Circadian Rhythmicity and Subjective Wellbeing of Carers Under Chronic Stress

Thesis submitted by
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I was assisted in this project by representatives of Carers Queensland (CQ). Toni Cannon, from CQ’s Brisbane office, advised on and accepted articles for the Carers First publication which provided me with an avenue for recruitment and post-study feedback. She also assisted with early discussions of logistical and practical considerations to carer participation. Toni facilitated mailouts to potential carer participants. Robyn Hillier, the Cairns CQ co-ordinator, also provided assistance with recruitment as I accompanied her to meetings and events within the Far North Queensland region.

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Abstract

While acute stress tends to be associated with release of cortisol which is adaptive and assists with the capacity to meet life’s challenges, prolonged stress has been linked to negative effects. Indeed, chronic stress may be associated with maladaptive physiological changes. There is increasing evidence of a bodily cost from chronic stress, termed allostatic load, due to the wear and tear on body systems, such as the hypothalamic-pituitary-adrenal axis (HPA), from chronic adjustment in the face of ongoing demand. Such changes are considered likely to compromise the ongoing capacity for homeostasis and health. It appears that this physiological disturbance may be linked to corresponding disruption to both immune functioning and circadian, or daily, body rhythms. Circadian patterns within body systems allow synchronisation of behavioural needs and their physiological prerequisites. Circadian cortisol patterns allow predictive homeostasis with respect to regular daily challenges such as a morning peak to support the change from rest to meeting the challenges of a new day. Under chronic stress, however, the resetting of daily pattern of HPA activity may occur, with lowering of the typical morning rise a potential physiological strategy to down-regulate excessive cortisol levels. However, in the longer term such changes are considered to be likely to have negative consequences for health. While diurnal patterns of the stress hormone cortisol have been the focus of much research to date, the hormone melatonin is considered to be an excellent marker of circadian rhythmicity and is beginning to be taken into account in studies of chronic stress. While such indications tend to support the notion of stress as the perception of a threat to bodily homeostasis, an alternative view is that of Lazarus and Folkman, that stress results from the sense that one’s wellbeing is at threat. Recent definitions of subjective wellbeing (SWB) describe it as a global assessment of psychological functioning which is made up of both an affective and cognitive assessment of satisfaction with one’s life circumstances. The maintenance of SWB has been proposed to
involve the protection of an underlying mood state within a narrow adaptive range. These efforts toward SWB homeostasis, however, are only thought to be effective up to an individual stress threshold, beyond which failure of SWB, and lack of resilience to external events, will likely result. SWB in the dissatisfied range has been described as indicative of homeostatic failure and high risk of depression. It has recently been proposed that this sense of personal wellbeing may, in fact, represent the reading of an underlying biological state, or core affect. Despite recent indications that SWB may represent the subjective experience of the underlying physiology necessary for adaptive mood and positive engagement with the world, the links between possible circadian dysregulation and SWB under conditions of chronic stress have not been explored. Unpaid family caregiving has been called a prototypical chronic stressor. Primary carers, who provide the bulk of the care required, are particularly likely to experience chronic adversity and subsequent health and wellbeing decrements. To date, studies of the circadian effects on carers’ immunity and cortisol rhythmicity have produced mixed results. The diurnal patterns of melatonin and core body temperature have not been investigated among primary carers. The current study sought to examine the biopsychosocial effects of chronic stress among informal family carers by examining the links between circadian rhythmicity, immunity and SWB. It was predicted that primary carers would exhibit reduced levels of immunity as well as circadian dysregulation of melatonin, cortisol, and core body temperature in the form of reduced amplitude of the diurnal pattern.

A sample of 31 carers who had been in their caring role for a minimum of two years (max 40 years) were compared with 35 age and gender-matched non-carers. Participants collected saliva samples in the morning and evening for two consecutive days and kept a 7-day sleep diary while maintaining their regular routine. From the saliva samples, determinations were made for morning and evening cortisol and melatonin and for morning sIgA antibody levels. Participants also completed psychological scales to measure stress, distress, hassles, uplifts, coping strategies,
subjective wellbeing, social functioning and circadian preference. A subset of 20 participants also collected core body temperature data using a rectal temperature sensor for 24 hours. All data collection took place within one week of late spring. The results showed substantially poorer outcomes for carers across all psychological measures compared to non-carers. In particular, carers were differentiated by high levels of stress and low SWB and social functioning. However, they did not show reduced SlgA levels or indicate dysregulation of cortisol or core body temperature rhythms. However, the findings did provide evidence of disturbed melatonin patterns among carers, with higher morning values and blunted amplitude. Furthermore, treatment of the data according to SWB levels, showed that carers were more likely to report dissatisfaction with life and that individuals in the dissatisfied SWB range exhibited cortisol dysregulation in the form of lower morning values and blunted amplitude. The current study provides support for the view that poor quality sleep and circadian dysregulation of melatonin are likely consequences of chronic carer stress. Further, the current results also indicate that failure of SWB maintenance appears to be associated with disturbed cortisol rhythmicity. Taken together, the current findings point to sleep disturbance as a potentially critical component of chronic stress effects. This study also lends support to the notion that SWB may represent the subjective reading of a physiological state associated with cortisol synchrony and biological readiness to engage with the world. Further investigation of chronic stress effects may have the potential to suggest interventions, both short-term such as administration of melatonin or its agonists, and long-term, toward addressing chronic disadvantage and provision of adequate support to those experiencing chronic adversity. Moreover, better understanding of the links between SWB and circadian rhythmicity, as a possible physical underpinning, has the potential to improve knowledge of the physiological basis of quality of life.
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Chapter 1 – Introduction

1.1 Stress

1.1.1 Definitional Issues

Given the ubiquity of the experience of stress, it is perhaps unsurprising that it is a popular topic within both research and everyday discussions (Jones & Bright, 2001; Lazarus, 1999; Segerstrom & O'Connor, 2012). Indeed, stress reactions are considered to be both critical to survival as well as potentially detrimental (Chrousos & Gold, 1998; McEwen & Lasley, 2002; McEwen, 2000a, 2008). Yet stress remains an ambiguous and somewhat paradoxical term (McEwen, 2000a; Segerstrom & Miller, 2004; Segerstrom & O'Connor, 2012; Toates, 1995). Historically, the word stress has carried connotations from simple hardship and adversity from the middle ages to engineering-inspired definitions of the twentieth century where internal ‘stress’ from an external ‘load’ eventually produced physical ‘strain’ (Lazarus, 1999; Wheaton, 1997). Mechanical metaphors have continued to be used (Viner, 1999) although an alternate and popular approach is to simply operationalise stress as the experience of stimuli that are considered stressful (Segerstrom & Miller, 2004; Segerstrom & O'Connor, 2012).

Methodologies within the stress literature also vary widely, from a focus on external stressors that induce stress, to the behavioural responses to those stimuli, to the internal psychological and physiological reactions that mediate the two (Moos & Swindle, 1990; Rinaldis, Pakenham, & Lynch, 2012; Toates, 1995; Wheaton, 1997). Timeframes for consideration of stress effects also differ, with a common focus on very limited time-frames, from hours to days or weeks (Gottlieb, 1997). It seems likely, however, that a valid examination of much human experience of stress necessitates consideration of much longer timelines as well as qualitative differences (O'Connor, 2005; Wheaton, 1997). A lack of clarity
within stress research has hampered interpretation of findings and made comparisons difficult (Gottlieb, 1997; Jones & Bright, 2001; Lazarus & Folkman, 1984; Segerstrom & O’Connor, 2012). While it is beyond the scope of this thesis to remedy such ambiguity, it is important to begin by clarifying the key aspects of the stress experience pertinent to the current study.

1.1.2 Stress as a Physiological Response

Selye (1976a, p.15), who first coined the term, defined stress as “the nonspecific response of the body to any demand”. His model of stress focused on four key elements: 1) stressors, or threats; 2) conditioning, or ameliorating, factors; 3) physiological responses; and 4) behaviours, which may or may not, be adaptive. Following Cannon’s discovery of adrenalin and the fight-flight response (Biondi & Picardi, 1999; Cannon, 1929) Selye’s seminal research involved the lengthy investigation of the biological effects of subjecting rats to different ‘nocuous agents’ (Selye, 1936, p.32), such as exposure to cold and a range of chemicals, and their physiological responses. He concluded that, regardless of the precipitating stimulus, a general non-specific, biological response involving the nervous and endocrine systems could be observed. Seyle (1976a; 1976b) proposed a “General Adaptation Syndrome” involving a three-stage response of 1) alarm, a state of biological activation which could not be maintained for longer than 48 hours; 2) resistance, involving adaptation via opposing physiological mechanisms; and then, in the face of ongoing stress; and 3) exhaustion, where the signs of alarm reappeared and were unable to be reversed. This final phase was seen as an inevitable outcome in the face of unrelenting demand, due to the depletion of bodily resources and the failure of adaptive mechanisms (Selye, 1976a). Selye’s pioneering work provided a biochemical basis that continues to inform our understanding of the experience of stress (Biondi & Picardi, 1999; O’Connor, O’Hallaran, & Shanahan, 2000; Tsigos & Chrousos, 2002). It should be noted though that current biological approaches no longer see
stress responses as independent of the characteristics of the stressor (Goldstein, 2003).

Around the same time as Selye developed his model of stress, Cannon coined the term homeostasis. Homeostasis describes the active processes used by body systems to maintain conditions within limits that allow continued functioning in the face of external change (Cannon, 1929; Everly & Lating, 2002; McEwen & Lasley, 2002). Many body states, or homeostats, are considered to have an optimal functional range that will be defended (Goldstein, 2003). Thus, many theories of stress continue to draw on a homeostatic model and regard the experience of stress as the perception of a threat to physiological homeostasis (Cannon, 1929; McEwen, 2000a; O’Connor, et al., 2000; Selye, 1936, 1976b; Toates, 1995). In the homeostatic theory of stress, stress is “a condition where expectations, whether genetically programmed, established by prior learning or deduced from circumstances, do not match the current or anticipated perceptions of the internal or external environment” (Goldstein, 2003, p.72, italics added). Any perceived discrepancy between these is predicted to elicit compensatory, or stress, reactions (Goldstein, 2003). Homeostatic theory posits that regulation of the experience of stress occurs via multiple negative feedback loops involving perception of body states, both physical and mental (Goldstein, 2003). In this view, the stress response is critical to enabling adaptation to inevitable yet unpredictable environmental demands (O’Connor, et al., 2000).

1.1.3 Biology of the Stress Response

Stress has also been described as a state of the central nervous system (Toates, 1995). Indeed, the brain is the ultimate site of stress perception and its physiological correlates as well as the ultimate target of its effects (McEwen, 2000a). Within seconds of being faced with a threat, the neural axes are activated. These include the sympathetic and parasympathetic arms of the autonomic nervous system (ANS) as well as the neuromuscular nervous system (Kemeny, 2003). With continued
emotional arousal, the neuroendocrine axis becomes activated. This is characterized by a “cascade of autonomic adjustments” including increases in blood pressure and heart rate (Bernatova, Key, Lucot, & Morris, 2002, p.768). This is the classic fight-or-flight reaction, as described by Cannon (1929), which is driven by norepinephrine and prepares the body for the appropriate physical response to a perceived threat. A more recent nomenclature for this axis is the sympatho-adreno-medullary system, SAM, which has been described as an active coping system which is generally associated with effort and activity but not with distress (Everly & Lating, 2002).

By contrast, slightly longer stress responses are facilitated by the HPA, or hypothalamic-pituitary-adrenal axis (Kemeny, 2003). The HPA axis tends to facilitate stress responses that are more associated with psychological distress rather than physical activity (Everly & Lating, 2002). With HPA activation, perceptions of threat are relayed to the hypothalamus which then stimulates production of pituitary hormones whose end-product is the stress hormone, cortisol (Chrousos, 1998). This glucocorticoid cascade is essential to an understanding of the physiology of stress (Sapolsky, Krey, & McEwen, 1986; Sapolsky, Romero, & Munck, 2000). Cortisol production generally peaks around 30 minutes after an acute stressor (Kemeny, 2003). Glucocorticoid receptors are present in most tissues and organs of the body (McEwen & Seeman, 1999).

Cortisol modulates the physiology of stress by altering the expression of a range of genes (Biondi & Picardi, 1999) and excess cortisol has been associated with suppression of growth, reproduction and immunity (O'Connor, et al., 2000). While cortisol was once thought to simply enhance stress reactivity, it may also play a role in dampening defensive reactions and helping to prevent over-activation within stress response systems (Biondi & Picardi, 1999). Indeed, glucocorticoids may have a protective and recuperative role in the stress response (Sapolsky, et al., 2000). Thus, while cortisol is considered to be an ideal indicator of HPA axis activation the relationship between cortisol levels and stress
perception depends on a complex interaction between the HPA and other neuroendocrine axes and linkages are unlikely to be direct or linear (Hellhammer, Wust, & Kudielka, 2009). It is also important to note that there is wide inter-individual variability in stress reactivity to objectively similar stressors, a finding that reinforces the notion that HPA activation is tightly linked to subjective perceptions of what constitutes a stressful interaction (Biondi & Picardi, 1999; Kudielka & Wust, 2010; Sapolsky, 1994).

