73.6 (12.4)	77.8 (12.0)
Time 3	71.8 (11.5)	70.7 (10.4)	73.7 (13.5)	81.2 (12.7)
Time 4 (High Stress)	70.4 (9.7)	69.2 (11.2)	72.8 (13.2)	77.5 (11.9)
Time 5	70.2 (10.6)	68.5 (10.3)	71.2 (12.6)	76.0 (11.9)
Time 6	68.9 (10.5)	68.6 (10.9)	70.7 (11.8)	75.2 (12.4)
Time 7	68.7 (10.0)	68.0 (11.0)	71.2 (12.4)	76.0 (12.8)
Time 8	68.7 (10.5)	68.0 (10.5)	70.1 (12.0)	75.4 (13.6)
Time 9 (Recovery)	69.0 (11.4)	67.2 (10.7)	69.7 (11.6)	74.5 (12.0)
Change 1	1.2 (5.5)	1.9 (3.6)	0.8 (4.7)	0.0 (4.3)
Change 2	1.4 (8.3)	2.0 (3.7)	3.1 (5.9)	3.0 (4.1)
Change 3	2.6 (8.9)	3.9 (3.5)	0.8 (4.7)	0.0 (4.3)

Note. Standard deviations in parentheses; Change 1 = Baseline to High Stress; Change 2 = High Stress to Recovery; Change 3 = Baseline to Recovery.

Table 20. *Correlations: TBI survivors with intact (n = 48) and impaired (n = 31) awareness of deficits, and significant others of survivors with intact (n = 40) and impaired (n = 25) awareness of deficits.*

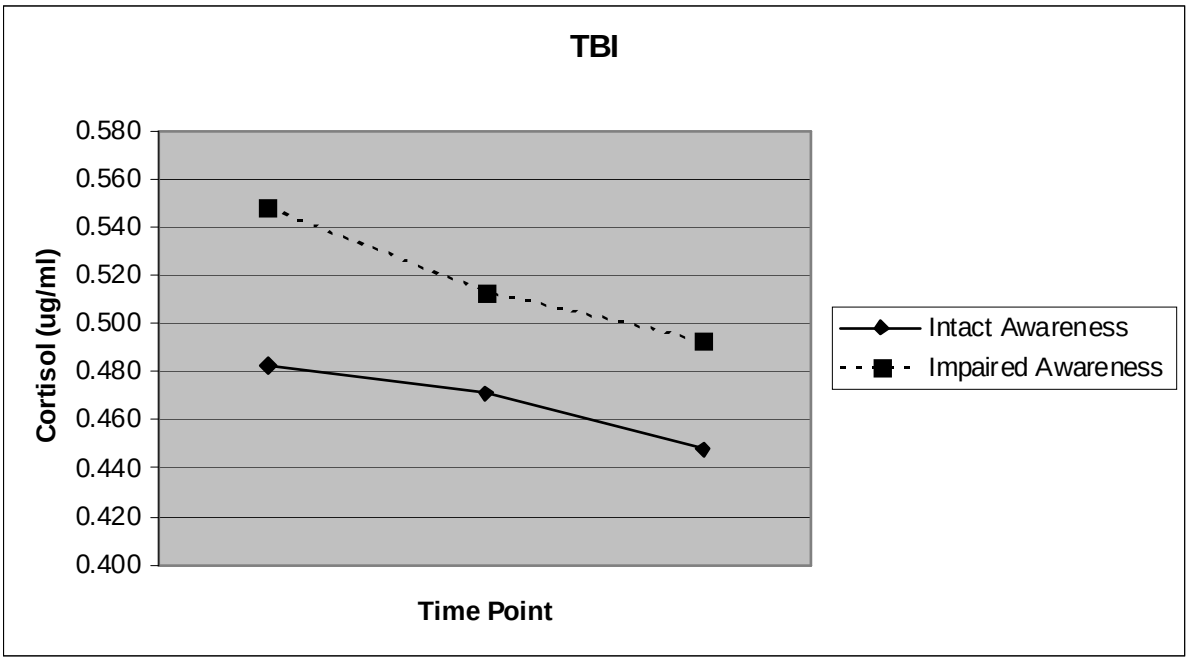
	Distress (BSI)				Life Satisfaction				Perceived Burden		Caregiving Mastery	
	TBI		Significant other		TBI		Significant other		Significant other		Significant other	
	Intact	Impaired	Intact	Impaired	Intact	Impaired	Intact	Impaired	Intact	Impaired	Intact	Impaired
1. Cortisol (Baseline)	.14	.18	-.13	-.32	.21	-.09	.08	.29	.20	.32	.13	-.04
2. Cortisol (Stress)	.01	.17	-.09	-.42*	.22	.16	.02	.48*	.07	.54**	.06	.10
3. Cortisol (Recovery)	.02	.19	-.15	-.48*	.21	.21	.05	.47*	.23	.48*	.08	.14
4. Systolic (Baseline)[1]	.07	-.12	.39*	-.23	.05	.36*	-.25	-.42*	-.36*	.12	-.22	.27
5. Systolic (Change 1)	.37*	-.09	.01	.03	-.32*	.25	.09	-.16	.03	-.13	-.48**	.38†
6. Systolic (Change 2)	-.28	-.17	-.06	-.51*	.30*	.26	.22	.29	-.04	.44*	.45**	.06
7. Systolic (Change 3)	.05	-.24	-.05	-.69**	.01	.49**	.31†	.22	.01	.46*	-.04	.55**
8. Diastolic (Baseline)[1]	.02	-.16	.38*	-.25	.01	.11	-.40*	-.11	-.30†	.00	-.05	-.12
9. Diastolic (Change 1)	.00	.01	.07	.07	.03	-.27	-.22	.10	.01	.16	-.05	.29
10. Diastolic (Change 2)	.07	-.23	-.06	-.39†	-.06	.39*	.36*	.21	.29†	.17	.17	.01
11. Diastolic (Change 3)	.07	-.20	-.01	-.42*	-.05	.11	.22	.29	.35*	.32	.15	.21
12. Heart Rate (Baseline)[1]	.00	-.12	.00	-.21	.04	-.10	.05	.25	.08	.27	-.02	.10
13. Heart Rate (Change 1)	-.21	-.13	-.14	.26	-.18	-.30	.14	-.38†	.08	-.36†	-.05	.18
14. Heart Rate (Change 2)	.23	.24	.21	-.25	-.10	-.08	-.05	.45*	-.10	.31	-.00	.07
15. Heart Rate (Change 3)	-.09	.12	.12	.02	-.20	-.38*	.07	.05	-.05	-.08	-.05	.29

