Emotional Regulation, Processing, and Recovery After Acquired Brain Injury
CONTRIBUTORS TO LIFE BALANCE

Beatriz C. Abreu, Dennis Zgaljardic, Joan C. Borod,
Gary Seale, Richard O. Temple, Glenn V. Ostir,
and Kenneth J. Ottenbacher

INTRODUCTION

Life balance is an elusive term used to describe the personal satisfaction that an individual experiences when his or her obligations, rules, and duties are in harmony. The social sciences literature suggests that life balance is important for healthy living (Christiansen & Matuska, 2006; Drago, 2007). In today’s frenetically paced world, life balance is a challenge and a very unique construct when we consider that it represents one’s satisfying arrangement of personally meaningful roles and occupational choices. Life-balance conflict is largely seen as connected to the difficulty posed when fulfilling commitments to family, friends, and community in a world in which one feels pressured to work and produce more and more (Bloom & Van Reenen, 2006; Premeaux, Adkins, & Mossholder, 2007). The identification of variables affecting life balance can help us explore lifestyle patterns in health promotion, disease prevention, and social policy (Allan, Loudoun, & Peetz, 2007; Bryson, Warner-Smith, Brown, & Fray, 2007; Christiansen & Matuska, 2006). Life balance describes a subjective human condition shaped by ethical, political, economic, and psychological perspectives.

In this chapter, we will portray life balance as an emotional cultural judgment in individuals with and without acquired brain injury (ABI). Quality-of-life assessments are important to enhance understanding of the benefits of health-promotion and rehabilitation. We will suggest that the emotional regulation and emotional processing deficits frequent in persons with ABI might affect subjective and objective well-being and life-balance appraisals.

ACQUIRED BRAIN INJURY (ABI)

ABI includes the diagnoses of traumatic brain injury and stroke. In the brain injury literature, quality of life is associated with positive emotion (Ergh, Hanks, Rapport, & Coleman, 2003; Gordon et al., 2006), but frequently ABI is characterized by an inability to regulate positive and negative emotions (Bay, Hagerty, Williams, & Kirsch, 2005; Wilz, 2007). This lack of emotional regulation influences individual coping and adaptation strategies after trauma as well as their
well-being and quality-of-life appraisals (Finset & Andersson, 2000; Schultz, 2007). In general, rehabilitation researchers have studied negative consequences after brain injury, such as anxiety and depression (Cicerone et al., 2005; Gordon et al., 2006). Published narratives of individuals with ABI provide a window into clients’ struggles to meet goals that contribute to well-being and life balance. The narratives of clients, families, and caretakers generally reveal a conspicuous negative portrait of life balance (Jongbloed, 1994; Krefting, 1989). Frequently, individuals are unable to attain a sense of belonging and a high quality of life due to multiple factors, including loss of relationships, friendships, and spouses (Djikers, 2004). Indeed, there is overwhelming evidence that ABI can produce numerous losses.

Significantly less attention has been paid to the perceived positive consequences after brain injury, such as making sense of one’s losses and the growth of positive emotions from coping with that loss. Some investigations have reported that clients awaken at a deep level that sustains them in a positive manner even when they appear to struggle with personal roles and occupational choices (Faircloth, Boyce, Rittman, Young, & Gubrium, 2004; Gillen, 2005; McColl et al., 2000).

Life-balance conflicts between home and work in people with and without ABI can exhibit different adaptation issues.

**LIFE BALANCE**

Several studies that assess life balance have placed a focus on the association between home and work (Loretto et al., 2005; Steptoe, Crolpey, & Joekes, 1999). In particular, some studies report that personal dissatisfaction can be created as a function of the time spent engaged in activities at work versus in the home or by the intensity of work versus the intensity of conflicts in the home (Sverko, Arambasic, & Galesic, 2002). Voydanoff (2005) suggests that work–life harmony involves a cognitive (subjective) appraisal of the balance between demands and resources. He posited that when demands exceed resources, one could experience strain, stress, or even physical illness. On the other hand, when resources meet or exceed demands, a positive state of mental and physical health may follow. Some believe that life balance will be experienced when work and family resources, such as skills, aptitudes, coping strategies, time, and energy, are sufficient to meet demands and when participation is effective in both domains (Sverko et al., 2002). In addition, it is important to note that demographics and sociocultural factors such as age, gender, ethnicity, marital status, and disability influence work–life balance (MacDonald, Phipps, & Lethbridge, 2005).

The meaning of work changes after brain injury. Some individuals with ABI no longer experience work as the primary event in life, and the social dimension becomes much more important (Johansson & Tham, 2006). Many individuals can achieve life balance without reentering the workforce. Therefore, instead of examining the relationship between work and family life following brain injury or the opportunities for work after community reintegration, our team has chosen to examine the social and neuropsychological underpinnings of emotion and how they may contribute to the understanding of life balance after brain injury.

Life balance has been viewed from a time-use perspective by determining the percentages of a 24-hour day spent in various categories of occupations and the level of intensity of each activity (Christiansen, 1996). Although occupational scientists suggest that structured and balanced daily activities may result in improved well-being, researchers have been unable to support this assumption (Leufstadius, Erlandsson, & Ekland, 2006). Life balance can also be appraised from the emotional regulation perspective by analyzing the manner in which a person processes and experiences positive and negative emotions. The exploration of emotional regulation deficits following ABI is critical for a better understanding of objective and subjective well-being and life balance appraisals.