1.1.4 Stress as a Psychological Response

Even predominantly biological models now also recognise the importance of subjective appraisal within the stress process, acknowledging that merely an implied threat to homeostasis is sufficient to elicit a physiological response (McEwen & Lasley, 2002). Moreover, the large differences in stress responses within and between individuals points to the influence of cognitive mediators as well as such factors as genetics and developmental influences (Sapolsky, 1994). It is noteworthy that, while extreme variability can make interpretation of stress reactivity data difficult (Sapolsky, 1994), idiosyncratic responses to stress are key determinants of individual health outcomes (Matheny, Roque-Tovar, & Curlette, 2008; Mroczek & Almeida, 2004; Murray, Allen, & Trinder, 2002; Schneiderman, Ironson, & Siegel, 2005).

Lazarus and Folkman (1984) developed a cognitive-appraisal model that remains a popular framework for conceptualising the human stress experience (Knight & Sayegh, 2010; Lazarus, 2000; Matheny, et al., 2008; Peeters, Boersma, & Koopman, 2008; Sideridis, 2006; Tennen, Affleck, Armeli, & Carney, 2000). In their model, stress is defined as a “relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being” (Lazarus & Folkman, 1984, p.19). Stress is thus transactional (Matheny, et al., 2008) involving a dynamic and interactive process of determination of the personal significance of an event
alongside a parallel search for “information and meaning on which to predicate action” (Lazarus, 1999, p.76). The combination of appraisal of the likelihood of harm, threat, or challenge as well as an examination of the available response options, allow unpredictable environmental demands to be dealt with in a manner that will protect core values, goals and beliefs (Lazarus, 1999). Thus, stress is a quintessentially subjective experience involving defence against, and adaptation to, perceived environmental demands.

Affect is considered a primary mediator between stress and health (Cohen, Tyrrell, & Smith, 1993). Both positive and negative affect have adaptational value (Folkman & Moskowitz, 2000; Watson, Wiese, Vaidya, & Tellegen, 1999), with positive emotions linked to proactive reward-seeking behaviours and negative emotions associated with the highly reactive stress system (Mathew & Paulose, 2011; Murray, 2007; Watson, et al., 1999). Thus, while positive affect is associated with approach behaviours and positive engagement, negative affect is linked to avoidance behaviours and response to threat (Watson, 2000) such that negative affect is commonly used as an indicator of stress (Cohen, et al., 1993; Graham & Maybery, 2001; Marsland, Cohen, Rabin, & Manuck, 2001) and seen as a driver of responses to unpredictable life challenges (Watson, et al., 1999). Indeed, neuroticism has been described as the personality correlate of sensitivity to threat (Mroczek & Almeida, 2004; Murray, Allen, Trinder, & Burgess, 2002). Stress and negative affect have been implicated in health effects such as lowering immune responses (Marsland, et al., 2001; Mroczek & Almeida, 2004). In sum, psychological reactions to stress are closely linked to emotion and considered critical to health outcomes (Lazarus, 1993, 1999; Lazarus & Folkman, 1984; Marsland, et al., 2001; Matheny, et al., 2008; Mathew & Paulose, 2011; Sideridis, 2006).
1.1.5 Stress and Coping

Coping involves “ongoing cognitive and behavioral efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the resources of the person” (Lazarus, 1993, p.237). It is an effortful process (Compas, Connor, Osowiecki, & Welch, 1997) with important adaptational consequences (Lazarus, 1993). Coping tends to be broadly categorised as problem-focused, with the goal of altering the actual parameters of the person-environment nexus, or as emotion-focused, wherein the effort is directed to changing the meaning of the person-environment relationship (Lazarus & Folkman, 1984). While active efforts toward problem-solving are often seen as a more rational approach to dealing with stress, reappraisal of the meaning of potentially stressful interactions can be equally adaptive (Lazarus, 1993). Indeed, when a situation is seen as unchangeable, emotion-focused coping is the obvious strategy of choice allowing revision of the personal meaning and implications where no other changes may be possible (Lazarus, 1999). The best outcomes may depend on joint use of problem and emotion focused approaches (Lazarus, 1999; Sideridis, 2006).

The effect of moderate to severe stress on life satisfaction can be significantly moderated by strong coping resources (Matheny, et al., 2008). Recognised coping strategies include planning, reframing, acceptance, humour, denial and disengagement (Carver, 1997; Skinner, Edge, Altman, & Sherwood, 2003). Individuals have a tendency to choose particular coping styles and no one method is considered universally adaptive (Lazarus, 1993). Indeed, the specifics of the person-environment interaction are important determinants of the coping process (Lazarus, 1993; McEwen & Gianaros, 2010). Importantly, while coping is usually discussed in terms of the management of distress and negative affect, it should be noted that it also occurs in the presence of concurrent positive affect (Folkman, 1997; Folkman & Moskowitz, 2000).
Coping, in the form of seeking social support and problem solving, has been found to be significantly and negatively associated with total daily salivary cortisol output, though not to waking cortisol levels (O’Donnell, Badrick, Kumari, & Steptoe, 2008). This provides support for the notion that positive coping strategies may be linked to cortisol reactivity rather than circadian cortisol patterns. This is consistent with the interpretation of negative affect as a response to threat. Indeed, the strength of cognitive mediators in stress management points to parallel opportunities for change in individual stress reactivity and physiology (Sapolsky, 1994). It is suggested that the psychological ability to cope is underpinned by conducive physiological conditions. Specifically, lower waking cortisol levels may be both the result of prolonged stress exposure as well as a risk factor for poorer coping in the event of daily challenges (O’Connor, et al., 2009). In a similar vein, positive affect has been described as the corollary of an underlying endogenous coping capacity (Murray, 2007). Thus coping appears to depend on adequate physiological foundations. It is important to note, in this era of the ‘power of positive thinking’ that an individual’s coping capacity is not without limits and will have an upper threshold (Somerfield & McCrae, 2000).

1.1.6 Timeframes for Stress

Proposed categories for conceptualizing and studying the effects of stress differ according to the timeframe. Acute time-limited events, such as the arithmetic tasks, as well as brief naturalistic stressors, such as exams, are commonly used in experimental paradigms. Stressors involving longer time-frames may be described as stressful life event sequences, such as in a natural disaster; chronic stressors, usually associated with social roles; or distant stressors, where there is past trauma (Segerstrom & Miller, 2004). It is noteworthy that the experience of prolonged stress tends to be a neglected area within research (Hammen, 2005; Kudielka, Hellhammer, & Wust, 2009; McEwen, 2008) and existing stress models are unable to adequately explain chronic effects (Bhatia, et al., 2011;
Gottlieb, 1997; Liu & Alloy, 2010). These difficulties with modelling chronic stress will be discussed further in sections 1.2.4 to 1.2.6. It is noteworthy that, while acute stress reactions tend to be adaptive and without serious consequence, longer-term stress is linked to negative outcomes and stress-related harm (Burchfield, 1979; Compas, et al., 1997; McEwen & Lasley, 2002; O’Connor, 2005; Schneiderman, et al., 2005). The timing and duration of stress appear to be key to its consequences (Lupien, McEwen, Gunnar, & Heim, 2009).

1.2 Chronic Stress

1.2.1 Chronic Stress

The word ‘stressor’ tends to invoke notions of a discrete event, but many stressful stimuli are in fact ongoing conditions or continuous states (Wheaton, 1997). Furthermore, the experience of chronic stress is considered to differ from that of acute stress in important ways (Gottlieb, 1997; Lupien, et al., 2009). For instance, social support may moderate acute but not moderate chronic stress (Smerglia, Miller, Sotnak, & Geiss, 2007). Moreover, “pathology occurs when the natural recovery phase to a noxious stimulus is prevented from occurring” (Sapolsky, et al., 2000, p.79). Lazarus (1999) describes chronic stress as due to situations which are stable and yet are felt to constitute ongoing threat or harm. By definition, this would also involve the ongoing perception of a threat to wellbeing. Thus, due to being both commonly experienced and likely to cause stress-related harm, chronic stress appears likely to be critical to the experience of wellbeing.

Despite its importance, conceptualizing chronic stress can be problematic and relatively little progress appears to have been made toward development of pertinent psychological theory (Frodl & O’Keane, 2012; Ganzel, Morris, & Wethington, 2010; Gottlieb, 1997; Mathews & Gallo, 2011; Rinaldis, et al., 2012). Moreover, studies ostensibly investigating chronic stress have used arbitrary timeframes for
distinguishing between chronic and acute stressors, making comparisons fraught (Baum, Cohen, & Hall, 1993; Kudielka & Wust, 2010). To illustrate this, Izawa et al. (2012) studied the experience of a two week teaching practical to investigate the effects of ‘prolonged stress’, while Ohman and colleagues (2007) examined data across a decade. Yet another consideration for conceptualizing chronic psychological stress, is that duration of a stressor alone is likely to be an insufficient indicator. There may be habituation to a stressful stimulus, with arousal in the face of a particular stressor decreasing over time (Compas, et al., 1997) or, on the other hand, the peak of stress-related physiological activation may come to precede the stressor due to anticipatory effects (Burchfield, 1979; O'Donovan, et al., 2012). Another problem with a simplistic acute-chronic distinction is that an ostensibly acute event may produce extremely long-term effects, such as with childhood trauma (Frodl & O'Keane, 2012) or post-traumatic stress (Compas, et al., 1997). A further consideration is that even relatively minor and time-limited life events such as an exam, may result in physiological changes that last for weeks afterwards (Deinzer, Kleineidam, Stiller-Winkler, Idel, & Bachg, 2000).

According to Baum et al. (1993), chronic stress needs to be identified using three key determinants: the duration of the event, the duration of the feeling of threat and the duration of the stress response. He offers a definition of chronic stress as “the persistent negative exposure to or experience of threat or excessive demand” (Baum, et al., 1993, p.277). He further argues that ‘perfect’ chronic stress involves the event, sense of threat and stress response enduring to the same degree. Indeed, with chronic stress there is typically a sense of continued threat, with either constant expectation of possible harm or ongoing feelings of being overloaded and overwhelmed (O'Donovan, et al., 2012; Wheaton, 1997). It is pertinent to the current study that informal family caregiving is considered to be an archetypal chronic stressor (Lupien, et al., 2009; Vitaliano & Young, 2004).
1.2.2 Chronic Stress tends to be Social

Most chronic stressors are social in origin (Gottlieb, 1997; Lazarus, 1999; McEwen & Gianaros, 2010). Chronic social stress has been associated with loneliness, stigma, role conflict, migration and stressful life events (Lepore, 1997). Lepore (1997) describes how life events can have enduring impacts for some individuals where, rather than normative and/or transitional effects, the experience is traumatic and enduring changes to social experiences occurs after the stressful event. Importantly, the antecedents of social stress, which involve sociocultural elements, may be very difficult to alter at an individual level (Mathews & Gallo, 2011). For this reason chronic stressors may be particularly insidious. They may, of course, be ameliorated by the social environment (McEwen, 2001), with social support and/or role strains recognized as potential moderators of wellbeing (Lepore, 1997). However, in an experiment on the effects of residential crowding, the buffering effect of social support, while evident at two months, appeared to diminish after eight months of chronic social stress (Lepore, Evans, & Schneider, 1991). It appears that stress effects are likely to involve complex reciprocal influences, particularly over extended time periods (Young, Abelson, & Lightman, 2004).

1.2.3 Life Events, Hassles and Chronic Stress

Some earlier approaches to examining longer term exposure to stress focused on stressful life events (Wheaton, 1997), and the links between such events and health outcomes such as increased susceptibility to upper respiratory infection (Turner Cobb & Steptoe, 1996). Nevertheless, the study of life events involves examining the effect of infrequent occurrences such as the death of a spouse or moving house. This focus has been described as unlikely to be representative of the type of stress relevant to the bulk of health and wellbeing outcomes (Lazarus & Folkman, 1989). An alternative approach is to consider daily hassles, the frequent and frustrating demands typical in everyday transactions (Reding
& Wijnberg, 2001) or the numerous separate concurrent demands that may be experienced (Hahn & Smith, 1999). Such hassles have the capacity to permeate all environmental interactions and, when unremitting, have a greater impact than major life events (Lazarus, 1999). As well as being difficult to change or ameliorate, ongoing hassles are considered particularly likely to undermine coping efforts by also eroding personal resources and strengths (Reding & Wijnberg, 2001). It has been argued that chronic stressors are "aspects of the environment that are demanding in an ongoing and relatively unchanging basis" (Hahn & Smith, 1999, p.90) whereas hassles are less stable. Others have made a distinction between the two in relation to the intensity of the underlying frequent stressful interactions, with chronic stress involving high intensity and hassles encompassing low intensity events (Hahn & Smith, 1999).

1.2.4 The Dynamics of Chronic Stress

It is also clear that ongoing stressors and acute stressors are likely to be inter-related, with one exacerbating the other (Compas, et al., 1997). Acute stress processes contribute to the experience of chronic stress in several ways (Compas, et al., 1997). For example, role strain and relationship problems may arise due to receiving a diagnosis of serious illness. This is likely to be accompanied by internal processes such as intrusive negative thoughts and emotions (Brosschot, 2010; Compas, et al., 1997). Additionally, after prolonged exposure to stress, negative responses to other social strains may become exaggerated and result in relatively higher levels of stress compared to that in the absence of chronic stress (Kudielka & Wust, 2010; Lepore, 1997). Persistent life stressors have been shown to alter both psychological and physiological responses to acute stressors. Indeed, following a mental arithmetic task, men who had experienced chronic stress had greater subjective distress and increased sympathetic nervous system activity combined with immune decrements (Pike, et al., 1997). Thus, acute and chronic stressors can have an interactive effect (Rich & Romero, 2005), such that individuals...
exposed to ongoing challenges may have more difficulty adapting to shorter-term demands (Bevans & Sternberg, 2012; Gottlieb, 1997). Indeed, stressful experiences in childhood, as well as over the lifetime, have been linked to changes in stress reactivity (Hammen, 2005) as well as decrements in physical and mental health (Shonkoff, Boyce, & McEwen, 2009).