1. Square-root transformation.
† $p < .10$, *$p < .05$, **$p < .01$, *** $p < .001$.

FIGURES

Figure 1.

Cortisol as a Function of Group (TBI vs. Significant Other) and Awareness Status (Intact vs. Impaired)



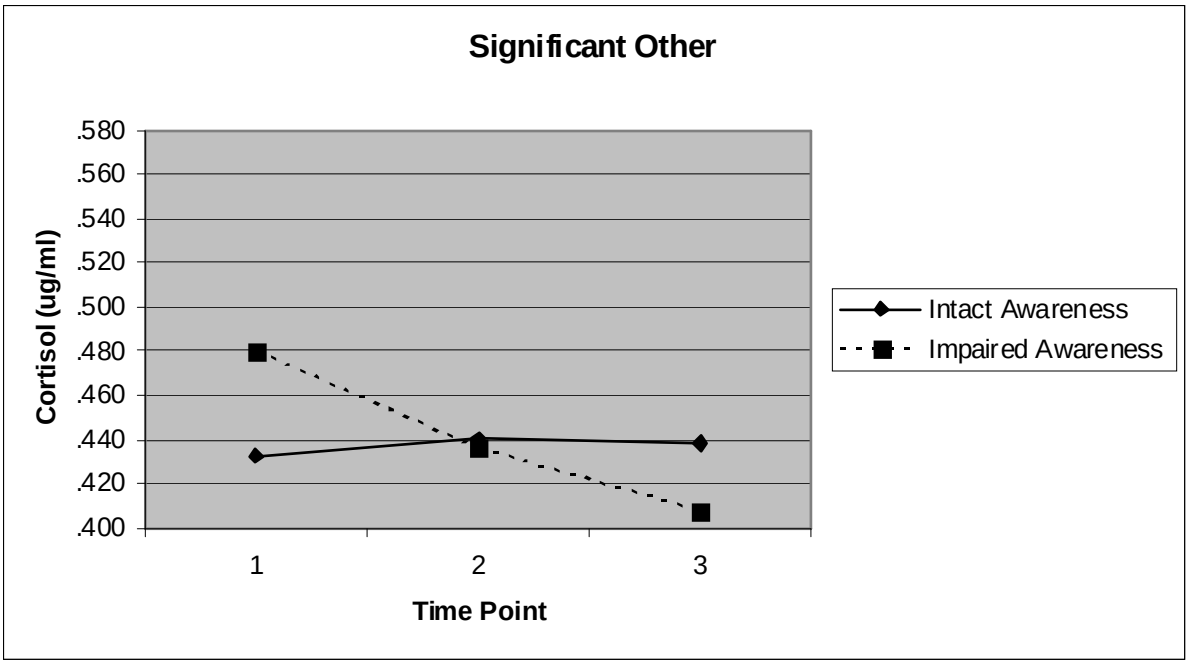
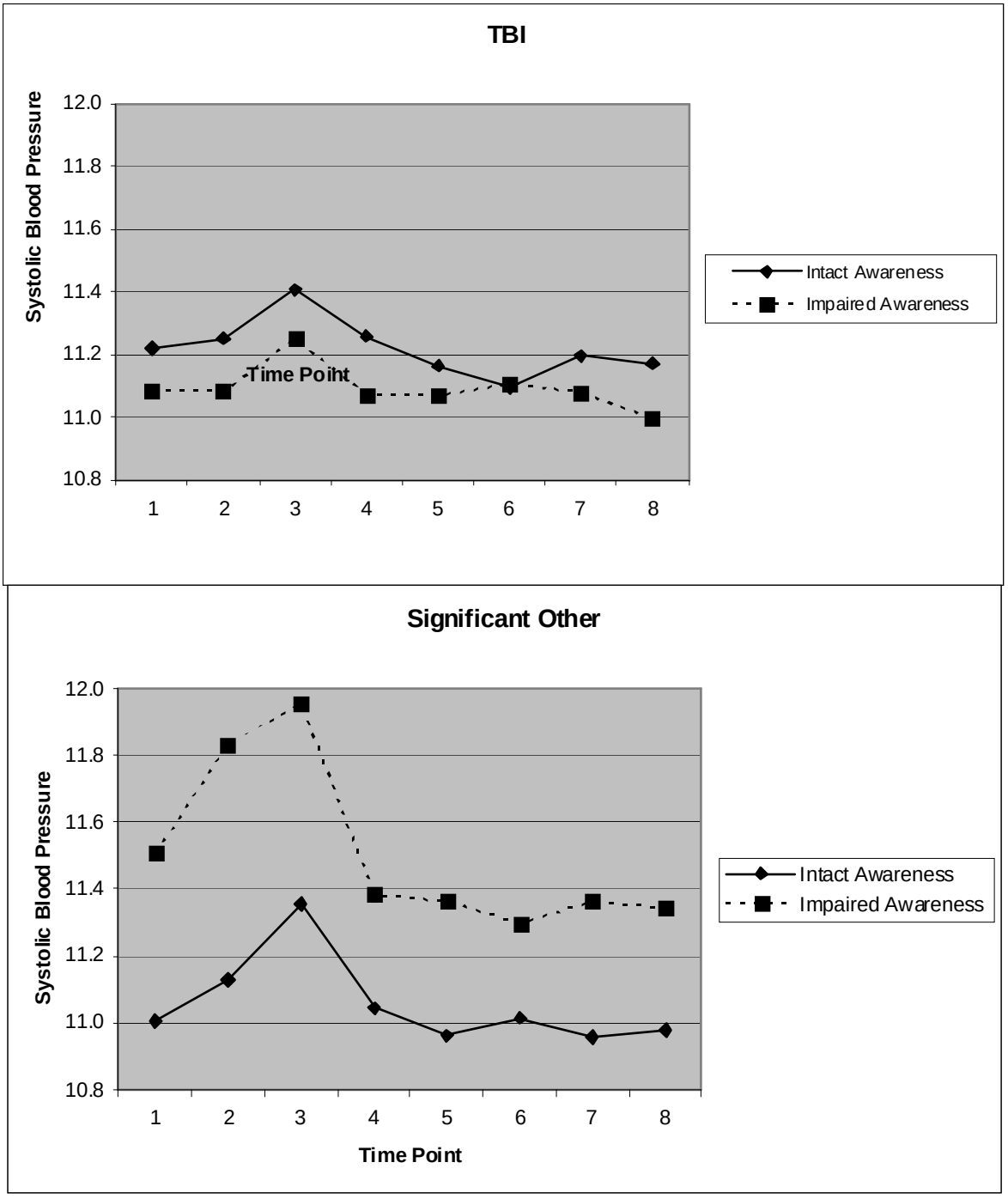