In the following section, we will review emotional processing deficits following brain insult.
EMOTIONAL PROCESSING DEFICITS AND ABI

Emotional disturbance is common following ABI. Individuals with ABI typically report symptoms related to depression and anxiety, although increases in levels of aggression, agitation, and apathy are also common (for a review, see Prigatano, 1992). With time, pathological levels of emotionality can diminish; however, residual symptoms could persist (Lippert-Grüner, Kuchta, Hellmich, & Klug, 2006). These disturbances in emotion can either occur secondary to one's reaction to a brain injury (i.e., exogenous) or be intrinsic factors that are involuntary (i.e., endogenous). The following section will discuss the latter as it pertains to deficits in emotional processing in individuals with ABI. More specifically, inter- and intrahemispheric theories of emotional processing will be reviewed, as well as recent findings on the recovery of emotional processing deficits secondary to ABI. Here, we will consider emotions as being distinct from affective traits or moods (Alpert & Rosen, 1990; Borod, 1993; Rosenberg, 1998; Ross, 1985).

From a neuropsychological perspective, the term emotion is defined as an individual's reactions to appropriately evocative stimuli that include appraisal, expression, experience, arousal, and goal-directed activity (Plutchik, 1984). By emotional processing, we refer to the ability to perceive, express, or experience emotions (e.g., happiness, sadness) across multiple channels of communication involving the face, prosody (i.e., vocal intonation), gesture, and speech content (Borod, 1992). Traditionally, the literature has placed emotional processing within subcortical regions of the brain, such as the limbic system (e.g., MacLean, 1958; Papez, 1937); however, more contemporary work suggests that the grey matter of the brain (i.e., neocortex) also maintains a significant role in emotional processing (Adolphs, 2002; Borod, 1992). This is a crucial point to consider, because diffuse cortical and subcortical structures can be damaged following ABI, which may in turn lead to emotional processing deficits and subsequently disrupted life balance.

In conjunction with theories on hemispheric dominance for language, a considerable focus in the emotional processing literature has been placed on hemispheric lateralization for emotion (for reviews, see Borod, 2000; Borod, Bloom, Brickman, Nakhutina, & Curko, 2002; Borod, Zgaljardic, Tabert, & Koff, 2001; Heilman, Blonder, Bowers, & Valenstein, 2003; Rogers, Borod, & Ramig, 2008). Hemispheric lateralization is important to address in this context because ABI does not discriminate. In other words, individuals can sustain left- or right-sided brain injuries. Lesion location (right or left side) is a strong indicator of the type of cognitive, functional, and emotional deficits observed in those who have sustained ABI.

Specific lesion areas may be likewise related to particular dysfunctional strategies that can limit or disrupt an individual's emotional interpretation and reaction to a given environment or situation. Felzkman, Lazarus, Gruen, and Delongis (1986) defined coping as "the person's cognitive and behavioral efforts to manage (reduce, minimize, master, or tolerate) the internal and external demands of the person—environment transaction that is appraised in taxing or exceeding the resources of the person" (p. 572).

Hence, psychological, cognitive, and behavioral sequelae secondary to ABI can very well lead to difficulty in gauging, monitoring, and self-regulating one's ability to cope with life stressors, which can, in turn, lead to emotional dysregulation.

Finset and Andersson (2000) assessed coping strategies in 70 individuals who had sustained ABI (e.g., due to stroke, anoxia, and/or trauma) and in a group of 71 healthy volunteers. In their study, Finset and Andersson (2000) used the COPE (Carver, Scheier, & Weintraub, 1989) to establish participants' coping styles. In addition to the COPE, measures that assess symptoms related to depression and apathy were also administered. Their findings indicated that brain-damaged individuals displayed coping strategies similar to the sample of healthy volunteers; however, patients with brain damage tended to use approach strategies relatively less frequently. With regard to lesion laterality, there was no significant evidence to support an association between coping strategy style and the hemisphere of a brain lesion. Furthermore, brain-damaged individuals with
Chapter 15

significant levels of apathy were less likely to use an active coping approach style, whereas a more passive/avoidant approach was associated with brain-damaged individuals with significant levels of depressive symptomatology. Significant levels of apathy in participants were associated with right-hemisphere lesions, whereas significant levels of depressed mood were related to left-hemisphere or bilateral lesions. Although these findings do not support a relationship between lesion lateralization and coping strategy per se, they do provide evidence that certain affective states (e.g., apathy, depression) may influence one’s approach to the formation of coping strategies and should be considered when studying emotional processing deficits in individuals with ABI. This is crucial because, as mentioned above, changes in affective states are common following brain damage and may potentially influence the profile of deficits related to emotional processing.

Emotion Processing Theories

Investigations using patients with ABI have resulted in the development of several neuropsychological theories regarding hemispheric mechanisms underlying emotional processing (for reviews, see Borod, 1992, 1996; Heilman, Blonder, Bowers, & Crucian, 2000; Mandal et al., 1999). In the following section, we will briefly address two hypotheses pertaining to cerebral lateralization of emotion: (1) the right hemisphere hypothesis and (2) the valence hypothesis.