1.2.5 The Physiology of Chronic Stress

Bodily responses to stress have few negative sequelae as long as they are of limited duration and homeostatic mechanisms can return body systems to baseline levels (O'Connor, et al., 2000). The hormones that mediate the stress response, mainly catecholamines and glucocorticoids, assist the body to adapt to changing and challenging environmental conditions. Cortisol and epinephrine, as example of these stress mediators, facilitate reactions such as the flight/flight response and, therefore, adaptation and survival (McEwen & Seeman, 1999). These physiological reactions to stress allow homeostasis to be maintained and short-term survival chances optimized.

Indeed, a process termed allostasis, which will be addressed later, allows the maintenance of stability in some systems through change in others and is considered to be a common mechanism used to support physiological homeostasis (McEwen & Seeman, 1999; Sterling & Eyer, 1988). Paradoxically, however, prolonged activation of the stress response can lead to physiological damage which can hasten disease processes and reduce long-term survival (Juster, McEwen, & Lupien, 2010; McEwen, 2000a). Thus, physiological responses to stress, which may be adaptive in the short-term can lead to a physical cost, termed allostatic load, if activated for prolonged periods (Esch, Stefano, Fricchione, & Benson, 2002; Juster, et al., 2010; McEwen & Seeman, 1999). One of the proposed effects of cumulative stress is a failure to be able to switch off stress responses (Abercrombie, et al., 2004; Brosschot, 2010). In studies of the experience of unemployment (Dettenborn, Tietze, Bruckner, &
Kirschbaum, 2010) and PTSD (Steudte, et al., 2011) hair analyses have revealed higher cumulative levels of cortisol.

In the face of overwhelming demand, altered HPA functioning has been found in animals (Uschold-Schmidt, Nyuyki, Fuchsl, Neumann, & Reber, 2012) and humans (Moriguchi-Jeckel, et al., 2010). This is thought to be associated with a failure of regular negative feedback systems, disruption of cortisol rhythmicity and, eventually, to dysregulation of other major body systems, including the immune, cardiovascular and metabolic systems (Abercrombie, et al., 2004; Wong, et al., 2012). Thus, chronic stress may be distinguished by long-term disturbance of homeostasis (Toates, 1995). Indeed, the condition of burnout, which is associated with exhaustion and fatigue, has been distinguished at the physiological level by apparent dysregulation of the HPA axis (Bellingrath, Weigl, & Kudielka, 2008; Grossi, et al., 2005; Marin, et al., 2011; Pruessner, Hellhammer, & Kirschbaum, 1999). Exposure to chronic stress has also been found to reduce cortisol responsivity to acute stress (Rich & Romero, 2005; Von Werne Baes, de Carvalho Tofoli, Martins, & Juruena, 2012).

Allostatic load was a concept introduced to the stress literature to describe the ‘wear and tear’ on the body due to repeated cycles of adjustment in the face of challenge (McEwen & Seeman, 1999; Sterling, 2004). It has been defined as “the cumulative physiologic toll exacted on the body over time by efforts to adapt to life experiences” (Seeman, Burton, Rowe, Horwitz, & McEwen, 1997, p.2259). Allostatic load results when short-term adaptation, or allostasis, becomes associated with long-term dysregulation (McEwen & Gianaros, 2010). Thus, while influenced by genetics, developmental experiences and lifestyle (McEwen & Seeman, 1999) allostatic load is, essentially, a consequence of excess exposure to stress (McEwen, 2000a, 2008). It has been proposed that a key pathway to allostatic load may be via stress-induced lifestyle choices, such as smoking, overeating, alcohol use etc (McEwen, 2008).

Other endocrine axes, besides the HPA, also appear to be affected by chronic or intense stress and these are considered likely to be
widespread throughout bodily systems. The somatotropic axis, regulating the release of growth hormone; the thyroid axis, with resultant hypo or hyperthyroidism; and the posterior pituitary axis, which is responsible for diuretic hormones and oxytocin production, are all implicated in prolonged or intense stress reactions (Kemeny, 2003; O'Connor, et al., 2000). Key health indicators of allostatic load involve metabolic parameters, such as obesity, hypertension, insulin resistance, glucose intolerance, and hyperlipidemia (Abercrombie, et al., 2004).

1.2.6 Coping and Chronic Stress

Chronic stressors require different coping strategies compared to time-limited stressors. Sustained coping efforts are needed when situations are unable to be resolved and continue indefinitely with no discrete endpoint (Aldwin & Brustrom, 1997). However, while responses to acute and relatively short-term stressors have been well studied, there has been relatively little work on the effects of coping with chronic stress (Gottlieb, 1997; Lupien, et al., 2009). While there are studies of burnout which suggest it is the result of ineffective coping with enduring work-related stress (Melamed, et al., 1999; Timms, Graham, & Cottrell, 2007), the burnout literature does not appear to address the experience of unrelenting demand experienced in the 24/7 role of the unpaid carer. Indeed, the complexity of chronic stress is considered to be poorly accounted for by models more suited to describing adaptation to time-limited events (Gottlieb, 1997; Kudielka & Wust, 2010). Moreover, there is no current model that offers a coherent explanation of the complex interactions within chronic stress (Bhatia, et al., 2011; Lazarus, 1999; Wheaton, 1997; Young, et al., 2004), despite its ubiquitous nature. Yet the study of chronic stress has the potential to improve current understandings of the depth and breadth of adaptive capacities as well as associated costs and benefits (Chatkoff, Maier, & Klein, 2010; Gottlieb, 1997). Indeed, since research suggests that “continuing, open-ended demands …have the stronger ability to undermine equilibrium” (Gottlieb, 1997, p.8), it is
these that are likely to provide insight into the key to successful adaptation. An examination of caregiving is one of the few ecologically valid ways to examine chronic stress and coping (Lupien, et al., 2009; Schulz & Quittner, 1998).

1.3 Carers

1.3.1 Informal Caregiving

A carer is an individual who provides personal care, support and assistance to another individual who has a disability; chronic or terminal medical condition; a mental illness; or is frail aged (Commonwealth of Australia, 2010). Carers may provide unpaid care and support to a parent, partner, child or friend (Gill, et al., 2007). Caregiving involves the provision of “extraordinary care” that far exceeds what might be provided within an ordinary spousal, parental, or other relationship and which is considered to consume disproportionate time and energy (Schulz & Quittner, 1998, p.107). Moreover, informal caregivers are considered vital to sustaining the independence and optimal functioning of the most vulnerable members of a community (Cummins, Oekerstrom, Woerner, & Tomyn, 2005; Gill, et al., 2007; Vitaliano, Scanlan, & Zhang, 2003). In Australia in 2009, around 2.6 million people, or 1 in 8 citizens, were identified as carers, with around one third of these recognized as primary carers who provide most of the care needed and most of these (68%) being women (Australian Bureau of Statistics, 2009). Informal caregivers contribute substantial amounts of unpaid work hours, with recent estimates for Australia of over $40b annually (Access Economics, 2010).

1.3.2 The Carer Role

Carers typically face extreme physical, emotional, financial and social demands (Pakenham, Stebbins, Cannon, & Samios, 2005). While the physical demands and financial constraints are substantial (Cummins, et al., 2007), carers identify the emotional aspects of their role as
especially problematic (Braithwaite, 1990; Briggs & Fisher, 2000; Brown, et al., 2009). Despite recent efforts to recognize the enormity and the value of informal carers (Commonwealth of Australia, 2010; Queensland Government, 2007), the true impact of the role has long been overlooked (Edwards & Higgins, 2009; Noon, 1999; O’Connell, Bailey, & Walker, 2003; Rohleder, Marin, Ma, & Miller, 2009).

The caregiving role is distinguished from roles such as parenting by a lack of defined pathways, goalposts, outcomes and institutionalized responses, such as daycare or school (Braithwaite, 1990). This creates a lack of predictability which, alongside a long list of other features – including disruption of previous routines, monotony of care tasks, unknown duration of the role, constant responsibility, grief regarding lost capacity of the care recipient, changed nature of relationships and difficulties interacting with service providers – creates a role that is particularly psychologically challenging (Braithwaite, 1990; Briggs & Fisher, 2000; Gottlieb & Gignac, 1996). The difficulties of caregiving have also been described in terms of problems of planning, time constraints, choice restrictions and atypical relationships (Braithwaite, 1990). This latter feature may be especially challenging, with intense caregiving likely to completely alter any prior relationship between the caregiver and care recipient (Pearlin, Mullan, Semple, & Skaff, 1990). Of particular relevance to the current study is that carers tend to subjugate their own needs in order to fulfill their caring role, often forfeiting work, education, leisure and relationship opportunities (Raina, et al., 2005).

1.3.3 Carer Outcomes

It is important to note that there is much evidence that caregiving can be rewarding and associated with finding benefit and meaning (Beach, Schulz, Yee, & Jackson, 2000; Folkman & Moskowitz, 2000; Grant, Ramcharan, McGrath, Nolan, & Keady, 1998; Pakenham, et al., 2005). In addition, there is much variability between carers on measures of distress, burden and health (Schulz & Quittner, 1998). Nevertheless, many carers
report substantial stress and distress (Bass, et al., 2012; Bevans & Sternberg, 2012; Briggs & Fisher, 2000; Coon, Ory, & Schulz, 2003; Cummins, 2001; Cummins, et al., 2007; Hirst, 2005). Indeed, carers are likely to experience ‘psychological health inequalities’ (Hirst, 2005, p.697) with evidence of high levels of distress, depression, anxiety and somatisation among informal caregivers (Braithwaite, 1990; Cummins, et al., 2007; Gill, et al., 2007; Hirst, 2005; Pakenham, et al., 2005; Rohleder, et al., 2009; Schulz & Quittner, 1998; Taylor, Kuchibhatia, Ostbye, Plassman, & Clipp, 2008). In a large-scale Canadian survey, caregivers were found to have higher prevalence rates across most psychiatric diagnoses, with rates of anxiety and depression 1.7 times and 1.5 times the general population (Cochrane, Goering, & Rogers, 1997; Vitaliano, et al., 2005). The majority of Australian carers have been found to report both their mental and physical health had been negatively impacted by their caring role, with almost half rating their physical health as fair to poor (Briggs & Fisher, 2000). Indeed, the burden of providing extraordinary levels of care has long been identified as a factor in the physical and mental health status of carers (Bevans & Sternberg, 2012; Lovell, Moss, & Wetherell, 2012; Pearlin, et al., 1990) with more reports of chronic pain (Cummins, et al., 2007) and sleep problems (Brummett, et al., 2006). Indeed, in a longitudinal study of older spousal carers, caregiver strain was found to be an independent risk factor for mortality (Schulz & Beach, 1999). Although it should be noted that others have found no differences on physical health outcomes (Knight, Longmire, Flynn, Kim, & David, 2007) or even better health among carers (Brown, et al., 2009).

On the whole, however, longitudinal studies indicate that carers are at risk of ongoing distress, either continuous or recurrent (Hirst, 2005). Indeed, older carers were more likely to report depression and anxiety as well as lower levels of perceived health over a four year period than were non-carer controls (Schulz & Beach, 1999). There is even evidence of cognitive decline following years of caregiving (Vitaliano, et al., 2005). What there appears to be little evidence of, however, is positive adaptation
to the carer role over prolonged time periods (Cummins, et al., 2007; Kim, Spillers, & Hall, 2012; Lambert, Jones, Girgis, & Lecathelinais, 2012; Rohleder, et al., 2009). Indeed, carers are likely to report vital exhaustion (VE), a construct that includes stress, fatigue and demoralization (Edwards & Higgins, 2009; Vitaliano, et al., 2005), endorsing items such as ‘feeling tired’ and ‘worn out’ much more than non-carer controls (Edwards & Higgins, 2009). The physical and emotional exhaustion of carers can impact their capacity to provide ongoing care as well as their own mental and physical health (Rohleder, et al., 2009; Toms, 2006). As O’Connell et al. (2003, p.84) contend, the “sometimes twenty-four hour nature of the caring role multiplied across days and years cannot be under-estimated in terms of the potentially negative effects on carers’ health”. Indeed, caregiver strain is described as enduring changes that result from care commitments and that manifests as alterations in overall carer wellbeing and quality of life (Thornton & Travis, 2003). Yet carers’ compromised outcomes tend to go largely unnoticed (Edwards & Higgins, 2009; Kim, et al., 2012; O’Connell, et al., 2003) despite the fact that negative effects due to caregiving have been observed to last beyond the carer role (Hirst, 2005; Lambert, et al., 2012). It seems that poor psychological wellbeing may be a correlate of allostatic load among carers, though it appears this link has not yet been described.