Figure 2.

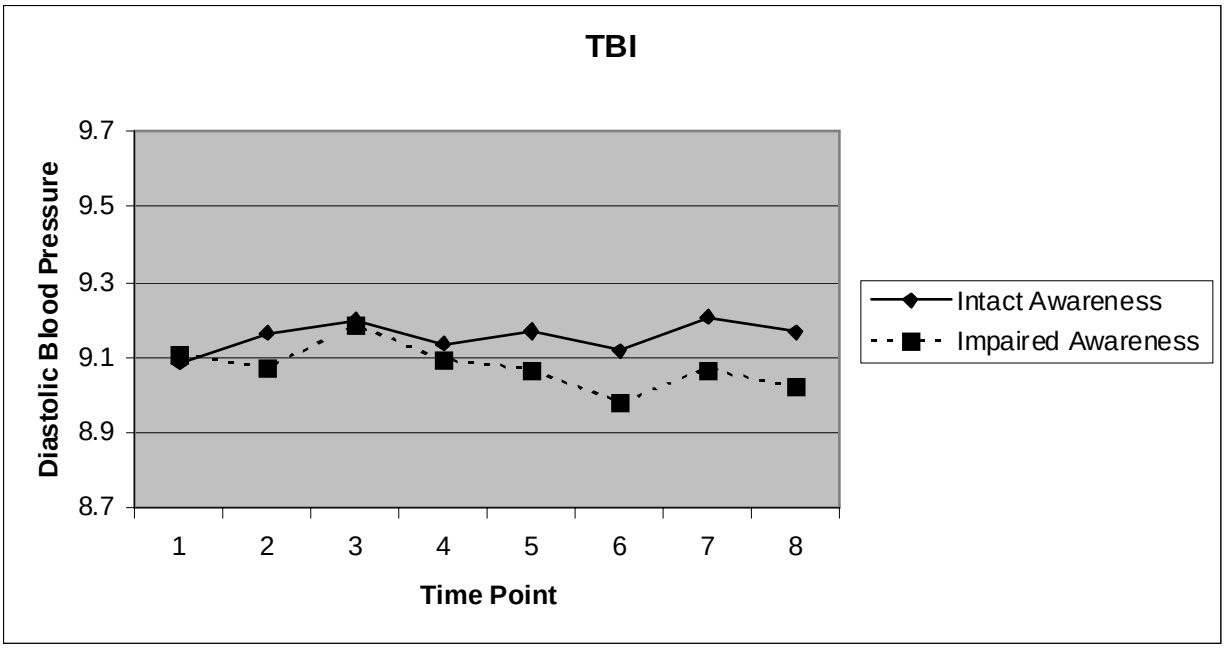
Systolic Blood Pressure (BPS) [1] *as a Function of Group (TBI vs. Significant other) and Awareness Status*