The right-hemisphere hypothesis maintains that the right cerebral hemisphere is dominant for emotional processing regardless of the valence (i.e., the pleasantness level) of the emotion (Borod, 1992; Borod et al., 2002). Support for this hypothesis, on a psychological level, is based on the assumption that processing emotion, in general, entails strategies (e.g., integrative, holistic) and functions (e.g., nonverbal, visuospatial) for which the right hemisphere of the brain is considered to be superior (Borod, 1992). From a neuroanatomical perspective, the cytoarchitecture of the right hemisphere is seen as supporting the strategies and functions associated with emotional processing (Borod, 1992; Borod, Bloom, & Haywood, 1998).

The valence hypothesis, on the other hand, posits two versions and incorporates both hemispheres. In one version, it is proposed that the right cerebral hemisphere is specialized for negative emotions (e.g., sadness) and the left for positive emotions (e.g., happiness), regardless of processing mode (e.g., perception, expression; see for example, Sackheim, Greenberg, Weiman, Hungerbuhler, & Geschwind, 1982; Sato & Aoki, 2006; Silberman & Weingarten, 1986). In a second version of the valence hypothesis (Borod, 1992; Davidson, 1984), it is proposed that differential hemispheric specialization (i.e., left or right) occurs for the expression and experience of emotion as a function of valence but that the right hemisphere is dominant for the perception of emotions of both valences. Moreover, in this version, differential specialization for the expression and experience of emotions occurs within anterior (i.e., motor) regions of the brain, whereas right-hemisphere dominance is specific to posterior (i.e., sensory) regions of the brain (Davidson, 1984).

Although we can only speculate about how differential effects of valence may have evolved, there has been discussion of how particular emotions might have come to be linked with particular behaviors (see Borod, 1992). Because negative emotions are associated with survival (e.g., with removing the organism from danger), a system that is sensitive to multimodal inputs and is able to quickly scan and evaluate the environment would be to the organism’s advantage. This ability to quickly evaluate the environment would also be beneficial in tailoring an individual’s approach in a given emotionally charged situation or environment. According to Borod (1992), such behaviors seem more compatible with gestalt, synthetic processing (a right-hemisphere approach) than with discrete, focused analysis (a left-hemisphere approach). Positive emotions, by contrast, may be more linguistic and communicative than reactive and potentially more strongly associated with the left hemisphere (Borod, Caron, & Koff, 1981). As regions for language processing are typically located in the dominant (left) hemisphere, the expression and perception of positive emotions may be diminished in those individuals experiencing an aphasia syndrome secondary to ABI.

In compartmentalizing emotional processing theory even further, we must also consider pro-
cessing modes (mentioned earlier) and communication channels of emotion. Emotional processing modes are likely governed by separate neuroanatomical regions, suggesting intrahemispheric (not interhemispheric) specialization (Borod, 1993). Lesions toward the front of the brain have been shown to have a greater effect on emotional expression, whereas lesions toward the back have a greater impact on emotional perception (e.g., Ross & Monnot, 2007). This notion of emotional processing mode complements the motor (i.e., anterior) and sensory (i.e., posterior) intrahemispheric neuroanatomical layout of the neocortex.

Nonetheless, whether people are in the process of expressing or perceiving emotion, they do so via a single or a combination of communication channels (e.g., facial, prosodic, lexical). For the facial channel, the most frequently used behavioral measures in research investigations are visual-field differences in response to tachistoscopic or computerized presentation of facial emotional expressions and hemispace advantages in free-field viewing paradigms. For the prosodic channel, the most commonly used measures are ear differences in response to dichotic presentation of emotionally intoned verbal (e.g., speech) or nonverbal (e.g., environmental sounds) stimuli. Similar to the facial channel, measures of the lexical channel are visual-field differences to tachistoscopic or computerized presentation of emotionally meaningful verbal materials, most typically words imbued with emotional meaning.

Borod and colleagues (2001) conducted a review of the literature from a 12-year period (1987–1998) assessing emotion laterality in healthy individuals. The studies that were reviewed employed various techniques assessing processing mode (expression and perception) and communication channel (facial, prosodic, and lexical). Right-hemisphere dominance for the perception of emotion, regardless of valence, was found for the facial and prosodic channels but not for the lexical channel. For the lexical channel, greater left-hemisphere involvement than right was discovered. This finding perhaps reflects the language aspect of this channel and, hence, mediation by the left hemisphere. As for emotional expression studies, only the facial channel was examined, as it is the only channel amenable to behavioral lateralization research protocols. For facial expression, the findings revealed left hemiface dominance (i.e., a right hemisphere advantage) for the expression of emotion. Findings from this review of the normal literature were generally similar to those observed by Borod and colleagues (2002) in their review of the literature assessing emotion laterality in individuals with unilateral brain damage. The findings from the Borod and colleagues' review indicated that patients with right-hemisphere brain damage demonstrate specific deficits in the expression and perception of emotion via the facial and prosodic channels compared to patients with left-hemisphere brain damage and healthy volunteers. Further, the perception of emotional materials via the lexical channel was also implicated as being subserved by the right hemisphere. This is in contrast to findings from the review of emotional processing in the healthy adults by Borod and colleagues (2001) suggesting a left-hemisphere advantage for emotional perception via the lexical channel.

