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Masquerades of Brain Injury Part V: Pre-Injury Factors Affecting Disability Following Traumatic Brain Injury

Michael F. Martelli, PhD
Concussion Care Centre of Virginia, Ltd. and Tree of Life, LLC
Medical College of Virginia of Virginia Commonwealth University Health System
University of Virginia, Glen Allen, VA, Richmond, VA and Charlottesville, VA

Mark C. Bender, PhD
Concussion Care Centre of Virginia, Ltd. and Tree of Life, LLC, Glen Allen, VA
Medical College of Virginia of Virginia Commonwealth University Health System
Glen Allen, VA and Richmond, VA

Keith Nicholson, PhD
Comprehensive Pain Program
The Toronto Western Hospital
Toronto, Canada

Nathan D. Zasler, MD
Concussion Care Centre of Virginia, Ltd.,
Pinnacle Rehabilitation, Inc., and Tree of Life, LLC
University of Virginia, Glen Allen, VA and Charlottesville, VA

Please direct correspondence to:
Michael F. Martelli, PhD
Director, Rehabilitation Neuropsychology
Concussion Care Centre and Tree of Life
10120 West Broad Street, Suites G-I
Glen Allen, VA 23060
Phone: 804-747-8429
Fax: 804-346-1956
Email: *mikefm@erols.com*

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***Michael F. Martelli**, PhD, DAAPM, is the director of Rehabilitation Neuropsychology for Concussion Care Centre of Virginia and Tree of Life and has more than 15 years of experience in rehabilitation psychology and neuropsychology with specialization in practical, holistic assessment, and treatment services primarily in the areas of rehabilitation of neurologic and chronic pain disorders.*

***Mark C. Bender** works as a rehabilitation neuropsychologist at Concussion Care Centre of Virginia and Tree of Life and as clinical research coordinator in chronic pain in the psychiatry department at the Medical College of Virginia of Virginia Commonwealth University Health System.*

***Keith Nicholson**, PhD, is a psychologist with the Comprehensive Pain Program and Department of Psychology at Toronto Western Hospital and a consulting psychologist with several community clinics. He also maintains an independent private practice with a focus on clinical neuropsychology and chronic pain.*

***Nathan D. Zasler**, MD, FAAPM&R, FAADEP, CIME, DAAPM, is an internationally respected specialist in brain injury care and rehabilitation. He is medical director and CEO of the Concussion Care Centre of Virginia, Pinnacle Rehabilitation, and Tree of Life, a living assistance and transitional program for persons with acquired brain injury.*

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Traumatic brain injury (TBI) constitutes a major health and societal problem in the United States. Traumatic brain injuries occur in a tri-modal distribution with the highest incidence in children (*i.e.*, younger than five years old), young adults (*i.e.*, 16 to 34 years), and adults (*i.e.*, 65 years and older). TBI rates are highest for males age 15 to 24 years and for both sexes after the age of 70.[1] In general, adult men represent two-thirds of the brain injuries sustained between ages 15 to 70.

It is well-known that recovery from brain injury is a long-term process and that there is considerable patient variability in long-term outcome. TBI outcomes range from subtle changes in personality to profound physical, cognitive, and psychosocial disability. It is also widely accepted that neurobehavioral, cognitive, and adjustment difficulties, rather than physical impairments, represent the most disabling long-term effects of TBI.[2]

OUTCOME FOLLOWING TRAUMATIC BRAIN INJURY

Given the large individual variability, outcome following moderate to severe brain injury is difficult to predict. Persons with TBI represent a diverse group, and, to some extent, the variability in outcome is a function of pre-injury differences in personality, social roles, and intellect. Pre-injury status may be particularly important when evaluating long-term outcome and adaptation following brain injury.[3]

Diversity in patient outcome also arises from post-injury differences in pathophysiology and associated sequelae.[4] Variables such as length of coma, duration of post-traumatic amnesia, the presence of seizures, and type of brain injury are well documented and known to influence outcome from traumatic brain injury.[5,6,7,8] Furthermore, perceived outcome is often subjective. What one patient and family may consider "positive" may be viewed as an insurmountable loss by another individual and his or her family.

In limited studies, it has been found that persons with a pre-injury history of substance abuse, psychiatric disorder, low intelligence, and poor occupational adjustment tend to have more complicated recoveries than similarly injured patients without such histories.[9] Researchers, however, have generally paid less attention to premorbid factors that might influence outcome in comparison with trauma related variables (*e.g.*, duration of coma) or other post-injury biomedical factors (*e.g.*, radiological indicators of brain injury). This is due, at least in part, to the difficulty in obtaining reliable information concerning the nature of premorbid factors and the vast array of characteristics and events from which to choose.[10]

It is intuitively appealing to consider that when a traumatically brain injured person is confronted with the long-term outcome of TBI, premorbid psychological coping characteristics become engaged. The impact of the interaction between premorbid and post-injury personality variables and long-term outcome has not yet been determined, but clinicians involved in the rehabilitation of persons with TBI are frequently impressed that personality variables, both pre- and post-injury, contribute greatly to long-term outcome.[11] Given the variability in patient recovery, some empirical support, and a widely accepted but only partially investigated view that premorbid intellectual, personality, and sociocultural influences interact with acquired brain injury to produce a complex symptom picture,[12] further investigation is clearly warranted.