1.3.4 Caregiver Stress Models

As previously acknowledged, caregiving is likely to involve continuous persistent stress (Bass, et al., 2012; Pearlin, et al., 1990) and to constitute a severe and prolonged chronic stressor (Kim, et al., 2012; Lambert, et al., 2012; Schulz & Quittner, 1998). Primary carers, who provide the bulk of regular ongoing assistance required by an individual, are particularly vulnerable (Cummins, 2001; O’Reilly, Finnan, Allwright, Smith, & Ben-Shlomo, 1996) and living with the care recipient is likely to increase carer burden (Schulz & Beach, 1999). Long-term caregiving has actually been labelled a prototypic chronic stressor (Vitaliano & Young,
as well as described as a natural experiment in chronic human stress that would be ethically impossible to replicate otherwise (Lupien, et al., 2009). Indeed, caregiving provides a “human model of the impact of chronic stress” (Lupien, et al., 2009, p.436). Pearlin et al. (1990) suggested a stress-process model for caregiving. In their view, primary stressors, involving difficulties related to providing care, overlap with secondary stressors involving strains due to other roles and/or responsibilities as well as psychological stress. In this model, social support and self-efficacy moderate outcomes and, in recent revisions, form part of a complex explanatory web (Raina, et al., 2004). However, it is argued here that Lazarus and Folkman’s (1984) cognitive-appraisal model, remains a relevant and valid way to conceptualise caregiving stress and provides a comparatively simple alternative. From this perspective, caregiver stress can be simply conceived as a problem of over-demand combined with few coping options (Wheaton, 1997). While it can be argued that no current models adequately describe the experience of truly prolonged stress (Bhatia, et al., 2011; Gottlieb, 1997; Lazarus, 1999; Lupien, et al., 2009), the appraisal model does allow consideration of the ongoing dynamic and reciprocal interactions between the carer and the demands of their role. Of most relevance to the current study, it allows focus on the threat to personal wellbeing which is, arguably, the truly defining feature of long-term caregiving.

1.3.5 Caregiver Coping

There is evidence that carer coping can moderate carer outcomes (Gignac & Gottlieb, 1996) and that positive affect alongside negative affect is also associated with providing informal care (Folkman, 1997; Quinn, Clare, & Woods, 2010). A point of difference among carer coping strategies is that they tend to focus on interpersonal relationships, in addition to the commonly cited problem-solving and emotion regulation strategies (Gottlieb & Gignac, 1996; Raina, et al., 2005). For example, dementia carers tend to cope better if they can attribute the source of
interpersonal difficulties to the disease rather than to the individual requiring care (Gignac & Gottlieb, 1996). It is noteworthy, however, that the rewards associated with caregiving tend to be linked to improvement in the person receiving care, whereas the stressors tend to be related to risks to the carer’s own welfare (Grant, et al., 1998; Quinn, et al., 2010). Indeed, the crux of the problem for carers centres around restricted coping options and reaching the limits of their coping capacity (Somerfield & McCrae, 2000). While stress is an inevitable part of dealing successfully with any life challenge (McEwen & Lasley, 2002), caregivers tend to have to contend with circumstances that leave them “near the ceiling of their adaptive capacities” (Somerfield & McCrae, 2000, p.623). Indeed, the role of informal carer appears likely to exceed the adaptational capacity of most. Carers of individuals with a mental illness have been identified as likely to experience intolerable burden (Toms, 2006), while carers of those suffering from multiple sclerosis have been described as likely to be subjected to “chronic sorrow” (Pakenham, 2001, p.13).

1.3.6 Caregiver Physiology

Meta-analytic data indicates that carers are more likely to have elevated stress hormones and weaker immune responses compared to non-carers (Vitaliano, et al., 2003). As previously noted, HPA activity, as reflected by cortisol levels, is considered to be a potential measure of stress (de Vugt, et al., 2005). In caregivers, elevated cortisol levels are commonly reported (de Vugt, et al., 2005). Carers have also been found to have higher salivary cortisol levels across the day when compared to controls (Moriguchi-Jeckel, et al., 2010; Vedhara, et al., 1999). Non-depressed dementia carers had significantly higher salivary cortisol levels than controls in samples collected at midday and 2pm (Da Roza Davis & Cowen, 2001). Morning cortisol levels for caregivers coping with high levels of dementia-related behaviour problems has also been found to be elevated compared to non-carer controls (de Vugt, et al., 2005). However, cortisol results are mixed, with other studies finding lower total cortisol
among carers (Bella, Garcia, & Spadari-Bratfisch, 2011) or no differences between caregivers and controls (Lovell, et al., 2012; Provinciali, et al., 2004; Rohleder, et al., 2009; Vedhara, et al., 2003).

Caregiver distress and negative affect have generally been found to have a positive relationship with cortisol levels (Davis, et al., 2004; de Vugt, et al., 2005; Vedhara, et al., 1999) although others report a lack of association between cortisol and perceived stress among carers (Schwarz & Dunphy, 2003). The provision of care has been found to be linked to significantly higher cortisol levels among carers compared to levels when not providing care, although this elevation did not differ according to the type of care task required (Davis, et al., 2004). However, carers’ morning cortisol levels have been found to be lower on the days following times of increased demand (Barker, Greenberg, Seltzer, & Almeida, 2012). Interestingly, levels of both cortisol and tryptophan, the precursor to serotonin, among non-depressed carers have been found to be similar to those for patients with major depression. These biochemical characteristics were considered to reflect the stress of the caring role and provide the biochemical basis of risk for mood disorder (Da Roza Davis & Cowen, 2001). Carers risk for physical health problems are also considered to be related to stress-related physiological changes (Bella, et al., 2011; Vitaliano & Young, 2004). Carers of a spouse with Alzheimer’s are commonly used in studies of the impact of stress on immune function, although this data is doubtless confounded with the interactive effects of ageing on health outcomes (Lutgendorf & Costanzo, 2003; Moriguchi-Jeckel, et al., 2010). Unfortunately there has been sparse research investigating the biological correlates of caregiving in middle-aged or younger carers (Kuster & Merkle, 2004; Lovell, et al., 2012).

1.3.7 The Biopsychosocial Approach

The biopsychosocial model attempts to describe the reality of the complex relationships between biology, psychology and social milieu which influence health outcomes (Inui, 2003; Lutgendorf & Costanzo,
According to this well-established, if unwieldy, model, biology alone cannot account for disease. It is the dynamic interaction between biological influences, such as genetics, and other psychosocial factors, such as depression, and health behaviours that play a key role in disease processes (Lutgendorf & Costanzo, 2003). With respect to the progression from chronic stress to disease, pathways are uncertain (Juster, et al., 2010; Mathews & Gallo, 2011) but two possibilities have been proposed. The first involves health impacts due to the uptake of risky health behaviours, otherwise termed harmful coping options, in the face of psychosocial distress (McEwen, 2008). The second possible pathway involves chronic stress-induced psychosocial distress and subsequent activation of stress hormones, which when followed by prolonged HPA axis activation, results in a physiological toll (Lazarus, 1999; Vitaliano, et al., 2003). Either of these may be relevant to carers. With respect to outcomes among long-term caregivers, a biopsychosocial approach is critical to a full understanding of the interactions that ultimately lead to health or disease (Raina, et al., 2005; Schneiderman, et al., 2005). Yet, the biomedical model still predominates much health research and practice (Alonso, 2004; Fava & Sonino, 2008) and more focus on the underpinnings of positive health is needed (Ryff & Singer, 2000b). The study of immune regulation has nevertheless provided much evidence of the importance of biopsychosocial interactions.

1.4 Immunity

1.4.1 The Immune System

According to Rabin (1999, p.18) the immune system is “a sensory organ that surveys the interior of the body” for pathogens, thus playing an essential role in the maintenance of homeostasis and good health (Kiecolt-Glaser, McGuire, Glaser, & Robles, 2002). Without a well-functioning immune system we simply cannot survive (Rabin, 1999). The immune
system is comprised of both natural and specific responses. Natural immunity allows a general and rapid defense through the release of non-specific cells, such as macrophages, that target a wide range of pathogens (Segerstrom & Miller, 2004). This inflammatory response also involves release of cytokines, molecular messengers that inform the central nervous system of the instigation of an immune reaction (Weigent & Blalock, 1999). Natural killer cells and complement proteins are also part of the natural immunity armamentarium. Specific immunity, on the other hand, is a slower and more targeted immune reaction. It employs both cellular and humoral responses which seek out intracellular and extracellular pathogens respectively (Segerstrom & Miller, 2004). The humoral immune response involves the release of soluble antigen-specific proteins, or antibodies, into the blood or tissues. Five types of antibody, or immunoglobulin (Ig), have been identified; namely IgA, IgE, IgG, IgM and IgD (Rabin, 1999). These are responsible for neutralizing toxins from bacteria, preventing viral entry into cells and increasing the effectiveness of cells providing natural immunity (Segerstrom & Miller, 2004).

1.4.2 Immunoglobulin A

IgA is a subclass of antibody found in both blood serum and external secretions, such as the lining of the gut and respiratory system as well as saliva (Rabin, 1999; Woof & Kerr, 2006). Secretory IgA, or sIgA, is produced by cells underlying the epithelium, then excreted by the epithelial cells onto mucosal surfaces. It is thought to hinder the adherence of microbes to these surfaces and thus provide protection by preventing penetration of exposed tissues (Rabin, 1999). Immunoglobulin-A (IgA) is the primary mucosal antibody forming the first line of defense in the body (Lamm, 1997; Valdimarsdottir & Stone, 1997; Woof & Kerr, 2006). Beyond forming an external barrier to infectious agents, IgA antibodies appear to neutralize viruses intracellularly. Lamm (1997, p.7) contends that “most human infections involve mucous membranes, as either the locus of clinical disease or the portal of entry… infections tend to be initiated by
relatively small inocula of a pathogen, whether inhaled into the respiratory tract or ingested; therefore, even small amounts of pre-existing secretory IgA antibody can be effective in preventing disease”. Indeed, individuals with lower levels of slgA in their saliva have been found to be more likely to succumb to upper respiratory tract infections (Winzer, et al., 1999).

1.4.3 Stress and Immunity

As the first researchers to propose a psychoneuroimmunological approach, Solomon and Moos (1964), dared to speculate about possible links between stress, emotions, and immune function. Today the burgeoning field of psychoneuroimmunology, PNI, is considered to be fundamental to understanding the relationship between psychological states and health (Kiecolt-Glaser, McGuire, Robles, & Glaser, 2002; Lutgendorf & Costanzo, 2003; Suarez, Feramisco, Koo, & Steinhoff, 2012). PNI focuses on the interplay between psychological events, the central nervous system and the immune system (Kiecolt-Glaser & Glaser, 1992). The effect of the experience of stress on immunity is central to PNI (Segerstrom & Miller, 2004).

Evidence from studies employing acute laboratory stressors, such as cognitive tasks or social challenges like public speaking, indicates that these events, often only minutes in duration, can lead to transient increases in immune system activity (Herbert & Cohen, 1993). This is thought to be a response to stress-induced catecholamine release (Kiecolt-Glaser, McGuire, Glaser, et al., 2002). However, immune changes in response to acute stressors have also been found to vary depending on the type of immunity investigated. Natural immunity is considered more likely to be upregulated than specific immunity, which, with the apparent exception of slgA, appears to be downregulated after exposure to acute stress (Segerstrom & Miller, 2004). The immune system receives messages from the CNS via neuronal and hormonal signals, primarily the SAM and the HPA respectively. The glucocorticoids are the key end-point messengers at the immune cells and are able to stimulate lymphocyte
activity. Thus the SAM and HPA axes are considered to be the key components of the nervous system involved in the influence of psychosocial factors on the immune system (Lutgendorf & Costanzo, 2003). The immune system in turn, communicates with the CNS through cytokine release, providing a feedback loop regarding immune activity (Webster, et al., 2002).

Studies involving more naturalistic brief stressors, such as students undergoing examination stress, have shown that even in relatively young and healthy individuals there is evidence of slower wound healing (Marucha, Kiecolt-Glaser, & Favagehi, 1998), decreased natural killer (NK) cell activity and poorer antibody response to vaccination (Kiecolt-Glaser, 1999; Kiecolt-Glaser, et al., 1984) at such times. Thus, even relatively routine events can have observable immune consequences. Importantly, age has been observed to play a role in the size of immune system changes in individuals exposed to brief naturalistic events. Studies using older samples report greater reductions in cytokine activity following brief stressful events (Segerstrom & Miller, 2004).

Investigation of the experience of chronic stressors, such as long-term unemployment and dementia caregiving, have shown associations with disturbed regulation of endocrine and immune function, including impaired antibody formation and wound healing (Kiecolt-Glaser, McGuire, Glaser, et al., 2002; Moriguchi-Jeckel, et al., 2010). Despite early predictions of likely immune adaptation to chronic stressors with time (Herbert & Cohen, 1993) research indicates chronic stress is associated with ongoing immune impairment (McEwen, 2000a). A review of evidence from numerous studies of the immune effects of chronic stress concluded that the consequences of prolonged stress involve immune system suppression across almost all immune parameters, with both natural and specific immunity as well as cellular and humoral components effected (Segerstrom & Miller, 2004). Nevertheless, caregiving appears to be associated with varied immune effects, as exemplified by observations of cell-mediated immunity without comparable changes in humoral immune
measures (Wong, et al., 2012). It could be that chronic stress further impairs immune reactivity to acute stress. Indeed, natural killer (NK) cell activity has been found to be significantly reduced in chronically stressed males and this effect extended beyond cessation of the stressor (Pike, et al., 1997). Furthermore, dementia carers do not show evidence of immune adaptation but rather exhibit decreasing immunity over time (Lutgendorf & Costanzo, 2003). However, as previously noted, this may be the result of the interaction between the immune effects of chronic stress and those associated with ageing.