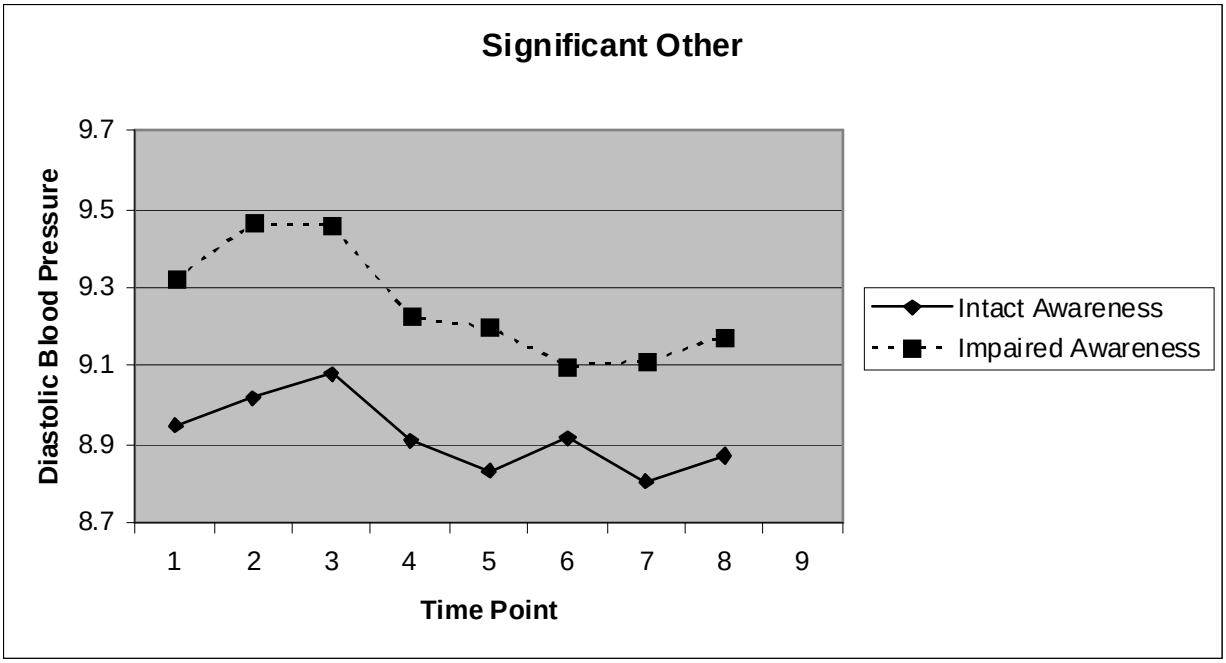


[1] Systolic blood pressure values are transformed by square root.

Figure 3.

Diastolic Blood Pressure (BPD) [1] *as a Function of Group (TBI vs. Significant other) and Awareness Status*