STRESS AND COPING MODELS OF ADAPTATION

Increasingly sophisticated models of behavior are emerging in the fields of medicine and psychology that assist with conceptualizing and designing treatment interventions for challenging healthcare situations. Biopsychosocial models represent alternative theoretical approaches to dualistic and reductionistic biomedical models that explain disease and health primarily in terms of measurable biological variables. A stress, coping, and vulnerability formulation of brain injury postulates that the injury results in multiple cognitive, emotional, social, and neurophysical

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demands which constitute, singularly and in combination, severe stressors which not only challenge the coping capabilities of the individual but directly diminish available resources through loss of premorbid skills and a combination of reductions in social and financial supports.[13] This formulation includes a complex interaction of factors surrounding brain injury, the history the individual brings to the injury, and the environment that the individual confronts afterwards.

In 1992, Kay[14] proposed a concept of individual vulnerability that suggests that a large number of variables, ranging from biological to psychosocial, influence the impact and outcome of a brain injury for any given individual. Individual differences in brain structure, hormonal and neurotransmitter balances, and other biologic systems represent pre-injury differences that may render one brain more susceptible to, or magnify, neurologic impairment. Subsequently, a wide variety of personality and psychosocial variables interact with the particular impairments to produce a unique functional outcome.

Importantly, case study review revealed several pre-injury personality styles that resulted in vulnerability to poorer relative outcome following mild TBI (MTBI). For example, highly driven, perfectionistic, overachiever types seem specifically prone to elevated stress levels and complicated recoveries due to catastrophic reactions to reductions in cognitive performance. Grandiosity and narcissistic features, as well as borderline personality disorder features, also complicated recoveries, as did prior traumatic experiences, or preexisting somatoform or dependency features. Ruff, Mueller, and Jurica[15] report on additional case study data supporting these and a few other "vulnerable" personality styles. The major "vulnerable" personality styles are included in Exhibit 1.

Satz,[16] after reviewing the clinical literature, proposed a "threshold factor" to account for instances of protection from, or vulnerability to, clinical symptoms when the central nervous system is diseased. The concept of "brain reserve capacity," as espoused by Satz, offers a useful explanation of threshold differences in the onset of clinical symptoms or the expression of impairments and disabili-

Exhibit 1: Vulnerable Personality Styles

Style	Premorbid traits	Postmorbid reactions
Overachiever	Sense of self derived from driven accomplishments, which is frequently accompanied by obsessive compulsive traits	Catastrophic reaction if drop in performance is perceived
Dependent	Excessive need to be taken care of, frequently leading to submissive behaviors and a fear of separation	Paralyzed by symptoms if critical erosion of independence occurs
Borderline personality traits	Pattern of instability in interpersonal relationships and self-image with fear of rejection or abandonment	Exacerbation of personality disorganization, including despair, panic, impulsivity, instability, and self-destructive acts
General insecurity	Weak sense of self, which can include shame, guilt, and dependency needs	Magnification of symptoms
Grandiosity	Overestimation of abilities and inflating accomplishments, can include need for admiration and lack of empathy	Minimization or denial of symptoms; if failure results, crash of self-esteem can result in catastrophic reaction
Antisocial traits	Tendency to be manipulative or deceitful, temperamental, impulsive, and irresponsible; lacks sensitivity to others	Possible exaggeration or malingering, increased risk taking, irritability, takes little responsibility for recovery
Hyperactivity	Restless, unfocused, and sometimes disorganized	Attentional difficulties and impulsivity may be compounded; possible oppositional behavior
Depressed	Mood fluctuations dominated by negative affect	Increase of depressive symptoms, despondency
Histrionic style	Emotionality and attention seeking behavior	Dramatic flavor to symptom presentation; blaming behavior
Somatically focused	Preoccupation with physical well being, reluctance to accept psychological conflicts	Endorsement of multiple premorbid physical symptoms intermixed with new or changing post-morbid residua
Post traumatic stress disorder	Prior stressors produced an emotional reaction of fear and helplessness	Decreased coping ability, cumulative effect of traumas with exaggerated reaction to current crisis

Reference: Ruff, RM, Mueller, J and Jurica, P. (1996). Estimation of Premorbid Functioning after traumatic brain injury. NeuroRehabilitation, 7, 39-53.

ties after brain injury. Psychosocial factors, intelligence, and educational level represent indirect, albeit imprecise, measures of this construct.