Studies have shown that negative mood, perceived stress and anxiety can impair antibody response to vaccination. This effect appears to be most evident for vaccinations such as those for influenza, and in situations of prolonged, chronic stress (Wong, et al., 2012). This latter point would appear to indicate that chronic stressors are implicated more in inferior maintenance of immune functioning than in impaired initiation of an immune response (Burns, Carroll, Ring, & Drayson, 2003). In a review of the role of cytokines in psychological stress, Kim and Maes (2003, p.148) conclude that these ‘soluble mediators’ of the stress response have widespread physiological effects that are likely to be clinically relevant. Prolonged stress, in the form of exam stress, childhood trauma and caregiver stress, has been found to change the balance toward release of proinflammatory cytokines (Miller, Chen, & Parker, 2011; Rohleder, et al., 2009). This tendency is considered to underpin many neurological and psychiatric symptoms as well as neuroimmune and neuroinflammatory responses (Miller, et al., 2011). Indeed, large increases in inflammatory markers have been observed over a 12 month period among cancer carers, with a concurrent decline in natural anti-inflammatory activity (Rohleder, et al., 2009). Psychological stress-induced cytokine changes have also been implicated in serotonin depletion and its sequelae. Thus, the effect of chronic stress on cytokine activity is seen to differ markedly from the experience of acute stress where upregulation of activity is the more likely outcome (Kim & Maes, 2003; Tagliari, et al., 2011).
1.4.4 Salivary IgA and Stress

In an early study of a brief naturalistic stressor, Kiecolt-Glaser et al. (1984) failed to find a relationship between exam stress and salivary IgA levels, although they did find increased plasma IgA in subjects taking final exams. More recently, however, examination stress has been found to produce long-term changes in sIgA levels. Medical students undergoing major exams were found to have lower sIgA concentrations than those not exposed to exam stress, both prior to the exam and afterward. Two weeks after the examination, there were still significant differences in sIgA between those who undertook the exam and those who did not (Deinzer, et al., 2000). This effect, however, was not found to be related to self-reported stress levels. Nevertheless, salivary IgA has been found to be negatively correlated with perceived work stress among nurses (Ng, et al., 1999). Additionally, salivary IgA has been used as a biomarker of stress resulting from deprivations associated with an Australian Defence Force survival course. Salivary IgA was deemed to be a simple yet useful indicator of the severity of stress due to a range of conditions, including fatigue, negative emotions and physical strain (Carins & Booth, 2001; Pacque, Booth, & Dwyer, 2002). In a study of the health impacts of examination stress, Volkmann and Weekees (2006) found that basal sIgA predicted vulnerability to upper respiratory tract infections though reactive sIgA levels did not. While some stressful tasks appear to very briefly increase sIgA levels (Benham, Nash, & Baldwin, 2009; Fan, et al., 2009), it is generally acknowledged that prolonged stress is associated with reduced sIgA (Segerstrom & Miller, 2004; Winzer, et al., 1999). Indeed, older caregivers and carers who experienced greater burden associated with their role have been found to have lower levels of sIgA (Gallagher, et al., 2008).
1.4.5 Stress and Health

Despite strong evidence of the effects of stress on the immune system, the association between psychosocial stressors, immune changes and demonstrated health effects remains somewhat tenuous (Lutgendorf & Costanzo, 2003; Mathews & Gallo, 2011). Sizeable knowledge gaps remain regarding the possible pathways from psychological states to observable health changes (Segerstrom & Miller, 2004; Segerstrom & O'Connor, 2012). Despite popular beliefs regarding the influence of stress, it has been argued that analyses often place unrealistic emphasis on the likely impact of stress on objective health outcomes (Lazarus, 1999). The reasons for this are claimed to relate to the problem of defining and measuring the nebulous concept that is health; the fact that health problems usually develop over considerable periods of time; that there are other highly influential variables, such as genetic vulnerabilities, likely to be at play; and that such other variables are likely to account for very large proportions of health outcomes (Lazarus, 1999). Nevertheless, there is growing recognition of a relationship between psychosocial stress and physical health with increasing scientific support for the long-held lay belief that psychological stress can lead to disease (Burns, et al., 2003; Kiecolt-Glaser, 1999; Kiecolt-Glaser, McGuire, Robles, et al., 2002; McEwen & Gianaros, 2010). As discussed earlier, research evidence is mounting regarding the relationship between the experience of stress and a range of immune parameters. However, the mechanism of action linking immunological changes to physical health outcomes is still not well understood (Hansen, Hogh, & Mikkelsen, 2012; Kiecolt-Glaser, McGuire, Glaser, et al., 2002; Segerstrom & Miller, 2004).

The research evidence appears to be strongest in relation to upper respiratory tract infection, URTI. Psychosocial stressors, in the form of stressful life events and daily hassles, have been found to increase the risk of URTI (Turner Cobb & Steptoe, 1996). Additionally, higher levels of self-reported stress have also been shown to be associated with higher IL-
6 concentrations and with objective and subjective measures of symptomology following exposure to an influenza virus (Cohen, Doyle, & Skoner, 1999). Moreover, while exercise-induced suppression of sIgA levels was not found to be related to URTI in athletes (Novas, Rowbottom, & Jenkins, 2003), a study of examination stress in young adults found that baseline levels of sIgA were predictive of upper respiratory tract infection (Volkmann & Weekes, 2006). However, only a limited number of studies have examined the effects of prolonged stress on health (Kudielka & Wust, 2010; Lupien, et al., 2009). It has been proposed that a research focus on discrete events instead of chronic stressors has underestimated the influence of stress in health outcomes (Mathews & Gallo, 2011; Wheaton, 1997).

Nevertheless, there is a growing body of evidence regarding the role of stress in the onset and progress of many diseases, particularly those involving depressive symptoms as well as the cardiovascular and immune systems (Esch, et al., 2002; Kashani, Eliasson, & Vernalis, 2012; McEwen & Gianaros, 2010). Stress is considered to impact on health through altering the functioning of such systems (Volkmann & Weekes, 2006). Indeed, in a notable experiment on mice subjected to chronic social stress, cardiac responses which appeared to habituate over several days were nevertheless associated with permanent physical damage. Despite normalization of initial cardiac rhythm disturbances, permanent structural changes in the heart tissue were noted after 15 days of social stress (Costoli, et al., 2004). Recent findings of links between stress and cardiovascular disease support predictions of enduring physical effects in the face of continued stress (Kashani, et al., 2012). Yet, cardiac effects may not exhibit linear relationships with the experience of stress (Chatkoff, et al., 2010). For example, it has been suggested that health gradients at the lower end of the socioeconomic scale may reflect the cumulative load due to efforts to cope with negative life events given limited resources (Mathews & Gallo, 2011; McEwen & Gianaros, 2010; McEwen & Seeman, 1999) and that immune suppression associated with depression may be
linked to HPA-dysregulation (Detanico, et al., 2009; Groer & Morgan, 2007). HPA dysregulation as a possible mechanism of caregiving stress effects has begun to be investigated, but with little clarity to date (Lovell, et al., 2012; Moriguchi-Jeckel, et al., 2010; Rohleder, et al., 2009).

1.5 Subjective Wellbeing and Stress

1.5.1 Conceptualising Wellbeing

The term wellbeing is often used interchangeably with happiness and life satisfaction (Diener & Diener, 1996; Lyubomirsky, 2001; Ryff, 1989; Watson, 2000). Wellbeing is recognized as an essentially subjective state (Watson, 2000). Indeed, the term subjective wellbeing (SWB) is used to describe an enduring sense of feeling positive and enthusiastic about one’s self and one’s life (Cummins, Lau, & Stokes, 2004; Manderscheid, et al., 2010; Simsek, 2009). An increased research focus on wellbeing has been attributed to recent positive psychology approaches (Diener, 2008; Diener, Suh, Lucas, & Smith, 1999; Manderscheid, et al., 2010; Seligman, Steen, Park, & Peterson, 2005) with subjective wellbeing now considered to be an essential component of any thorough consideration of health (Diener, Sapyta, & Suh, 1998; Lazarus, 1999; Manderscheid, et al., 2010; Norrish & Vella-Brodrick, 2008; World Health Organization, 2007). It is described as comprising both an affective component, relating to felt happiness, and a cognitive component, involving assessment of life satisfaction (Cummins, Gullone, & Lau, 2002; Davern, Cummins, & Stokes, 2007; Lyubomirsky, 2001). Nevertheless, SWB is considered to be a broad, overarching construct which, though underpinned by emotional responses and domain-specific assessments, involves a global evaluation of life (Diener, et al., 1998; Diener, et al., 1999; Schimmack, 2008).

It should be noted that while SWB is considered to represent a combination of both satisfaction with life and felt happiness, the SWB literature nevertheless encompasses divergent perspectives and much potential ambiguity (Norrish & Vella-Brodrick, 2008). Two approaches to
positive emotional states have been identified: eudaimonic and hedonic (Ryff, Singer, & Dienberg-Love, 2004). From the eudaimonic perspective, wellbeing is associated with personal development, connection with values and a sense of purpose in life. From an hedonic viewpoint, wellbeing is linked to feelings of happiness and contentment (Norrish & Vella-Brodrick, 2008; Ryff, et al., 2004). For populations such as caregivers, both these approaches are likely to have relevance and the contribution of these different components of wellbeing may be associated with unique wellbeing effects. For instance, it has been suggested that eudaimonic wellbeing may have stronger links to physiological markers (Ryff, et al., 2004).

1.5.2 Stress and Subjective Wellbeing

As previously noted, the perception of a threat to personal wellbeing is, in fact, at the core of the definition of stress. Indeed, according to Lazarus and Folkman’s (1984) original transactional model, the key markers of adaptation to stress are social functioning, somatic health and wellbeing (which they termed ‘morale’). The relatively infrequent use of subjective wellbeing as an outcome measure in stress research is speculated to result from definitional difficulties around a relatively elusive topic (Diener, 2000; Ryff, 1989) as well as a psychological tradition of focusing on negative outcomes (Diener, et al., 1999; Myers & Diener, 1995; Seligman, et al., 2005). Nevertheless, SWB, as a key quality of life measure (Cloninger, 2006; Diener, et al., 1998; Graham, 2008; Norrish & Vella-Brodrick, 2008; Ryff & Singer, 1998), would appear to be a fundamental indicator of successful navigation of life challenges. Indeed, some recent definitions of wellness now include “the ability to cope effectively with stress” (Manderscheid, et al., 2010, p.1). An ever increasing interest in wellbeing outcomes (Diener, 2008) and growing evidence that the experience of stress may be associated with reduced quality of life (Burchell, 2011; Matheny, et al., 2008; Peeters, et al., 2008; Schneiderman, et al., 2005) lends weight to a central tenet of this thesis:
that examination of SWB and the sense that one’s wellbeing is threatened can provide key insights within a biopsychosocial approach.

Interestingly, the affective state ‘stressed’ was one of six key affects found to be predictive of SWB and the only one with negative valence (Davern, et al., 2007). According to this affective model, SWB is a higher order concept that represents a neurophysiological state or “Core Affect”, (Davern, et al., 2007, p.435). Cummins and his colleague (2010; Tomyn & Cummins, 2011) have extended this concept further to describe an underlying positive mood state the stability, or homeostasis, of which will be defended, as homestatically protected mood (HPM). It is of interest that previous studies of positive affect in the context of stress have already indicated that it can have important positive adaptational consequences (Folkman, 1997; Folkman & Moskowitz, 2000; Steptoe, Wardle, & Marmot, 2005). Moreover, evidence is mounting that higher reported subjective wellbeing is predictive of improved physical health outcomes (Diener & Chan, 2011; Howell, Kern, & Lyubomirsky, 2007). The effect of SWB may involve improved immune function and stress buffering effects (Howell, et al., 2007).

1.5.3 Subjective Wellbeing Homeostasis

SWB is generally considered to be an extremely stable individual trait which, for most individuals and indeed populations, lies in the upper range, indicative of satisfaction (Diener, Lucas, & Scollon, 2006; Kitchen & Muhajarine, 2008). That is, for most individuals SWB is assessed as positive. In Western populations, on a 0 to 100 scale, the distribution of life satisfaction is negatively skewed with a range of 40 to 100, a mean of 75 and standard deviation of 2.5 (Cummins, 2003). Moreover, such subjective evaluations do not correlate well with objective measurements of quality of life unless the objective circumstances are extremely poor (Cummins, 2000). This combination of evidence is taken as support for the notion that a homeostatic mechanism modulates SWB (Cummins, 2000, 2003, 2010).
Indeed, in addition to maintaining physiological parameters within a narrow homeostatic range, it has been suggested that it is also adaptive to maintain a homeostatic level of SWB (Cummins, 2005b). The key components of this proposed mechanism of SWB homeostasis include 1) unconscious adaptation or habituation processes, 2) awareness of met and unmet needs, and 3) cognitive buffers (Cummins, et al., 2002). This latter element, involving cognitive devices to promote SWB, is considered to be critical to a stable positive evaluation (Cummins, 2000, 2003, 2005a; Diener, 2008; Diener, et al., 2006; Lyubomirsky, 2001) through providing a means of sustaining a sense of global SWB in the face of challenge (Cummins, 2005b). Thus SWB in the positive range appears to be a highly adaptive and advantageous state (Diener & Chan, 2011; Diener, et al., 2006; Xu & Roberts, 2010).