Emotional Recovery

The recovery from emotional processing deficits secondary to ABI is a topic that has received very little attention in the literature. On the other hand, an extensive amount of the research investigating functional recovery subsequent to ABI has been conducted on speech and language functions. Research using patients with aphasia (Fazzini, Bachman, & Alpert, 1986; Kertesz, 1993) has shown that most spontaneous recovery occurs within the first 6 months after left-hemisphere stroke onset (Kertesz, 1993). As to the possible neuronal mechanisms, there are both behavioral and brain injury explanations (Fazzini et al., 1986), with some theories proposing a reorganization or substitution of right-hemisphere (Kinsbourne, 1971) or subcortical (Geschwind, 1974) substrates for damaged left-hemisphere ones. Hence, we can hypothesize that a reorganization or substitution of left-hemisphere structures may occur for individuals with unilateral right-hemisphere brain damage who experience emotional processing deficits.
In another interpretation of inter-hemispheric differences with regard to lesion location (Zgaljardic, Borod, & Sliwinski, 2002), impairments subsequent to right-hemisphere damage, such as visuospatial deficits and unilateral neglect, have often been associated with poor functional outcome (Sterzi et al., 1993). Liotti and Tucker (1992) reported that individuals experiencing depression often have left visual-field impairments that are indicative of some type of right-hemisphere dysfunction, perhaps by interfering with right-hemisphere arousal mechanisms. Similarly, previous research has attributed deficits in arousal and attention to functional recovery outcome. Robertson, Ridgeway, Greenfield, and Parr (1997) reported that patients with right-hemisphere damage demonstrated less recovery of motor functions over a 2-year period than did patients with left-hemisphere damage. These differences were attributed to a greater incidence of attentional impairments in the patients with right-brain damage. Nelson, Cicchetto, Satz, Sowa, and Mitrushina (1994) reported that patients with left-brain damage demonstrated mood stabilization 6 months after stroke onset, whereas patients with right brain damage tended to become progressively worse over time, suggesting that additional factors might impede emotional recovery in individuals with right-brain damage.

More recent work has assessed recovery of emotional perception and expression in individuals who experienced unilateral strokes (Nakhutina, Borod, & Zgaljardic, 2006; Zgaljardic et al., 2002). Zgaljardic and colleagues (2002) administered the New York Emotion Battery (NYEB; Borod, Welkowitz, & Obler, 1992) to 23 participants, including 9 with right-brain damage, 7 with left-brain damage, and 7 healthy volunteers. Emotional perception tasks, including non-emotional control, (assessing facial, prosodic, and lexical communication channels) were administered at two separate time points, with a median interval of approximately 2 years. The three subject groups were well matched on demographic, screening, and non-emotional control variables. Individuals with right- or left-brain injury performed significantly worse on the emotional tasks compared to healthy volunteers. For the three communication channels, there was no evidence of recovery of emotional perception in patients with either right- or left-brain damage. However, when sex differences were taken into account, men with right-hemisphere brain damage demonstrated improved performance over time on emotional tasks within the lexical channel (i.e., for both sentence and word identification tasks). Using the same sample of participants, Nakhutina and colleagues (2006) assessed recovery of posed prosodic emotional expression. Posers (study participants who produced the prosodic emotional expressions) were required to produce neutral-content sentences using four different emotional tones (happiness, sadness, anger, and fear). Raters (undergraduate students) were trained to judge poser output for accuracy and intensity and to evaluate the confidence with which they (i.e., the raters) made their accuracy judgments. The findings from this study revealed limited recovery in individuals with left-brain damage and significant declines in performance for individuals with right-brain damage. Inspection of group means suggested that frontal lobe lesions had a particularly negative impact on performance for individuals with right-brain damage. This is not surprising given that emotional expression is thought to be governed by anterior brain regions, especially within the right-hemisphere (Pick, Borod, Ehrlichman, & Bloom, 2003; Wasserman, Borod, & Winnick, 1998).

The next section will highlight positive as well as negative emotion regulation.

**POSITIVE AND NEGATIVE EMOTION REGULATION**

Positive and negative emotions are distinct from each other, and it is difficult to describe their role under one theoretical framework (Aspinwall, 1998; Isen, 2001). Nearly 60 years ago, the World Health Organization (WHO; 1948) defined health as “a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity.” This definition constitutes a positive perspective on human function, but most of the literature in emotional regulation after ABI primarily focuses on negative outcomes. Some researchers suggest that negative emotions have a strong survival value, are more urgent than positive emotions, and can be powerful enough
to override positive emotions in case of immediate problems or objective dangers (Seligman, 2005; Seligman & Csikszentmihalyi, 2000). Nevertheless, positive affect expressed by clients and caretakers plays a role in health outcomes. Adams (1996) showed that the use of positive emotions during reframing, adaptation, and growth after ABI does not take away the suffering but makes the tragedy more bearable. Two examples of positive emotional responses are optimism and post-traumatic growth.