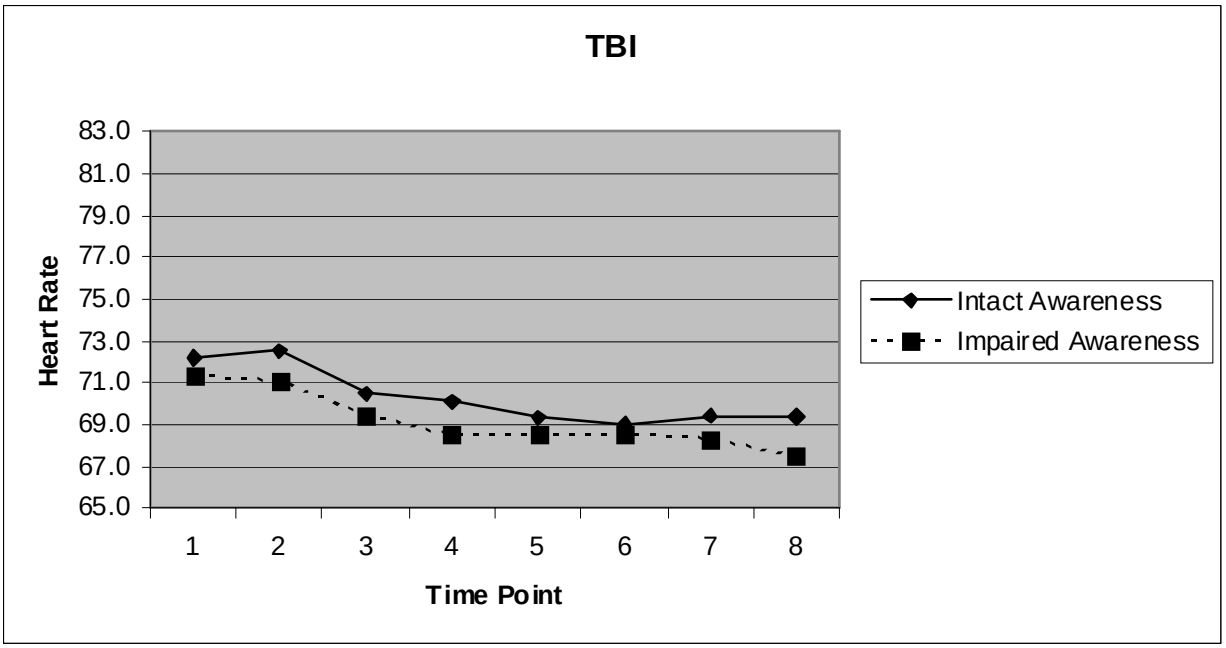


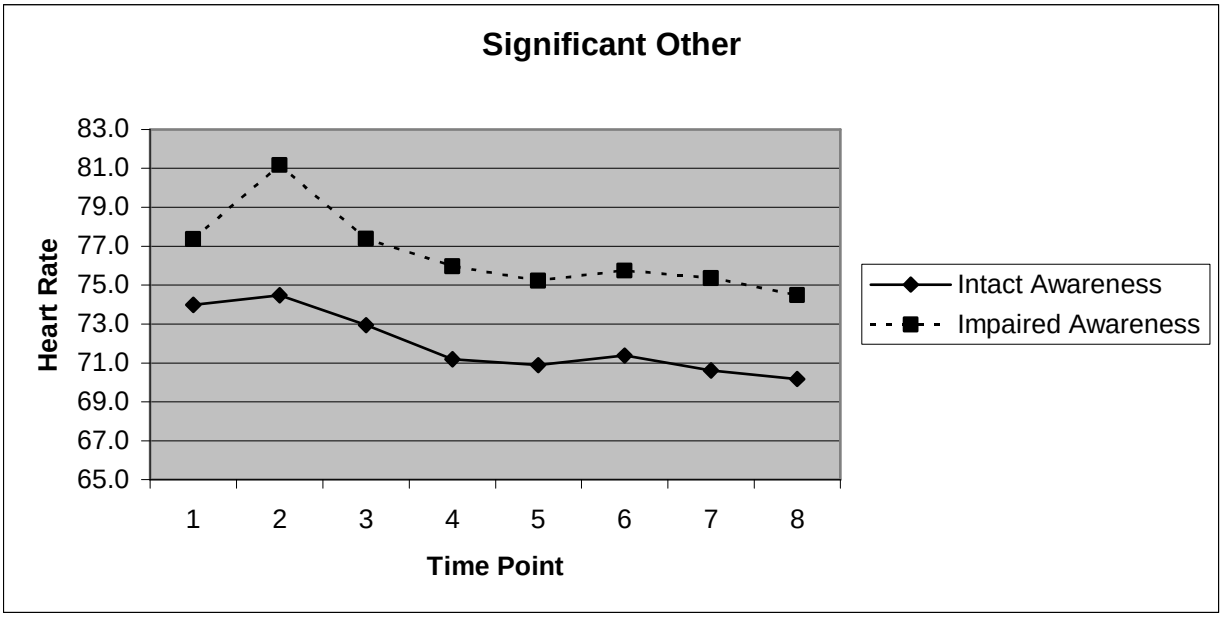


[1] Diastolic blood pressure values are transformed by square root.

Figure 4.

Heart Rate (HR) as a Function of Group (TBI vs. Significant other) and Awareness Status





APPENDICES

APPENDIX A

Stressful Aspects of Recovery Form (Survivor Form)

Stressful Aspects of Recovery
Survivor Form

Recovery from Traumatic Brain Injury (TBI) is different for everyone. Most people find at least some aspects of recovery stressful, but the most stressful aspects are different from person to person. Below is a list of things that could be stressful during recovery from TBI. Please read each item carefully **rate how stressful each was during the most difficult part of your recovery on a scale of 1 to 10** in which 1 means "not at all stressful" and 10 means "extremely stressful."

1. Physical Problems (like difficulty moving arms and legs, difficulty seeing, etc.)
Not at All Stressful ……...….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

2. Emotional Problems (like sadness, depression, anxiety)
Not at All Stressful ……...….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

3. Cognitive Problems (like difficulty concentrating or remembering)
Not at All Stressful ……...….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

4. Functional Problems (like loss of independence, need for assistance, unable to do things that previously could do)
Not at All Stressful ……...….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

5. Behavioral Problems (difficulty controlling anger, impulsiveness, etc.)
Not at All Stressful ……...….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

6. Financial Problems (like difficulty paying medical or other bills)
Not at All Stressful ……...….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

7. Social Support Problems (like not having enough support from family and friends)
Not at All Stressful ……...….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

8. Legal Problems (like lawsuits arising from injury, arrests, etc.)
Not at All Stressful ……...….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

9. Other Problem (describe): _____
Not at All Stressful ……Extremely Stressful

1 2 3 4 5 6 7 8 9 10

APPENDIX B.

Stressful Aspects of Recovery Form (Significant Other Form)

Stressful Aspects of Recovery
Significant other Form

Helping someone recover from Traumatic Brain Injury (TBI) is different for everyone. Most people find at least some aspects stressful, but the most stressful aspects are different from person to person. Below is a list of things that could be stressful when helping someone recover from TBI. Please read each item carefully and **rate how stressful each was <u>during the most difficult part of the recovery</u> on a scale of 1 to 10** in which 1 means "not at all stressful" and 10 means "extremely stressful." You can also choose any number between 1 and 10.