Thus, while the experience of stress may influence SWB (Matheny, et al., 2008) particularly with lengthy exposure (Schneiderman, et al., 2005), SWB is considered to remain relatively stable up to an individual critical stress threshold (Cummins, 2000, 2005a). Beyond this point, Cummins’ (2010) model of SWB homeostasis predicts that homeostatic efforts will be exhausted and SWB will fail. In particular, global SWB scores below the mid-point (that is, scores in the dissatisfied range) are considered to indicate homeostatic defeat and subsequent risk of depression (Cummins, 2001, 2005a, 2005b, 2010).

### 1.5.4 Carers and Subjective Wellbeing

Caregivers are seen as facilitating the wellbeing of the recipients of their care (Brown, 2007; Cummins, 2005a). Indeed, the carer role is considered to involve ongoing assistance toward maintenance of optimal functioning across most life domains and to be centred around a belief that the care recipient has the right to the best possible quality of life and to achieve their maximum potential (Vitaliano, et al., 2003). However, as noted previously, while quality of life for the care recipient is likely to be higher within informal settings, informal carers themselves often do not
fare well. SWB among informal caregivers has received relatively little attention (Cummins, 2001; Cummins, et al., 2007; Kim, et al., 2012; Llacer, Zunzunegui, Gutierrez-Cuadra, Beland, & Zarit, 2002). What evidence there is, indicates that many informal carers have extremely low levels of SWB (Cummins, 2001; Cummins, et al., 2007; Pinquart & Sorensen, 2003). Moreover, it appears that, when extensive care is required, the type of disability of the care-recipient is relatively unimportant to carer SWB (Cummins, 2001; Raina, et al., 2005). Importantly, SWB has been found to be inversely related to the number of hours spent providing care and appears to be worse in primary carers (Cummins, et al., 2007). Indications that higher SWB is likely to be associated with greater sleep length (Birchler-Pedross, et al., 2009; Cummins, et al., 2012; Yokoyama, et al., 2008), seem particularly germane to the caregiving experience. Indeed, in his review of eight studies of carer wellbeing, Cummins (2001) noted that all caregiver means fell outside the normal range of the comparison non-caregivers. Indeed, the overall average caregiver score was three standard deviations below the lowest non-caregiver mean.

1.5.5 Wellbeing and Physiology

As discussed earlier, negative psychological states have been shown to be associated with changes in physiological markers (Kudielka, Bellingrath, & Hellhammer, 2006; McEwen, 2001; Ryff & Singer, 2000a). Moreover, there is growing evidence that positive psychological states are linked to “health-relevant biological processes”, independent of negative states (Steptoe, et al., 2005, p.6508). Happiness (as an aggregate of positive affect reported over one day) was found to be inversely related to 24-hour cortisol output in healthy middle-aged adults. Significantly lower cortisol outputs were linked to greater reported happiness. As Steptoe et al. suggest, such a large difference over an extended period seems likely to have the potential for long-term health advantages among happier individuals and corresponding disadvantages for those at the other extreme. Mindfulness-based therapy has been associated with improved
diurnal cortisol profiles alongside enhanced ‘meaning in life’ among breast cancer survivors (Hsiao, et al., 2012) and may assist end-stage cancer patients and their carers to improve their quality of life (Lengacher, et al., 2012).

In their review of the health effects of positive psychological states, Pressman and Cohen (2005) also concluded that trait positive affect was linked to lower levels of cortisol. Reviews of studies of the relationship between positive psychological states and mortality have also concluded that positive wellbeing is adaptive and an important predictor of health and longevity (Chida & Steptoe, 2008; Diener & Chan, 2011; Mathew & Paulose, 2011; Xu & Roberts, 2010). However, it should be noted that some studies report no relationship between self-reported quality of life and endocrine markers (Provinciali, et al., 2004). Yet others have concluded that factors such as personal growth and engagement were predictive of physiological changes such as lower basal cortisol levels, but that happiness and satisfaction were not (Ryff, et al., 2004).

Of particular interest to the current study, is the notion of SWB as the subjective experience of a biological state (Davern, et al., 2007). From this perspective, underlying physiology may equate to a sense of personal wellbeing (Davern, et al., 2007). The omission of SWB from many past studies of neuroendocrine effects appears to have been a serious oversight (Mathew & Paulose, 2011). The notion of a homeostatically controlled SWB also appears to be closely aligned with Murray’s (2007) ‘biobehavioural system of engagement’. From an engagement readiness viewpoint, positive mood is conducive to interaction with the environment (Murray, 2007). Indeed, positive affect follows a regular daily pattern that is considered to support responses to predictable periodic challenges, thus allowing ‘predictive homeostasis’ (Murray, Allen, & Trinder, 2002, p. 1153). Such synchronisation of responses points to links with the circadian system.
1.6 Circadian Rhythmicity and Stress

1.6.1 The Circadian Clock

Circadian rhythms refer to endogenously generated rhythmic changes in behaviour, physiology and biochemistry with a period of approximately 24 hours (Harmer, Panda, & Kay, 2001, p.14). These biological rhythms are ubiquitous in most organisms and bodily processes (Landgraf, Shostak, & Oster, 2012; Refinetti, 2006; Vitaterna, Takahashi, & Turek, 2001) and take their name from the Latin circa, meaning ‘about’, and dies, ‘day’ (Cardinali, 2000). Such rhythmicity allows for anticipation of, as well as adaptation to, regular, predictable environmental challenges (Holzberg & Albrecht, 2003). Typically, such challenges are associated with the day/night cycle but also include seasonal accommodations (Wehr, 1991). The evolution of circadian cycles has allowed for co-ordination and regulation of many behaviours with the necessary internal biochemical environment to support them (Czeisler, et al., 1999; Moore, 2007; Vitaterna, et al., 2001). Indeed, “the synchrony of an organism with both its external and internal environment is critical to the organism’s wellbeing and survival” (Vitaterna, et al., 2001, p.85).

While circadian rhythms clearly evolved in response to external environmental conditions, they are endogenously generated and run freely in the absence of external input (Duncan, 1996; Refinetti, 2006). In the mammalian circadian system the central pacemaker, which generates the oscillation, is the suprachiasmatic nucleus, SCN, of the hypothalamus (Duncan, 1996; Refinetti, 2006) with the eyes and the pineal gland also key components (Stehle, von Gall, & Korf, 2003). In an environment free of time cues, humans have been found to exhibit rhythmicity of core body temperature, melatonin and cortisol with a period of 24.18 hours, timing which does not change significantly with age (Czeisler, et al., 1999). Within the SCN, clock genes regulate the transcription of important metabolic pathways using feedback loops which act as a time mechanism (Harmer,
et al., 2001; Holzberg & Albrecht, 2003). Circadian outputs from the SCN direct the activity of the endocrine system and behaviours that are essential in physiological control (Hastings, O'Neill, & Maywood, 2007; Karatsoreos & Silver, 2007). Indeed, neuro-anatomical evidence suggests that the SCN plays a critical modulating role with respect to balancing sympathetic and parasympathetic inputs from the hypothalamus to the periphery, particularly in relation to metabolism (Kalsbeek, et al., 2007). Such nervous system balance underpins health and wellbeing (Kalsbeek, et al., 2007). Circadian rhythms have been detected in most body tissues and these are synchronised by the SCN (Moore, 2007). Thus, secondary clocks, driven by the SCN, regulate sleep patterns, body temperature, hormone release and other peripheral functions (Duncan, 1996; Hastings, et al., 2007). In turn, hormonal feedback completes the loop by influencing the functioning of the SCN (Karatsoreos & Silver, 2007).

1.6.2 Zeitgebers – Temporal Synchronizers

Although circadian rhythmicity is primarily under endogenous control, the central pacemaker is also influenced by external cues, or zeitgebers, which help reset the 24 hour cycle to local environmental conditions (McEachron & Donnelly, 2012; Sharma & Chandrashekaran, 2005; Wirz-Justice, 2003). The primary pathway is photic and involves the entrainment of the pacemaker via the retino-hypothalamic tract with projections from the retina terminating in the core of the SCN (Moore, 1996). This pathway is particularly sensitive to changes in daylength due to seasonal differences or movement across time zones (Sharma & Chandrashekaran, 2005). However, other non-photic influences on the SCN include endocrine activity, behaviour and sleep (Duncan, 1996; Rosenwasser, 2001). Indeed, external factors such as work or social schedules that do not follow the normal light-dark cycle have been shown to interact with endogenous rhythmicity (Paine, Gander, & Travier, 2006) resulting in what has been described as ‘social jetlag’ (Wittman, Dinich, Merrow, & Roenneberg, 2006). Furthermore, social routines that are out of
sync with circadian body temperature rhythms have been linked to reports of impaired psychological and physical health (Giebel, Wirtz, & Nachreiner, 2008).

### 1.6.3 Melatonin, Temperature and Sleep

As a key component of the circadian system, the singular pineal gland of the brain has been called “the regulator of the regulators” (Pierpaoli & Maestroni, 1987, p.356). Directly under control of the SCN, it releases the neurohormone melatonin into the bloodstream in the dark part of the light-dark cycle (Fischer, Smolnick, Herms, Born, & Fehm, 2003; Graham & Armstrong, 1995; Norman, 2009). It is melatonin that regulates and underpins circadian rhythmicity (Arendt, 2005; Cardinali & Golombeck, 2009; Dubocovich, 2007) and also modulates the amplitude of other daily rhythms (Dubocovich, 2007). Melatonin is considered likely to influence every organ system of the body (Reiter, 1991; Tan, et al., 2010) with particular influence on immunity, hormone production, reproduction and sleep (Dubocovich, 2007; Guénelé, et al., 2011; Norman, 2009; Srinivasan, Cardinali, Pandi-Perumal, & Brown, 2011; Tosini, Ye, & Iuvone, 2012; van Maanen, Meijer, Smits, & Oort, 2011).

Incredibly, the pineal gland was considered to be irrelevant to human physiology by researchers prior to the 1950s (Graham & Armstrong, 1995). In the evening hours, melatonin production gradually increases, peaking around midnight and then declining towards dawn (Fischer, et al., 2003). Its synthesis is thus “encoding for the duration of darkness” (Stehle, et al., 2003, p.383) and, under normal conditions, the endogenous melatonin rhythm complements the typical rest-activity cycle (Cajochen, Krauchi, & Wirz-Justice, 2003). Melatonin production is controlled by SCN projections to the areas of the hypothalamus linked to autonomic control and the inhibition of the arousal system and facilitation of sleep (Moore, 2007). The circadian rhythm of melatonin secretion is inversely coupled with that of core body temperature, increasing as temperature is decreasing (Cagnacci, Elliott, & Yen, 1992). Thus, core
body temperature is also considered to be an excellent and easily measured indicator of circadian rhythmicity (Brown, Choe, Luithardt, & Czeisler, 2000; Cagnacci, et al., 1992; Refinetti, 2006).

Melatonin is considered to have anti-stress (Baxi, Singh, Vachhrajani, & Ramachandran, 2010; Brotto, Gorzalka, & LaMarre, 2001; Kiarostami, Samini, & Ghazi-Khansari, 2006; Reiter, 1991; Reiter, et al., 2007), anti-oxidant (Macchi & Bruce, 2004; Tan, et al., 2010) and anti-depressant (Crupi, et al., 2010; Detanico, et al., 2009; Srinivasan, Cardinali, Pandi-Perumal, et al., 2011) properties. It has also been proposed to be an immunoregulator, which may oppose the immunosuppressive effect of stress (Cikler, Ercan, Cetinel, Contuk, & Sener, 2005; Pierpaoli & Maestroni, 1987). Melatonin is also considered likely to influence disease risk more broadly (Arendt, 2005; Cardinali, Cano, Jiménez-Ortega, & Esquifino, 2011) and may play an important stress-protection role in chronic stress (Persengiev, Kanchev, & Vezenkova, 1991; van Maanen, et al., 2011). It appears that melatonin patterns may also influence SWB or, alternatively, may be impacted by such states.

1.6.4 Behavioural Rhythms and Mood

While rest and wakefulness is perhaps the most readily recognisable circadian pattern (Cardinali, 2000; Dedert, et al., 2012), many other behaviours, such as alertness (Folkard, Hume, Minors, Waterhouse, & Watson, 1985), positive mood (Porto, Duarte, & Menna-Barreto, 2006; Watson, 2000), memory and attention (Schmidt, Collette, Cajochen, & Peigneux, 2007) have been observed to follow a circadian cycle. The daily cycle observed in positive affect, with a pattern mirroring that of core body temperature with a peak around the middle of the day (Murray, Allen, & Trinder, 2002), is of particular relevance to the current study. This pattern has been described as “the subjective component of an adaptive biobehavioural system of engagement which takes predictive information from the endogenous circadian oscillator” (Murray, 2007, p.51). Negative
mood, on the other hand, does not appear to display a circadian rhythm, a feature consistent with its role in reaction to unpredictable threats rather than cyclic challenges (Murray, 2007).