When an individual sustains a brain injury, a dramatic imbalance in psychological, biological, and environmental function occurs. The observed diversity in individual outcome certainly reflects the influence of pre-injury differences in neurologic status, personality, and coping skills, intellect, and social resources and roles interacting with post-injury differences in pathophysiology and associated sequelae and changing environmental demands.[17,18,19,20]

Neurologic disease occurs within a multiaxial matrix of a person's physiologic, psychologic, and social history and environment to produce a complex presentation in which diversity in outcome is expected. In conceptualizing adaptation and outcome from a "demands versus resources" model, Satz argues that an individual's unique history is critical in determining what vulnerabilities and resources he or she brings to the injury, as these resources act as "deposits" in a resource "bank" that enhance future adaptation.[21]

When confronted with managing the long term impact of brain injury, an individual's premorbid personality and coping resources, including premorbid intellectual, personality, and sociocultural factors, interact with the sequelae of acquired brain injury to produce a complex symptom picture.[22] This conceptualization is consistent with the stress and coping literature,[23] which conceptualizes coping as an individual's cognitive and behavioral efforts to master demands and conflicts, including the sequelae of neurologic disease, and where an individual's traditional mastery of coping is expected to influence his or her responses to injury.

Despite criticisms about the lack of studies investigating the influence of pre-injury characteristics on brain injury outcome,[24,25] a few studies have incorporated such recommendations. Two empirical investigations to date have sought to elucidate a theoretical model derived from the cerebral reserve/individual vulnerability and stress and coping literature.[26,27] This model posits that individuals possess adaptational reserve for meeting neurologic and other demands and accordingly, greater degrees of reserve would be associated with higher levels of resilience and improved adaptation and recovery from neurologic trauma, while individuals with limited or previously depleted adaptational reserve would be expected to demonstrate increased vulnerability and poorer response.

Martelli and colleagues[28] specifically investigated a vulnerability, stress, and coping model of adjustment following TBI. They argued that the multiple cognitive, emotional, physical, and social sequelae of TBI constitute, singularly and in combination, severe stressors that both challenge coping capabilities and directly diminish available coping resources through loss of abilities, independence, self-esteem and identity, financial, and social supports. Recognizing that recognized prognostic variables sometimes exert relatively weak or variable influences, they developed a composite vulnerability to disability scale including premorbid psychiatric (presence of symptoms of mental illness), neuropsychological (estimated premorbid IQ), attitudinal (victimization perception), relationship (marital status), as well as injury related (*i.e.*, length of post traumatic amnesia, presence of post traumatic seizures) variables.

Using this scale, they combined vulnerability factors and differentiated patients based on a clinically derived cutoff score into high and low vulnerability groups. Group membership (*i.e.*, high versus low vulnerability) was highly accurate in discriminating post-traumatic vocational and disability status. In terms of vocational status, only one of the eight subjects in the high vulnerability group was employed or in school, while 14 of the 20 low vulnerability subjects were employed or in school. With regard to disability status, six of the eight high vulnerability subjects were receiving disability compensation versus five of the 20 low vulnerability subjects. These results are presented in Exhibit 2 and Exhibit 3.

Macmillan *et al*[29] conducted an investigation focusing on a select subgroup of vulnerability variables identified by Martelli *et al*.[30] Investigating premorbid psychiatric and substance abuse history, Macmillan *et al*[31] found that the presence of pre-injury psychiatric and substance abuse problems were both very highly associated with lowered employment and independent living status. Dividing subjects into high and low vulnerability groups (*i.e.*, simple addition of rating scores for premorbid psychiatric and substance abuse histories), they found that only two of the 20 persons (10 percent) in the high vulnerability group were working, and this was in a part time capacity.

In contrast, 19 of 23 of the low vulnerability subjects were employed. In addition, 90 percent of persons with no sig-

Exhibit 2: Employment Status for High and Low Vulnerability Groups

	Current Work Status By Vulnerability Group		
Current Work Status	**High Risk**	**Low Risk**	***Total***
Not Working/No School	*7*	6	*13*
Part-Time Work/School	1	6	*7*
Full-Time Work/School	0	8	*8*
Total	*8*	*20*	

Exhibit 3: Disability Status for High and Low Vulnerability Groups

	Current Disability Status By Vulnerability Group		
Current Disability Status	**High Risk**	**Low Risk**	***Total***
No Disability	2	14	*16*
Receiving Disability	6	6	*12*
Total	*8*	*20*	

nificant premorbid substance abuse were living independently, while only a small minority (*i.e.*, 23 percent, or 3 of 13) of those with premorbid substance abuse were living independently. Interestingly, none of the vulnerability variables were associated with patient's assessment of their own functional status. These results are included in Exhibit 4 and Exhibit 5.