Optimism is the tendency to look on and expect the most positive results regarding events and conditions. Optimism can affect the adaptation capacity to adjust and modify behavior readily after trauma and disability (Grote, Bledsoe, Larkin, Lemay, & Brown, 2007). According to Isen and Reeve (2005), optimism depends on a combination of factors, including an individual’s goals, judgments, and expectations about situations (Isen, 2000a, 2000b). Interestingly, optimistic individuals use different coping methods than pessimistic individuals (Scheier & Carver, 1992). Optimists used more planning, problem-focused coping, reframing, and acceptance, and were at much less risk of developing clinical depression compared with those who were pessimists (Isaacowitz & Seligman, 2001; Scheier, Weintraub, & Carver, 1986). In contrast, pessimists are more likely to use denial and avoidance (Scheier & Carver, 1992). Interestingly, Peterson (2000) suggests that unrealistic optimism can lead to increased personal risk for illness and injury.

The second positive emotional response is post-traumatic growth. This growth is viewed as the perception of benefits after trauma, such as improved interpersonal relationships, positive change in the perception of self, and a positive philosophy of life (Tedeschi & Calhoun, 1996, 2004). McGrath and Linley (2006) examined the degree and time course of positive psychological change among persons with ABI. They studied individuals both in the early (i.e., acute) and chronic stages of recovery. The chronic group reported higher levels of anxiety and depression but also higher levels of positive change than the acute group, indicating that it may take time for post-traumatic growth to take place. Post-traumatic growth is not precluded by severe brain injury. Optimism and post-traumatic growth are important constructs that require further investigation (Westphal & Bonanno, 2007).

The relationship between positive emotions and psychological well-being is complex and creates interesting challenges for researchers and clinicians. Researchers continue to explore the differentiation between the cognitive and action components of post-traumatic growth (Pat-Horenczyk & Brom, 2007; Westphal & Bonanno, 2006). Hobfoll and colleagues (2007) found that, within the context of terrorism, post-traumatic growth was related to negative outcomes such as psychological distress and support for radical political attitudes and retaliatory violence.

We believe that to optimize rehabilitation and healthcare outcomes, practitioners need to understand and promote adaptive processes after trauma that facilitate resilient and positive outcomes. This perspective in research and clinical practice is derived from the new discipline, positive psychology (Csikszentmihalyi & Csikszentmihalyi, 2006; Eid & Larsen, 2008), which is largely dedicated to expanding theory, practice, and social policy to amplify the individual’s strengths rather than repair the weaknesses (Diener & Seligman, 2002; Seligman, 2005; Seligman & Csikszentmihalyi, 2000). We advocate the identification and analysis of both positive and negative emotion regulation in rehabilitation and health care.

Investigations on the physiological connections among life experience, emotion, and health outcomes have also focused on the negative or stress-related factors (Ryff & Singer, 1998). In the next section, we provide an overview of physiological indicators of stress.

Physiological Indicators of Stress

Stress has been defined as an actual or perceived threat to the body’s ability to maintain stability or homeostasis (Szanton, Gill, & Allen, 2005). The responses and adaptation to stress supplied by the sympathetic nervous system, the neuroendocrine system, and the immune system have been described as allostatic systems (McEwen & Stellar, 1993; Selye, 1976; Sterling & Eyer, 1981).
Chapter 15

The cognitive activation theory of stress postulates that the stress response produces a general activation of increased arousal (Ursin & Ericksen, 2004). This response is essential and presents no threat to health, and it is indeed the process used to adapt to events in daily life. Individuals can have a positive response to stress (e.g., coping), a negative response (e.g., hopelessness), or no response (Ursin & Ericksen, 2004).

Allostatic load refers to the quantification of prolonged or chronic stress and was originally introduced by Sterling and Eyer in 1988. In 1993, McEwen and Stellar proposed the construct as a cumulative measure of physiologic dysregulation. Examining the allostatic load of individuals with ABI may help researchers understand stress and coping during the rehabilitation and community-integration process (McEwen, 2003; Szanton et al., 2005).

The brain interprets experiences as stressful or nonstressful and determines the behavioral and physiological responses to each situation (McEwen, 2007). There are cortical and subcortical structures related to stress. Arousal activity depends on the brainstem reticular activating system but also includes limbic structures and the frontal lobes. The limbic system is a functional arrangement of brain structures associated with memory, learning, motivation, visceral functions, and a wide range of emotional processes. The limbic system regulates personal drive, automatic responses, and hormonal activity; it also has connections to the frontal lobe and other regions of the brain. This widespread network integrates information and mediates physiological, behavioral, and psychological responses (Flannely, Koenig, Galek, & Ellison, 2007; White et al., 2008). The limbic system includes the amygdala, hippocampus, and hypothalamus, which are structures believed to be involved with helplessness, hopelessness, fear, and pain (LeDoux, 1993; White et al., 2008). These structures interpret and regulate stress. The amygdala has been found to be hyperactive in post-traumatic disorders and depressive illness (McEwen, 2003). The hypothalamus, which is a small cluster of nuclei, influences body physiology and sits below the thalamus along the wall of the third ventricle. These structures communicate with neurons all over the body and brain, helping the individual maintain a state of homeostasis by controlling blood pressure, metabolic rate, and body temperature. The pituitary gland exists underneath the hypothalamus. Damage in the pituitary gland after brain injury can lead to a hormonal deficiency called hypopituitarism (Masel, 2004). This hormonal deficiency may be confused with the sequelae of brain injury; therefore, all patients with ABI should be evaluated for hypopituitarism, which can lead to further complications, such as sleep disorders and post-traumatic hypersomnia, that can affect stress (Masel, 2004). A characteristic of the stress response is the activation of the autonomic nervous system and hypothalamic–pituitary–adrenal axis (HPA). Depression and chronic stress have been associated with HPA and the hypothalamus–pituitary–thyroid axis (HPT; Olff, Güzeltan, de Vries, Assies, & Gersons, 2006; Simeon et al., 2007).