1.6.5 Diurnal Preferences

It should be acknowledged that individuals differ with respect to their circadian patterns and, subsequently, their functioning at different times of day (Horne & Ostberg, 1976; Roenneberg, et al., 2007; Roenneberg, Wirz-Justice, & Merrow, 2003). Terms such as ‘morning lark’ and ‘night owl’ are clearly commonly used references to such differences. Within the research literature, Morning and Evening typologies have been identified according to preferences for the timing of sleep and activity (Horne & Ostberg, 1976; Paine, et al., 2006). Morning types, as the name suggests, have a natural tendency to rise earlier (Sukegawa, et al., 2009) and to reach peaks of alertness and performance earlier in the day compared to Evening types (Natale & Cicogna, 1996). Intermediate types which display circadian patterns in between these extremes have also been described (Horne & Ostberg, 1976; Natale & Cicogna, 1996) and, moreover, typically represent the largest proportion of any population (Natale & Cicogna, 2002; Natale & Danesi, 2002; Paine, et al., 2006; Sukegawa, et al., 2009). Despite a tradition of categorization, it has been convincingly argued that morningness-eveningness can also be viewed as varying along a continuum (Caci, et al., 2005; Caci, Nadalet, Staccini, Myquiel, & Boyer, 2000; Mecacci & Rocchetti, 1998; Natale & Cicogna, 2002; Roberts & Kylkonen, 1999) and that this individual difference measure reflects stable characteristics that relate to variability in the functioning of the endogenous central circadian clock (Cavallera & Giudici, 2008). Circadian preferences have been shown to mirror other observable differences within physiological, psychological and behavioural variables such as core body temperature, mood and task performance (Cavallera & Giudici, 2008; Schmidt, et al., 2007; Smith, Reilly, & Midkiff, 1989; Wittman, Paulus, & Roenneberg, 2010), although evidence is mixed
regarding cortisol patterns (Dockray & Steptoe, 2011; Randler & Schaal, 2010; Toda, Kawai, Takeo, Rokutan, & Morimoto, 2012). An increasing tendency toward morning preference has also been observed with increasing age (Carrier, Monk, Buysse, & Kupfer, 1997; Kim, et al., 2008), and this trend is attributed to age-related changes in the central circadian mechanism (Carrier, et al., 1997).

1.6.6 Circadian Dysregulation

Circadian rhythm disruption involves altered temporal programming and subsequent physiological as well as behavioural changes (Holzberg & Albrecht, 2003). A number of diagnoses of psychopathology, including that of unipolar and bipolar depression, panic disorder, anorexia and schizophrenia, are characterized by circadian rhythm disturbances (Duncan, 1996; Germain & Kupfer, 2008; Kennaway, 2010; McClung, 2007; Stones, Groome, Perry, Hucklebridge, & Evans, 1999). Distinct daily patterns of sleep, mood, melatonin secretion and cortisol release have been observed within different patient groups (Duncan, 1996; Srinivasan, Cardinali, Srinivasan, et al., 2011). The administration of antidepressant medications can remediate circadian disturbances and appears to lower nocturnal core body temperature and improve sleep in some individuals (Duncan, 1996; McClung, 2007). Antidepressants may act directly on the SCN itself (Kennaway, 2010; McClung, 2007; Rosenwasser, 2001) and the resynchronization of circadian rhythms is a recent focus of pharmacological treatments (Gorwood, 2010; Hickie & Rogers, 2011).

Depression has also been described in terms of a reduction in the circadian component of the diurnal variation of positive mood (Murray, 2007). That is, the pattern of positive mood variation in depressed individuals, such that mood is low in the morning and improves throughout the day, is proposed to be related to circadian physiology. Even within a non-clinical sample individuals with higher depression scores have been found to have reduced amplitude in daily positive mood variation compared to those with lower depression scores (Murray, 2007). In this
sense, low positive mood may be linked to a weakening of the normal circadian pattern (Murray, 2007). Such a process has been described in bereaved individuals, where decreased positive affect was associated with changes in diurnal cortisol (Ong, Fuller-Rowell, Bonanno, & Almeida, 2011). As stated earlier, positive mood may reflect an underlying biological state of preparedness to engage with the world. Such a view supports the notion that SWB may reflect circadian synchrony.

Other factors have also been implicated in circadian disturbance including alcohol use, social schedules, and psychosocial stress (Wittman, et al., 2010). Alcohol use or withdrawal can also effect circadian rhythms of a range of physiological, endocrine and behavioural variables (Devaney, Graham, & Greeley, 2003; Rosenwasser, 2001). The chronobiological effects of alcohol have been likened to those induced by antidepressant medications and, thus, have been speculated to be serotonin-mediated (Rosenwasser, 2001). Work schedules that are out of sync with normal circadian periodicity have been found to be predictive of poorer health and wellbeing outcomes (Giebel, et al., 2008; Hastings, et al., 2007; Klerman, 2005; Pati, Chandrawanshi, & Reinberg, 2001; Reinberg, Ashkenazi, & Smolensky, 2007; Vogel, Braungardt, Meyer, & Schneider, 2012). Additionally, circadian dysregulation has been found to accompany disease states, such as diabetes, cardiovascular problems (Klerman, 2005) and immune dysfunction (Sephton & Spiegel, 2003). Indeed, immune and other changes associated with disruption to endogenous rhythms such as the sleep-wake cycle, are suggested to be an important area for investigation in cancer risk (Bovbjerg, 2003; Dedert, et al., 2012; Sephton, Sapolsky, Kraemer, & Spiegel, 2000). Indeed, disrupted circadian rhythmicity due to shift work is proposed to be as a potential carcinogen (Erren & Reiter, 2009) though this continues to be debated (Vogel, et al., 2012; Wang, Armstrong, Cairns, Key, & Travis, 2011).

Chronic stress is proposed to be linked to ‘homeostatic resetting’ (Goldstein, 2003, p.73) and possible SCN changes (Jiang, et al., 2011).
Indeed, circadian rhythmicity has been described as an indicator of self-regulatory competence in the face of ongoing stress (Sephton & Spiegel, 2003) and rhythm abnormalities are proposed to predict greater vulnerability to stress and its sequelae (Lupien, et al., 2009). Animal studies would appear to support these views (Kate, et al., 2012; Lutterschmidt & Mason, 2010; Nikaido, et al., 2010). Nevertheless, animal studies indicate that coping behaviours can also be associated with circadian changes (Stewart, Rosenwasser, Hauser, Volpicelli, & Adler, 1990). While shock-stress was shown to lengthen the period of rat activity rhythms, changes in circadian periodicity have also been observed after successful shock-escape behaviours. Thus altered rhythmicity may also occur with successful adaptation to stress (Stewart, et al., 1990). It appears that the role of circadian rhythmicity in chronic stress outcomes is yet to be clearly elucidated.

1.6.7 Circadian Cortisol

Cortisol and epinephrine, as well as responding to immediate environmental cues, exhibit their own rhythmic fluctuations of basal levels (McEwen & Seeman, 1999). Indeed, the activity of the HPA axis is determined by circadian influences as well as stress reactivity (Cardinali, 2000; Sapolsky, 1994; Toates, 1995) yet cortisol is considered to be a stable circadian marker (Selmaoui & Touitou, 2003). Typically, basal cortisol levels peak in the morning and decline throughout the day (de Vugt, et al., 2005; Fries, Dettenborn, & Kirschbaum, 2009; Tsigos & Chrousos, 2002) with the characteristic waking peak occurring approximately 30 mins after waking (Hucklebridge, Clow, & Evans, 1998; O'Connor, et al., 2009; Pruessnner, et al., 1997; Williams, Magid, & Steptoe, 2005). A pattern of high morning and low evening cortisol levels is considered to signify healthy HPA axis functioning (Rosmond, Dallman, & Bjorntorp, 1998) and provide a vital foundation for the maintenance of homeostasis (Fries, et al., 2009; Tsigos & Chrousos, 2002). It should be
noted, however, that around 10% of individuals could lack this classic diurnal pattern (Stone, Schwartz, & Smyth, 2001).

Disturbances in cortisol rhythmicity are considered to provide a reliable indicator of stress-related changes in endocrine functioning (Goldman-Mellor, Hamer, & Steptoe, 2012; Gustafsson, Janlert, Virtanen, & Hammarstrom, 2012; O’Connor, et al., 2009; Volkmann & Weekes, 2006; Weekes, et al., 2008), with the awakening cortisol rise commonly used to compare stress levels (Gustafsson, et al., 2012; Hellhammer, et al., 2007; Pruessner, et al., 1997; Schulz, Kirschbaum, Prubner, & Hellhammer, 1998). Waking cortisol levels appear to be related to both anticipatory stress for the oncoming day in addition to endogenous circadian rises (Wilhelm, Born, Kudielka, Schlotz, & Wust, 2007). It has also been linked to the stressfulness of the previous day (Barker, et al., 2012). For instance, experience of prolonged temporary employment status has been linked to a higher morning cortisol rise off a low morning baseline (Gustafsson, et al., 2012). Indeed, a comprehensive review concluded that the weight of evidence supports the view that higher perceived stress is associated with higher waking cortisol and that this link is largely due to anticipation of the demands of the day ahead (Fries, et al., 2009). However, the same review reported evidence of both increased and decreased morning levels in cases of chronic stress (Fries, et al., 2009). Thus, it appears that while waking cortisol levels can be strongly influenced by situational variables (Hellhammer, et al., 2007), broader psychosocial factors are also critical to the direction of the association between stress and morning cortisol levels (Chida & Steptoe, 2009). Higher perceived stress has been linked to higher waking cortisol in teachers (Izawa, et al., 2012; Pruessner, et al., 1997), but reduced morning cortisol was associated with the post-stress period (Izawa, et al., 2012) as well as with burnout (Izawa, et al., 2012; Pruessner, et al., 1999) in the same respective samples. However, low waking cortisol levels have also been reported in individuals with high perceived stress levels (Edwards, Hucklebridge, Glow, & Evans, 2003; O’Connor, et al., 2009).
Morning cortisol levels may also be related to stress-induced lifestyle choices (O'Connor, et al., 2009).

Caregiving, has been associated with high cortisol levels during the day (Da Roza Davis & Cowen, 2001) and on waking (de Vugt, et al., 2005). Nevertheless, others have found lower waking cortisol for carers (Barker, et al., 2012), no differences between caregivers and controls (Gonzalez-Bono, De Andres-Garcia, & Moya-Albiol, 2011; Provinciali, et al., 2004; Rohleder, et al., 2009; Vedhara, et al., 2003) or reported a lack of association between cortisol and perceived stress among carers (Schwarz & Dunphy, 2003). In general, it appears that the morning rise may be positively associated with general life stress and job stress but negatively correlated with chronic demand (Fries, et al., 2009), exhaustion, fatigue or burnout (Chida & Steptoe, 2009). Nevertheless, the relationship between morning cortisol and the experience of stress is yet to be fully understood.

The diurnal slope of the cortisol rhythm has also been proposed as a stress marker (Clow, 2004; Hellhammer, et al., 2009; Vreeburg, et al., 2009). Indeed dysregulation of the diurnal pattern in the form of extreme (high and low) morning cortisol values has been observed with chronic disadvantage due to low socioeconomic status (Li, Power, Kelly, Kirschbaum, & Hertzman, 2007) and long-term job insecurity (Gustafsson, et al., 2012). However, chronic stress is most commonly associated with decreased cortisol amplitude with both reductions in the morning zenith and elevation of the evening nadir observed (Chrousos & Gold, 1998; O'Connor, Wellisch, Stanton, Olmstead, & Irwin, 2012; Rosmond, et al., 1998). Additionally, flattened cortisol profiles have been linked to depression (Cunningham-Bussel, et al., 2009; Deuschle, et al., 1997; Gex-Fabry, et al., 2012; Souetre, et al., 1989; Van den Bergh & Van Calster, 2009), poor sleep quality (Lasikiewicz, Hendrickx, Talbot, & Dye, 2008), chronic fatigue (Crofford, et al., 2004; Di Giorgio, Hudson, Jerjes, & Cleare, 2005), vital exhaustion (Lindeberg, et al., 2008; Nicholson & van Diest, 2000), complicated grief (O'Connor, et al., 2012), post-traumatic
stress disorder (Yehuda, Golier, & Kaufman, 2005; Yehuda, Teicher, Trestman, Levengood, & Siever, 1996) and the experience of adverse life events in both childhood (Gunnar & Vazquez, 2001) and adulthood (Miller, Cohen, & Ritchey, 2002). With chronic stress, disruptions in cortisol rhythmicity are anticipated (Goldstein, 2003).

A high, flat diurnal cortisol profile is most likely to occur in situations where the chronic threat is traumatic, uncontrollable and/or physically threatening (Miller, Chen, & Zhou, 2007). Low decision-making authority has also been associated with a profile that includes high evening cortisol levels (Harris, Ursin, Murison, & Eriksen, 2007). On the other hand, exhaustion, as measured by SF-36 vitality scale responses of working adults, has been found to be associated with reduced diurnal cortisol in the form of a low flat profile (Lindeberg, et al., 2008). Indeed, HPA activity also appears to be similarly reduced in PTSD (Miller, et al., 2007) and spousal grief (Ong, et al., 2011). Whether chronic stress is associated with HPA axis hyper- or hypo- responsiveness to acutely stressful events remains unknown, with studies producing varied results (Kudielka, et al., 2009). Furthermore, glucocorticoid rhythm disruptions may lead to even greater vulnerability to stress (Lupien, et al., 2009).

Conversely, improved relationship functioning has been linked to greater cortisol rhythm amplitude (Adam & Gunnar, 2001). Additionally, greater diurnal cortisol amplitude appears to predict less activation in the limbic system during exposure to distressing stimuli (Cunningham-Bussel, et al., 2009) which would appear to indicate a protective effect with respect to stress reactivity. Indeed, vitality among nurses has been found to be positively correlated with daily cortisol declines, though unrelated to morning cortisol levels (Harris, et al., 2007). Although it should be noted that individuals who reported more positive psychological states in conjunction with fewer negative psychological states were found to have lower waking cortisol values (Evans, et al., 2007).