1. Physical Problems (like difficulty moving arms and legs, difficulty seeing, etc.)
Not at All Stressful ……...….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

2. Emotional Problems (like sadness, depression, anxiety)
Not at All Stressful ……...….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

3. Cognitive (Thinking) Problems (like difficulty concentrating or remembering)
Not at All Stressful ……...….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

4. Functional Problems (like loss of independence, need for assistance, unable to do things that previously could do)
Not at All Stressful ……...….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

5. Behavioral Problems (difficulty controlling anger, impulsiveness, etc.)
Not at All Stressful ……...….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

6. Financial Problems (like difficulty paying medical or other bills)
Not at All Stressful ……...….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

7. Social Support Problems (like not having enough support from family and friends)
Not at All Stressful ……...….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

8. Legal Problems (like lawsuits arising from injury, arrests, etc.)
Not at All Stressful ……...….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

9. Other Problem (describe): _____
Not at All Stressful …….Extremely Stressful
1 2 3 4 5 6 7 8 9 10

APPENDIX C.

Timing of Procedure

CORTISOL Study Procedure			
ADJUSTMENT PERIOD		0	Welcome the Participant
		1	Informed Consent
		2	
		3	Introduce the Procedure
		4	
		5	
		6	**Practice BP HR (don't move, don't talk, feet flat on floor)**
		7	Administer as many of the following questionnaires as possible until the baseline measurements. Anything left unfinished can be completed following the rest period: PART-O (ask caregiver about SURVIVOR), Health Behaviors Questionnaire (ask caregiver about SURVIVOR and SELF), C-INFO.
		8	
		9	
		10	
		11	
		12	
		13	
		14	
		15	
		16	
		17	
		18	
		19	
STRESS PERIOD		20	**CORTISOL, BASELINE BP, HR**
		21	
		22	Stressful Aspects of Recovery Form.
		23	
		24	
		25	
		26	
		27	
		28	(Before leaving the room, explain to the participant that you will leave for four minutes. When you return, they will still have one minute of preparation remaining as you set up camera and take BP/HR)
		29	
	0	30	5 minute speech preparation…. You should return to the room after approximately four minutes. Take the BP/HR measurement indicated below (BP/HR 3). Get camera ready while cuff is inflating. At the end of the five minutes, press record on the camera, say the participant's ID number, and then indicate that they should begin. Begin timing three minutes from when they start speaking.
	1	31	
	2	32	
	3	33	
	4	34	**BP HR 3 (don't move, don't talk, feet flat on floor)**
	5	35	3 minute speech
	6	36	
	7	37	
	8	38	**HIGH STRESS BP AND HR (don't move, don't talk, feet flat on floor)**
	9	39	Post-Stress Induction Questionnaire (3 items)
REST PERIOD	10	40	
	11	41	Rest (magazines)
	12	42	
	13	43	
	14	44	**BP HR 5 (don't move, don't talk, feet flat on floor)**
	15	45	Rest (Magazines)
	16	46	
	17	47	
	18	48	**BP HR 6 (don't move, don't talk, feet flat on floor)**
	19	49	Rest (magazines)
	20	50	**HIGH STRESS CORTISOL**
	21	51	Rest (magazines)
	22	52	**BP HR 7 (don't move, don't talk, feet flat on floor)**
	23	53	Rest (magazines)
	24	54	
	25	55	
	26	56	**BP HR 8 (don't move, don't talk, feet flat on floor)**
	27	57	Rest (magazines)
	28	58	
	29	59	
	30	60	**CORTISOL, RECOVERY BP HR (don't move, don't talk, feet flat on floor)**

APPENDIX D.

Awareness Questionnaire (AQ) Survivor Form

		Much Worse	A Little Worse	About the Same	A Little Better	Much Better
1.	How good is your ability to live independently now as compared to before your injury?	1	2	3	4	5
2.	How good is your ability to manage your money now as compared to before your injury?	1	2	3	4	5
3.	How well do you get along with people now as compared to before your injury?	1	2	3	4	5
4.	How well can you do on tests that measure thinking and memory skills now as compared to before your injury?	1	2	3	4	5
5.	How well can you do the things you want to do in life now as compared to before your injury?	1	2	3	4	5
6.	How well are you able to see now as compared to before your injury?	1	2	3	4	5
7.	How well can you hear now as compared to before your injury?	1	2	3	4	5
8.	How well can you move your arms and legs now as compared to before your injury?	1	2	3	4	5
9.	How good is your coordination now as compared to before your injury?	1	2	3	4	5
10.	How good are you at keeping up with the time and date and where you are now as compared to before your injury?	1	2	3	4	5
11.	How well can you concentrate now as compared to before your injury?	1	2	3	4	5
12.	How well can you express your thoughts to others now as compared to before your injury?	1	2	3	4	5
13.	How good is your memory for recent events now as compared to before your injury?	1	2	3	4	5
14.	How good are you at planning things now as compared to before your injury?	1	2	3	4	5
15.	How well organized are you now as compared to before your injury?	1	2	3	4	5
16.	How well can you keep for feelings in control now as compared to before your injury?	1	2	3	4	5
17.	How well adjusted emotionally are you now as compared to before your injury?	1	2	3	4	5

APPENDIX E.