All individuals, including those with ABI, display a variety of neurobiological alterations due to emotional dysregulation that can cause stress and illness. This point further emphasizes the importance of continued study of changes in biomarkers after stress.

Variations of Biomarkers in Stress

Some researchers have attempted to measure allostatic load based on a summary indicator comprising a group of biomarkers that reflect alterations in levels of activity that have been linked to increased disease and stress. Allostatic load measures include, but are not limited to, multiple variables such as saliva, urine, blood cortisol, epinephrine, norepinephrine, dopamine, insulin-like growth factors, metabolic markers, and cardiovascular markers such as systolic and diastolic blood pressure. It is not clear which is the best way to combine the allostatic load markers that predict health risks (Karlamangla, Singer, McEwen, Rowe, & Seeman, 2002). A number of studies have examined the association between cortisol, one of the biomarkers, and three factors: age, gender, and work stressors. Some researchers have supported the opinion that biomarkers of stress can vary with age. Crimmins, Johnston, Hayward, and Seeman (2003) used a sample of over
18,000 U.S. noninstitutionalized people ages 20 years or older to examine age differences in 13 allostatic load markers including cortisol. Their findings showed that all the static loads increased up to about age 60 and then the loads decreased and remained stable through the 70s, 80s, and 90s. They found that the allostatic load noted in all age groups participating in the study indicated either lower stress or increased frailty linked to mortality in this population.

The second association that has been investigated by rehabilitation scientists is gender and cortisol levels. Although there has been some support of the notion that men and women differ in their levels of how they experience and interpret anxiety (Jones & Cale, 1989), researchers have not found clear evidence of gender differences in cortisol levels (Thatcher, Thatcher, & Dorling, 2004). Masi, Rickert, Hawkley, and Cacioppo (2004) examined gender and ethnic differences in overnight urinary cortisol and other biomarkers of stress in a sample of 229 adults in an urban community. They found no gender or ethnic differences in cortisol production. They attributed their findings to the different urine and hormone calculations in their studies. In another study of 12 adult field-hockey players (6 women, 6 men), Thatcher and colleagues (2004) investigated gender differences in hormonal responses to competitive sport stressors. Their findings also did not support the gender differences suggested by previous research. Further investigations are needed to clarify the gender association with cortisol.

The third factor related to cortisol levels is work-related stress. There is some suggestion that there is a link between work-related stress and cortisol. Morning cortisol is believed to be a sensitive indicator of work overload in women. Lundberg and Hellström (2002) investigated the association between workload and morning cortisol in women. They analyzed saliva cortisol collected 15, 30, and 45 minutes after awakening on the morning of a nonworking day in 2,000 full-time workers. They found that women working more than 10 hours overtime per week had significantly higher cortisol levels than women working regular hours. In another study, Wellens and Smith (2006) investigated 84 white-collar workers divided into four groups: those (1) with no stressors, (2) with temporal stressors only, (3) with physical stressors only, and (4) with both temporal and physical stressors. They found that the participants exposed to a combination of stressors had significantly elevated levels of both blood pressure and salivary cortisol levels. Additional research is needed to understand the association of cortisol with age, gender, and work.

**Cortisol Levels and Brain Injury**

Investigations of biomarkers of stress and depression, as measured by cortisol levels after brain injury, are limited and show conflicting results (Tchiteya, Lecours, Elie, & Lupien, 2003). In 1989, Jackson and Mysiw demonstrated that cortisol levels were lower in people with ABI who did not respond to antidepressants when compared to people who responded well to antidepressants. Bay and colleagues (2002) found that stress created a high level of cortisol but in 2005, they did not support their previous findings. They attributed the lack of support to their measurement protocol. Researchers have found that brain lesions impact cortisol secretion and have attempted to relate cortisol levels to specific brain areas. Wittling and Pfluger (1990) have suggested that regulation of cortical secretion is under primary control of the right-hemisphere. In 2005, Wolf, Fujiiwa, Luwinski, Kirschbaum, and Markowitsch found that patients with severe global amnesia had no morning cortisol response when compared with a without brain injury control group. They speculated that the possible underlying mechanism for this lack of cortisol response could be related to hippocampus and prefrontal cortex damage as frequently seen in amnesic patients. Tchiteya and colleagues (2003) showed that frontal lesions produced higher levels of cortisol than posterior ones.

There is growing support for the view that biomarkers such as cortisol are of key importance for explaining behavioral factors and quality-of-life judgments. The understanding of the effect of cortisol levels in brain injury may contribute to the understanding of life balance. Cortisol levels have been related to negative emotions such as stress. However, further studies are needed.
to understand the possible role of positive emotions with respect to biomarkers and health outcomes.