In another study on the influence of a preexisting vulnerability on subsequent brain injury, Raskin[32] investigated whether repeated sexual abuse and subsequent mild traumatic brain injury (MTBI) led to poorer neuropsychological testing results. Based on hypothesized neuropathological changes secondary to the stress associated with sexual abuse, results indicated that individuals with a history of both sexual abuse and MTBI had a greater number of deficits than normal controls or those with either condition alone.

Further evidence of the influence of psychiatric factors on test performance comes from Klonoff and Lamb[33] who cited the neuropsychological test performance of nine individuals with MTBI in which the presence of psychiatric disturbance and/or malingering better explained the poor neuropsychological performance over the trauma. Similarly, Greiffenstein and Baker,[34] in a selected sample prospective study, reported that pre-existing somatoform problems may predict symptomatology in late postconcussion claimants. Finally, Youngjohn *et al*[35] highlighted the need to consider psychiatric disturbances when conducting forensic neuropsychological evaluations.

Taken together, these studies provide support for the assertion that preexisting stress/vulnerability factors can have an appreciable impact on both neuropsychological and daily living functioning subsequent to TBI.

CONCLUSION

There are an estimated two million traumatic brain injuries each year in the United States. Psychosocial and neurobehavioral disorders, rather than physical impairments, are the most disabling consequences. Variability in outcome following TBI more often is the rule rather than the exception, and this phenomenon has not been well understood. Overwhelmingly, outcome studies have focused on the effect of post-injury variables and generally employed gross measures of physical and cognitive status versus quality of life and adaptation to disability.

Many studies have excluded persons with psychiatric and substance abuse histories. There is increasing appreciation, however, that pre-injury characteristics such as coping history may influence outcome and contribute to individual variability in terms of vulnerability to persistent disability. This vulnerability undoubtedly reflects a complex combination of both premorbid and post-injury variables.

Exhibit 4: Employment Status for High and Low Combined (Premorbid Psychiatric, Substance Abuse) Vulnerability Groups

	Current Work Status by Vulnerability Group		
Current Work Status	**High Risk**	**Low Risk**	***Total***
Not Working/No School	0	11	*11*
Part-Time Work/School	2	8	*10*
Full-Time Work/School	20	4	*24*
Total	*22*	*23*	

Exhibit 5: Living Status for High and Low Combined (Premorbid Psychiatric, Substance Abuse) Vulnerability Groups

	Current Living Status by Vulnerability Group		
Current Living Status	**High Risk**	**Low Risk**	***Total***
Independent	0	11	*11*
Home-Supv/Attendant	2	8	*10*
Assisted Living/Nursing Home	20	4	*24*
Total	*22*	*23*	

From the studies presented, it is clear that premorbid vulnerability factors such as psychiatric status, substance abuse, and sexual abuse histories can exert a very strong influence on neuropsychological functioning and ability to cope with and adapt to demands and challenges associated with TBI. Perhaps more importantly, convergent findings fit nicely with the growing trend toward biopsychosocial conceptual models of adaptation following TBI. Incorporating specific concepts of individual vulnerability and cerebral reserve identified through a multifactorial, biopsychosocial interactive model has strong implications for assessing impact of injury and illness on adaptation and disability.

These conceptualizations offer the promise of more useful assessment procedures and treatment interventions. Increasingly, researchers and clinicians are recognizing the importance of evaluating the collective influence and interaction of psychological, social, and cultural factors with biological factors in explaining disease and its variable expression in terms of healthcare outcomes. Such an effort offers a strategy for better understanding the multiple factors mediating the functional expression following impairment that produces more or less disability, and, ultimately, for enhancing adaptation following brain injury.

An increased sensitivity to the role of vulnerability, stress, and coping factors is ultimately required for any efforts to optimize functional capabilities and improve design of interventive strategies in this patient population. Evaluating the influence of premorbid and post-injury variables should result in better predictions with increased understanding of the risk factors associated with TBI and the design of more appropriate intervention programs. The

importance of understanding the variables that mediate the relationship between impairments, disability, and handicap cannot be underestimated, and continued investigations of vulnerability and stress and coping formulations are clearly indicated.

Importantly, a biopsychosocial model, as described, represents a more integrated and through understanding of the effects of brain injury. Such a model reveals more complex pathways for explaining causality and apportionment than ones describing simpler trauma dose response relationships. For the medicolegal setting, these formulations represent challenging models that require innovate approaches by both expert witnesses and attorneys. The implications of a complex biopsychosocial model of injury, impairment, and disability will be reviewed in future articles that specifically address causality and apportionment issues.

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