Awareness Questionnaire (AQ) Significant Other Form

		Much Worse	A Little Worse	About the Same	A Little Better	Much Better
1.	How good is the patient's ability to live independently now as compared to before his/her injury?	1	2	3	4	5
2.	How good is the patient's ability to manage his/her money now as compared to before his/her injury?	1	2	3	4	5
3.	How well does the patient get along with people now as compared to before his/her injury?	1	2	3	4	5
4.	How well can the patient do on tests that measure thinking and memory skills now as compared to before his/her injury?	1	2	3	4	5
5.	How well can the patient do the things he/she wants to do in life now as compared to before his/her injury?	1	2	3	4	5
6.	How well is the patient able to see now as compared to before his/her injury?	1	2	3	4	5
7.	How well can the patient hear now as compared to before his/her injury?	1	2	3	4	5
8.	How well can the patient move his/her arms and legs now as compared to before his/her injury?	1	2	3	4	5
9.	How good is the patient's coordination now as compared to before his/her injury?	1	2	3	4	5
10.	How good is the patient at keeping up with the time and date and where he/she is now as compared to before his/her injury?	1	2	3	4	5
11.	How well can the patient concentrate now as compared to before his/her injury?	1	2	3	4	5
12.	How well can the patient express his/her thoughts to others now as compared to before his/her injury?	1	2	3	4	5
13.	How good is the patient's memory for recent events now as compared to before his/her injury?	1	2	3	4	5
14.	How good is the patient at planning things now as compared to before his/her injury?	1	2	3	4	5
15.	How well organized is the patient now as compared to before his/her injury?	1	2	3	4	5
16.	How well can the patient keep his/her feelings in control now as compared to before his/her injury?	1	2	3	4	5
17.	How well adjusted emotionally is the patient now as compared to before his/her injury?	1	2	3	4	5

APPENDIX F.

Satisfaction with Life Scale

Instructions: For each of the following statements, give the number that best corresponds to how you feel. For instance, if you slightly agree with the statement, “I am satisfied with my life”, indicate number 5 for that statement.

1 = Strongly Disagree

2 = Disagree

3 = Slightly Disagree

4 = Neither Disagree nor Agree

5 = Slightly Agree

6 = Agree

7 = Strongly Agree

1	In most ways my life is close to my ideal.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2	The conditions of my life are excellent.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3	I am satisfied with my life.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4	So far I have gotten the important things I want in life.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5	If I could live my life over, I would change almost nothing.	**1**	**2**	**3**	**4**	**5**	**6**	**7**

APPENDIX G.

Caregiver Appraisal Scale (CAS)

Instructions: The following statements describe feelings that caregivers of persons with brain injury sometimes have. We are interested in knowing how you are feeling regarding your situation as a caregiver at the present time. The information you provide will help us to understand your concerns and will help us to understand how you have been affected by your role as caregiver. (In the following statements, this individual refers to the person with the brain injury).Please show us how you are currently feeling about the following statements by telling me the response that corresponds to your answer (go over response choices).

Caregiver Appraisal Scale	**Strongly disagree**	**Disagree**	**No strong feelings either way**	**Agree**	**Strongly agree**
1. My health has suffered because of the care I must give this individual.	1	2	3	4	5
2. My social life has suffered because I am caring for this individual.	1	2	3	4	5
3. I can fit in most of the things I need to do in spite of the time taken by caring for this individual.	1	2	3	4	5
4. I feel isolated and alone as a result of caring for this individual.	1	2	3	4	5
5. A strong reason for taking care of this individual is to be true to family traditions.	1	2	3	4	5
6. I feel confident in my ability to care for this individual's needs.	1	2	3	4	5
7. Caring for this individual has interfered with my (my family's) use of space in my home.	1	2	3	4	5
8. I am very tired as a result of caring for this individual.	1	2	3	4	5
9. I should be doing more for this individual.	1	2	3	4	5
10. I can usually come up with different ways to solve problems when caring for this individual.	1	2	3	4	5
11. Other people look to me for advice on how to help this individual.	1	2	3	4	5
12. I am angry when I am around this individual.	1	2	3	4	5
13. I really enjoy being with this individual.	1	2	3	4	5

Caregiver Appraisal Scale continued	**Strongly disagree**	**Disagree**	**No strong feelings either way**	**Agree**	**Strongly agree**
14. It's hard to plan things ahead when this individual's needs are so unpredictable.	1	2	3	4	5
15. Frequently, I feel unsure of how to help this individual manage daily problems.	1	2	3	4	5
16. Taking care of this individual is a way for me to live up to my religious principles.	1	2	3	4	5
17. It makes me happy to know that this individual is being cared for by his/her family.	1	2	3	4	5
18. Taking responsibility for this individual gives my self esteem a boost.	1	2	3	4	5
19. I know that I am doing all I can to help this individual.	1	2	3	4	5
20. I could do a better job in caring for this individual.	1	2	3	4	5
21. I am pretty good at figuring out what this individual needs.	1	2	3	4	5
22. I am resentful of other relatives who could but who do not do things for this individual.	1	2	3	4	5
23. It's mostly this individual's needs that determine how my days are spent.	1	2	3	4	5
24. This individual seems to expect me to take care of him/her as if I was the only one he/she could depend on.	1	2	3	4	5
25. I am pretty good at knowing what to do to help this individual.	1	2	3	4	5
26. This individual's pleasure over some little thing gives me pleasure.	1	2	3	4	5
27. I have lost control of my life since this individual's injury.	1	2	3	4	5
28. Caring for this individual doesn't allow me as much privacy as I would like.	1	2	3	4	5
29. The things I do for this individual keep him/her from getting worse.	1	2	3	4	5