EMOTION AND HEALTH OUTCOMES

In this section, we will review selected evidence on emotion and health outcomes. Some researchers posit that the overall balance of positive and negative emotions in daily life predict the individual’s level of subjective well-being (Csikszentmihalyi & Csikszentmihalyi 2006; Eid & Larsen, 2008; Gross, 2007). Subjective well-being includes a broad collection of constructs that relate to the individual’s evaluative judgments of the quality of his or her life (Diener, 2000; Diener, Lucas, & Scollon, 2006; Eid & Larsen, 2008; Fredrickson, 2004, 2006).

Researchers have studied positive affect (PA) and negative affect (NA) and their effect on health outcomes. PA and NA are dispositional personality dimensions. NA is indicative of subjective distress and unpleasurable engagement, and PA reflects the extent to which an individual experiences pleasurable engagement with the environment (Crawford & Henry, 2004). NA and PA have been demonstrated to be orthogonal constructs; in other words, being high on one of the constructs does not necessarily indicate that the individual is low on the other. For example, an individual can experience a high level of pleasurable and unpleasurable engagement within the same environment.

One of the most widely used instruments for measuring positive and negative emotion is the Positive and Negative Affect Schedule (PANAS; Crawford & Henry, 2004; Kennedy-Moore, Greenberg, Newman, & Stone, 1992; Murray et al., 2007; Watson, Clark, & Tellegen, 1988). The PANAS has shown excellent reliability in medical rehabilitation (Ostir, Smith, Smith, & Ottenbacher, 2005). The relationships among PA, NA, and health outcomes have been well documented using the PANAS, and in particular, the benefits of high PA have been demonstrated across a number of studies.

Bood, Archer, and Norlander (2004) examined the relationship between PA and quality-of-life appraisals after brain injury. They reported that individuals with a combination of high PA and low NA showed a more psychologically healthy and self-actualizing profile than did individuals with a combination of low PA and high NA, who showed a self-destructive profile. In another study, Man and colleagues (2004), using a Chinese version of the PANAS, demonstrated that PA scores correlated significantly with overall quality of life in material well-being, health, productivity, safety, intimacy, and emotional well-being. In addition, they found that clients tended to have a higher intimacy score during the first 5 years post-injury rather than later in recovery. There is limited information regarding the association of PA and NA and functional outcomes following ABI.

Ostir and colleagues conducted a series of four studies that supported the relationship between PA and functional outcomes as measured by the Center for Epidemiological Studies Depression Scale (CES–D; Fisher, Al Snih, Ostir, & Goodwin, 2004; Ostir, Berges, Markides, & Ottenbacher, 2006; Ostir, Markides, Blank, & Goodwin, 2000; Ostir, Markides, Peek, & Goodwin, 2001). Ostir and colleagues (2006) used a 4-item positive affect scale created from the 20-item CES–D items to load onto a single positive emotion factor that showed high internal consistency. (Radloff, 1977; Sheehan, Fifffield, Reisine, & Tennen, 1995). The Ostir and colleagues study in 2000 was a prospective cohort study of 2,282 Mexican Americans, ages 65 to 99 years, with no reported activities of daily living limitations at baseline interview. They investigated the relationship between PA and subsequent functional ability and survival in this older population. When they reinterviewed 2 years later, they found that higher PA scores at baseline interview predicted a lower incidence of functional disability, faster walking speed, and a lower likelihood of having died compared to people with low PA.

In 2001, the same group conducted a second prospective cohort study of 2,478 older people who reported no history of strokes at the baseline interview. They assessed whether PA, NA, or
both predicted the risk of stroke. Their findings indicated that higher PA scores were significantly associated with a reduced risk of stroke over a 6-year follow-up period. These researchers suggested that PA seemed to protect against stroke in older adults.

In the Fisher and colleagues study in 2004, the team examined the relationship between PA and subsequent functional ability in 1,084 older Mexican Americans with arthritis. They found that higher PA scores at baseline interview were associated with a lower incidence of functional disability two years later.

In the Ostir and colleagues study in 2006, the team investigated the role of PA and hypertension in older adults. They conducted a cross-sectional study of 2,564 Mexican Americans ages 65 years and older. They found that higher PA scores were significantly associated with lower continuous systolic and diastolic blood pressure for those not on hypertensive medications. They also found that higher PA was also significantly associated with lower continuous diastolic blood pressure for those on hypertensive medication. An emerging literature suggests that PA may play a protective role in health and lead to less vulnerability to inflammatory diseases (Prather, Marsland, Muldoon, & Manuck, 2007).

Benyamini, Idler, Leventhal, and Leventhal (2000), in a longitudinal study of 851 elderly residents (ages 70–80 years) of a retirement community, found that PA influenced residents' perceptions of health. These studies provide support for a relationship between PA and health outcomes.

In summary, the notion that positive emotions are markers of optimal well-being is evident in the social sciences literature (Diener, 2000, 2008; Fredrickson 2001, 2006, 2008). The foregoing studies support the notion that positive emotions improve health outcomes. We would also suggest that positive and negative emotion regulation might moderate life-balance appraisals. In the following section, we will review qualitative evidence supporting positive emotion regulation after ABI.

QUALITATIVE EVIDENCE

Disability and illness have an impact on subjective well-being and quality-of-life appraisals, including life balance. Societal perceptions of disability may present barriers to participation in meaningful life activities, creating a sense of imbalance that can lead to negative self-appraisals. Some qualitative studies support the fact that many individuals who have experienced ABI struggle to attain a high quality of life and a sense of belonging that can contribute to their subjective well-being, while others show that some individuals can accept limitations and restrictions in a positive manner, even when they appear to struggle with limited personal roles and occupational choices. This form of positive emotional regulation is likely to improve their well-being and be a contributor to enhanced quality-of-life appraisals (Phillips, Henry, Hosie, & Milne, 2006).

There are several personal accounts in the qualitative brain injury literature that demonstrate some positive life changes after brain injury. Stone (2005) studied a group of women 3 years post-stroke. Many of the women found a new appreciation of life and worked to minimize the stress that was part of their pre-injury lifestyle. Some became less controlling and practiced letting go of worries and burdens. Gillen (2005) asked stroke survivors if they could identify any positive consequences of their injury. Of those interviewed, 63% were able to identify some positive consequences, including improving relationships with family, increasing awareness of the need to engage in a healthy lifestyle, feeling more religious, developing unselfish concern for others, and reprioritizing what was important in life.

McCoy and colleagues (2000) found that individuals 2 years post-traumatic brain injury or spinal cord injury reported changes in spirituality. Williams, Rittman, Boylstein, Faircloth, and Haijing (2005) reported that veterans who were not diagnosed with depression following stroke tended to face adversity with strength, tried to find meaning in their stroke (e.g., the stroke slowed them down
and caused them to appreciate family more), tried to focus on the present rather than think about the past or worry about the future, and were more hopeful about the future and expected further functional recovery. The effects of stroke were not as devastating for those who viewed it as a normal part of life or for those who had prior experience (e.g., they had watched family or friends struggle and eventually cope following a stroke). Positive psychological change can occur following onset of disability, and this type of change has been studied in individuals with ABI. Clinicians often neglect to identify positive emotions during the rehabilitation process. Limited understanding of positive affect hinders a holistic treatment approach; therefore, more research is needed to explore how positive affect influences functional recovery (McGrath & Linley, 2006).

Two processes that may reshape personal loss are finding meaning and finding benefits after trauma (Davis, Nolen-Hoeksema, & Larson, 1998; Davis, Wortman, Lehman, & Silver, 2000). An example of finding meaning has been described in the qualitative brain injury literature as when an individual views having a stroke as a natural part of the whole life cycle (Faircloth, Boylstein, Rittman, & Gubrium, 2005; Williams et al., 2005). Other narratives have described how individuals after brain injury shift their roles and self-perception, which can lead to a growth in character (McGrath & Linley, 2006). Religious belief appeared to help many participants find meaning and understanding about their loss (McColl et al., 2000). These are examples of how individuals can reconstruct the world after disability (Lopez & Snyder, 2003; Snyder & Lopez, 2005).

There is also support for the value of negative emotions in health outcomes. Tyerman and Humphrey (1984) confirmed that there were profound changes in self-concept in 25 individuals with severe head injury. Their findings suggested that people with severe head injury frequently show insight and self-awareness. Other people with brain injury may show continued reliance on unrealistic expectations that possibly can initially protect and motivate but can also constrain the rehabilitation and adjustment process (Tyerman & Humphrey, 1984). McGrath (2000) reported that NA was associated with emotionalism and tearfulness in a sample of individuals undergoing rehabilitation following severe brain injury.

**CONCLUSIONS**

Our review and attempt to describe emotional regulation, processing, and recovery after ABI as contributors to life balance appraisals suggests three major conclusions. First, the existing definitions and measurement of life balance are vague, conceptually complex, and not explicitly differentiated. Developing consistent definitions and measurements is never easy but may facilitate a clearer understanding of quality-of-life appraisals. Second, the methodological differences reflected in the cited investigations impede the interpretation of findings. The potential sources of variance among the studies of emotional regulation, processing, and recovery after ABI are enormous. Some studies were based on small sample sizes, and participants sustained diverse brain lesions and cognitive impairments. In addition, quasi-experimental designs were used; studies showed limitations in randomization, used different outcome measures, and collected biomarkers samples using different time frames and protocols. These variables clearly limit the generalization of the studies reviewed. Third, the social science literature and rehabilitation data-mining observational studies strongly suggest that emotional regulation, in particular PA, has a protective and buffering effect on health. Additional quantitative and qualitative studies investigating the positive and negative effects of acute and chronic stress, biomarkers, and rehabilitation outcomes are needed.

*Life balance* is a multilevel, multifactor term requiring an interdisciplinary, global perspective to understand its implications, validity, measurement, and use with healthy, as well as ABI, populations. Life balance needs to be studied as a personal and public health issue.
Emotional Regulation, Processing, and Recovery After Acquired Brain Injury

ACKNOWLEDGEMENTS

This work was supported in part by NIH R01 Grant DC01150 subcontract and professional staff congress—City University of New York Research Award, 69683-0038 for Queens College; by the National Institute on Aging, Grant K02-AG019736; by the National Institute of Child Health and Human Development, Grant KO1-HD046682; and by the Moody Foundation, Grant 2005-24. We also gratefully acknowledge Renee Pearcy for her research assistance.

REFERENCES


Chapter 15


Emotional Regulation, Processing, and Recovery After Acquired Brain Injury


Chapter 15


- 238 -


Chapter 15