Caregiver Appraisal Scale continued	**Strongly disagree**	**Disagree**	**No strong feelings either way**	**Agree**	**Strongly agree**
30. Nothing I do seems to please this individual.	1	2	3	4	5
31. Taking care of this individual gives me a trapped feeling.	1	2	3	4	5
32. The knowledge that I am doing my best gets me through the rough times with this individual.	1	2	3	4	5
33. Helping this individual has made me feel closer to him/her.	1	2	3	4	5
34. I think of the help I give this individual as an opportunity to repay him/her.	1	2	3	4	5
35. I don't have enough money to care for this individual in addition to the rest of my expenses.	1	2	3	4	5
36. This individual shows real appreciation of what I do for him/her.	1	2	3	4	5
37. I can take care of this individual with no help – or I could if I had to.	1	2	3	4	5
38. A strong reason to care for this individual is to provide a good model for others to follow.	1	2	3	4	5
39. Because of the time I spend with this individual, I don't have enough time for myself.	1	2	3	4	5
40. This individual is beyond being helped by most things I do for him/her.	1	2	3	4	5
41. This individual asks for more help than he/she needs.	1	2	3	4	5

APPENDIX H.

Social Provisions Scale

Instructions: I am going to read some statements with which you may agree or disagree. Your answers can be Strongly Disagree, Disagree, Uncertain, Agree, or Strongly Agree. Please rate the extent to which you agree or disagree.

		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1.	There are people I can depend on to help me if I really need it.	1	2	3	4	5
2.	There is no one I can turn to for guidance in times of stress.	1	2	3	4	5
3.	There are people who enjoy the same social activities I do.	1	2	3	4	5
4.	I feel personally responsible for the well being of another person.	1	2	3	4	5
5.	I do not think other people respect my skills and abilities.	1	2	3	4	5
6.	If something went wrong, no one would come to my assistance.	1	2	3	4	5
7.	I have close relationships that provide me with a sense of emotional security & well-being.	1	2	3	4	5
8.	I have relationships where my competence and skill are recognized.	1	2	3	4	5
9.	There is no one who shares my interests and concerns.	1	2	3	4	5
10.	There is no one who really relies on me for their well-being.	1	2	3	4	5
11.	There is a trustworthy person I could turn to for advice if I were having problems.	1	2	3	4	5
12.	I have a strong emotional bond with at least one other person.	1	2	3	4	5

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ABSTRACT

LONG-TERM PSYCHOLOGICAL OUTCOMES AND AWARENESS OF DEFICIT IN PERSONS WITH TRAUMATIC BRAIN INJURY AND THEIR SIGNIFICANT OTHERS: THE ROLE OF PHYSIOLOGICAL AND NEUROENDOCRINE REACTIVITY TO STRESS

by

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This study investigated the relationships between physiological/neuroendocrine reactivity to stress and long-term psychological outcomes among persons with TBI and their significant others. In addition, this study examined the potential moderating role of patient AOD in characterizing these relationships. The findings indicate that physiological stress reactivity predicts poor psychosocial functioning in survivors of TBI and their significant others. Chronic stress (reflected in high baseline values) and stress reactivity were generally *adversely* associated with psychological distress and life satisfaction. Among significant others of TBI survivors, this pattern was also observed for sense of caregiving mastery and burden. However, there were also some counterintuitive relationships that emerged as well. For instance, among TBI survivors, baseline systolic blood pressure was *favourably* associated with life satisfaction. Similarly, among significant others, baseline cortisol level was *favourably* associated with life satisfaction, psychological distress, and perceived caregiving burden. The

construct of survivor awareness of deficits helped to elucidate this intriguing pattern of results. In general, and as predicted, stress responses were larger among survivors with intact awareness of their deficits and significant others of survivors with impaired awareness of their deficits than among survivors with impaired awareness and significant others of survivors with intact awareness of deficits. Moreover, counterintuitive findings were only observed among survivors with impaired awareness of deficits and their significant others

AUTOBIOGRAPHICAL STATEMENT

Sarah-Jane Meachen moved with her family, from Cardiff, UK, to British Columbia, Canada, when she was seven years old. Throughout childhood and adolescence she was interested in the arts and humanities and much less so in science. When she began her studies at the University of Victoria in 1998, it was as a double major in theatre and English. However, a spontaneous decision to take a biological psychology class changed the trajectory of her future career toward neuropsychology. She soon transferred to Simon Fraser University, where, under the mentorship of Drs. Allen and Wendy Thornton, she completed her honours undergraduate thesis in Psychology and graduated first in her class, having been awarded the British Columbia Psychological Association Award for Undergraduate Excellence. She completed a Master's Degree at Wayne State University in 2007 with a thesis investigating pre-school aged neuropsychological outcomes in infants born prematurely, under the direction of Dr. Sarah Raz. She later began working under the mentorship of Dr. Lisa Rapport in the adult neuropsychology lab at Wayne State University. . Ms. Meachen completed practica at the Rehabilitation Institute of Michigan, working under the supervision of Dr. Robin Hanks among others. Highlights of her accomplishments include a competitive Rumble Graduate Fellowship (2008), Social Sciences and Humanities Research Council grant (2004), Gerald Rosenbaum Award (2009), publications in peer-reviewed journals, and paper presentations at several national and international conferences. She completed her predoctoral internship in 2010 and is currently working as a Registered Provisional Clinical Psychologist in the Geriatric Neuropsychology department at the Glenrose Rehabilitation Hospital in Edmonton, Alberta, Canada. Following the defense of her dissertation, she expects to be awarded her Ph.D. in May of 2011.