Interestingly, glucocorticoid (GC) rhythms have been identified as critical mediators of the output of the central circadian clock. Indeed,
glucocorticoid activity is considered to have a powerful influence on circadian functioning such that “it is not fanciful to view the SCN–adrenal–GC-axis as the body’s time standard” (Hastings, et al., 2007, p.194). Thus, while there is yet much to learn about the human circadian system, it is clear that multiple mechanisms, likely including the adrenal axes, play a role in ongoing internal synchronisation (Hastings, et al., 2007). Given the evidence regarding stress and dysregulation of cortisol rhythms, it appears likely that SWB would also be reflected in diurnal cortisol patterns.

1.6.8 HPA Dysregulation and Allostatic Load

A proposed explanation for the observed alterations in cortisol rhythmicity in the face of chronic stress, is that continued HPA activation resulting from ongoing challenge will eventually be followed by reduced responsiveness of the HPA axis and possible hypocorticolism (Gunnar & Vazquez, 2001). Thus disturbance of HPA axis regulation may be a likely consequence of prolonged exposure to stress due to prolonged HPA over-activation (Rosmond, et al., 1998). Indeed, flat profiles associated with exhaustion have been proposed as evidence of exhaustion-induced HPA axis hypoactivity (Lindeberg, et al., 2008). This explanation appears to mirror the exhaustion phase of Selye’s (1936) original stress adaptation model, though with a much longer time-frame. It has also been proposed that observations of reduced amplitude in the cortisol rhythm after chronic stress is the result of the resetting of HPA axis and/or the impairment of negative feedback loops (Chrousos & Gold, 1998). Suggested mechanisms for these include homeostatically driven changes in the sensitivity of cortisol-related receptors (Young, et al., 2004) as well as in HPA axis activity, particularly suppression of the morning cortisol surge (Chrousos & Gold, 1998; Gunnar & Vazquez, 2001; McEwen, 2001).

As mentioned earlier, allostasis involves altering homeostatically driven changes in the sensitivity of cortisol-related set-points (Goldstein, 2003; McEwen, 2000b; Ryff & Singer, 1998). Adjusting systems such as the HPA axis with a wide tolerance for change allows the maintenance of narrower homeostatic ranges in more critical parameters
such as oxygen concentrations and pH (McEwen, 2000b). However, allostatic load, as the toll due to prolonged efforts toward homeostasis, may take the form of disturbances to circadian rhythmicity (McEwen, 2000a, 2000b, 2008). While diurnal rhythmicity is generally preserved in old age, the relative amplitude tends to be dampened (van Cauter, Leproult, & Kupfer, 1996) and these age-related changes have been observed across many physiological markers, including cortisol (Duncan, 2007). However, flattened diurnal cortisol rhythms have been described as an indicator of cumulative allostatic load or, in other words, as evidence of wear and tear from long-term adaptive efforts (Abercrombie, et al., 2004; McEwen, 2000a). Thus, the dampening of cortisol rhythms found with ageing may also be consistent with the effects of a life-time of exposure to stress and subsequent erosion of HPA axis resiliency (van Cauter, et al., 1996). Thus, flattened diurnal cortisol rhythms may be an indicator of allostatic load or, in other words, evidence of wear and tear from long-term adaptive efforts (Abercrombie, et al., 2004; McEwen, 2000a).

1.6.9 Sleep, Rhythms and Stress

Sleep plays an important role in modulating and regulating many body systems, including cardiovascular and hormonal control (van Cauter, Spiegel, Tasalis, & Leproult, 2008) as well as mood and stress reactivity (Vandkerckhove & Cluydts, 2010). Thus, sleep should be an important consideration in the study of stress (Benham, 2010; Brand, Gerber, Puhse, & Holsboer-Trachsler, 2010). The circadian sleep-activity cycle is stable under controlled conditions and exhibits an endogenous period very close to 24 hours (Czeisler, et al., 1999). This pattern can also be found under everyday routine conditions if the effects of ambient light and physical activity are considered simultaneously (Kolodyazhniy, et al., 2011). As noted earlier, melatonin drives the circadian rhythm of sleep as well as other parameters such as alertness and mood and the regulation of most body systems (Arendt, 2005; Brzezinski, 1997; Dubocovich, 2007). While
the sleep-wake cycle and that of melatonin are separate, they are inevitably inter-linked (Dijk & Lockley, 2002).

It is argued that, with industrialization and modernization, human sleep patterns have altered over recent decades and that many people in western societies are now sleep deprived (Roenneberg, et al., 2003; Stephenson, Schroder, Bertschy, & Bourgin, 2012; van Cauter, et al., 2008). While brief sleep deprivation does not appear to result in changes to physiological parameters such as melatonin or cortisol rhythmicity (Redwine, Hauger, Gillin, & Irwin, 2000), examination of shiftworkers has shown that sleep that is not in sync with the day-night cycle is linked to a decreased cortisol awakening response (Griefahn & Robens, 2008). Moreover, sufficient sleep may also provide a buffer for diurnal cortisol effects (Rueggeberg, Wrosch, & Miller, 2012). Individual circadian morning or evening preferences can also lead to a mismatch between biological and social timing (Roenneberg, et al., 2007; Taillard, Phillip, & Bioulac, 1999; Wittman, et al., 2006). Such a differential has been described as ‘social jetlag’ and it has been linked to poorer sleep quality, lower levels of positive mood and increased use of stimulants (Wittman, et al., 2006, p.499) as well as differences in smoking and alcohol consumption (Wittman, et al., 2010). In rats, chronic sleep deprivation has been observed to lead to deterioration of the circadian rhythm of melatonin (Persengiev, et al., 1991). Furthermore, human studies indicate that chronic sleep loss can result in negative effects on memory, cognition, and mood as well as neuroendocrine dysregulation and subsequent metabolic changes associated with allostatic load, such as insulin resistance, (Orzel-Gryglewska, 2010; Troxel, et al., 2010; van Cauter, et al., 2008).

Sleep quality is also an extremely important, if highly subjective, sleep variable (Friedman, 2011; Pilcher, Ginter, & Sadowsky, 1997; Vandkerckhove & Cluydts, 2010). It is usually measured using a sleep diary with Likert type scales (Krystal & Edinger, 2008). Such self-reports of sleep quality provide a rough measure that, it has been suggested, make between-studies comparisons difficult (Krystal & Edinger, 2008).
Nevertheless, sleep EEG patterns have been found to be congruent with self-reported sleep quality (Sato, Kanda, Anan, & Watanuki, 2002). Moreover, studies indicate that more objective indicators such as improved immunity can be linked to subjective sleep quality (Redwine, et al., 2000). Indeed, sufficient good quality sleep is seen as a “biobehavioral resource that minimizes allostatic load” (Hamilton, Catley, & Karlson, 2007, p.288).

The relationship between psychosocial stress and disturbed sleep, though intuitively close, has received relatively limited research attention outside shiftwork paradigms (Akerstedt, 2006). Existing evidence indicates that perceived stress (Williams, et al., 2005) as well as exhaustion (Nicholson & van Diest, 2000) are likely correlates of disturbed sleep. Also, in individuals getting an average of 7 hours sleep per night, sleep quality has been found to be an important predictor of both positive and negative affect as well as life satisfaction (Pilcher, et al., 1997). Sleep quality has also been found to be positively linked to SWB (Birchler-Pedross, et al., 2009; Cummins, et al., 2012; Howell, Digdon, Buro, & Sheptycki, 2008; Yokoyama, et al., 2008). Other studies have shown that reports of insomnia (Zammit, Weiner, Damato, Sillup, & McMillan, 1999), a perception of poor sleep (Kutner, Bliwise, & Zhang, 2004) and sleep debt (Roenneberg, et al., 2003) are associated with poorer ratings of quality of life.

Of particular interest to the current study, is the finding that poor sleep quality in vital exhaustion, a syndrome of fatigue and demoralization, was found to be associated with HPA hypo-activity involving low evening cortisol levels (Nicholson & van Diest, 2000). Additionally, poorer self-reported sleep quality has been found to be associated with poorer humoral immunity (Friedman, 2011) lower waking cortisol levels (Backhaus, Junghanns, & Hohagen, 2004) and blunted diurnal cortisol profiles (Lasikiewicz, et al., 2008). Such evidence supports the view that the quality of one’s sleep can be an important buffer between stress and negative outcomes (Hamilton, et al., 2007, p.288). However, despite the fact that it could provide key information regarding circadian and wellbeing
outcomes under prolonged stress, there is limited research on carers’ sleep (Brummett, et al., 2006).

As might be expected, carers have been found to report greater levels of sleep deprivation (Access Economics, 2010; Carter, 2002; Teel & Press, 1999). Also, sleep loss among carers has been linked to decrements in emotional and physical caregiving capacity (Carter, 2002). Decreased sleep quality has also been linked to the carer role, though this was mediated by negative affect and social support (Brummett, et al., 2006). Objective data also supports the view that carer sleep quality may be compromised. In a small study involving nine carers, differences were found in the structure of their sleep EEG recordings compared to non-carers and these correlated with subjectively poorer sleep quality (Sato, et al., 2002). Overall, it appears that carers’ sleep is likely to be compromised compared to non-carers and this may provide insight into the mechanisms involved in long-term stress effects.

1.7 Aims and Hypotheses

The current study sought to investigate psychobiological interactions under conditions of chronic stress. The primary goal was to examine whether the experience of very prolonged stress would be associated with circadian dysregulation. A related goal was to examine the relationship between any evidence of disturbed rhythmicity and possible decrements in physical and/or psychological health. Specifically, the aim was to examine these interactions among informal family caregivers as a population recognized to experience chronic stress and poor wellbeing outcomes. It was predicted that carers would exhibit circadian rhythm dysregulation in the form of decreased amplitude for cortisol, melatonin and core body temperature rhythms. It was further hypothesized that circadian dysregulation would be associated with reduced levels of the antibody sIgA as well as higher levels of distress and lower SWB.
Chapter 2 – Methodology

2.1 Summary

This chapter provides a detailed account of the study methodology. This study employed mixed methods, using morning and evening saliva sampling, self-report questionnaires, a sleep diary and qualitative data derived from personal interviews in order to examine psychobiological interactions during chronic stress. While few caregiver studies address outcomes across biopsychosocial dimensions (Raina, et al., 2005; Smith, Folan, & Haaland, 2002; Somers, Keefe, & Porter, 2009), this is considered to be the most suitable framework for investigating subjective wellbeing under chronic conditions (Fava & Sonino, 2008). The current methodology aimed to provide this broader view of carer outcomes.

2.2 Participants

For the purpose of the current study, a carer was defined as someone who provides long-term in-home care for a parent, partner, child, other relative or friend, who has a disability, is frail aged or who has a chronic mental or physical illness (Gill, et al., 2007). Non-carer participants were individuals who did not fulfil such a role nor have any major current health or personal difficulties. Carers were recruited through Carers Queensland (CQ) support group meetings and mailouts in the Far North Queensland region. Two articles in local newspapers also sought carer and non-carer participants. Flyers and email networks were also used for non-carer recruitment. Contact details for non-carer volunteers were placed on file until required to match a carer participant on age and gender. If an exact age match was not available the person of nearest age was asked to participate. The original sample consisted of 35 primary carers and 35 non-carers. Four carers were unable to complete the study. The circumstances leading to their withdrawal included: the person being
cared for going missing; the carer’s own ill health; the injury of another family member (not the person with a disability); and the death of the person being cared for. The final sample was composed of 31 carers (4 males and 27 females; mean age = 54.56 years; SD = 15.25), and 35 non-carers (5 males and 30 females; mean age = 55.46 years; SD = 14.05).

The proportion of female carers, at 87.1% is consistent with the 80.32% reported in the most recent Australia-wide survey (Cummins, et al., 2007). The carer participants provided care for individuals with high needs due to a range of disabilities; including Autism Spectrum Disorder (n=5), cerebral palsy (n=2), Downs syndrome (n=3), dementia (n=3), acquired brain injury (n=3), Parkinson’s disease (n=1), schizophrenia (n=4), quadriplegia (n=2), chronic illness (n=5), and mood disorder (n=3). The mean length of time sample carers had been in their caregiving role was 12.64 years (SD = 10.32; range 2 to 40 years).

2.3 Materials

The following eight psychological measures were used in this study: the Depression Anxiety Stress Scale, DASS-21 (Lovibond & Lovibond, 1995); the Perceived Stress Scale, PSS-10 (Cohen, Karmarck, & Mermelstein, 1983); the Personal Wellbeing Index, PWI (International Wellbeing Group, 2006); the Work and Social Adjustment Scale, WSAS, (Mundt, Marks, Shear, & Greist, 2002); the Positive and Negative Events Scales, PES and NES, (Maybery, Jones-Ellis, Neale, & Arentz, 2006); the Brief Cope, (Carver, 1997); and the Composite Scale of Morningness (Smith, et al., 1989). These measures were placed into a participant questionnaire booklet according to a computer-generated random-order list which assigned a different order of presentation to each participant. In addition, participants completed a seven day sleep diary. See Appendices A to I.
2.3.1 The Perceived Stress Scale

The Perceived Stress Scale (PSS) aims to gauge the respondent’s appraisal of the stressfulness of their life situation (Cohen, et al., 1983). "PSS items were designed to tap the degree to which respondents find their lives unpredictable, uncontrollable, and overloading" (Cohen, 1986, p. 717). The PSS-10 is a 10 item version recommended for research purposes due to its tighter factor structure and slightly improved reliability compared to the original 14 item PSS (Cohen & Williamson, 1988). Cronbach’s alphas for the PSS-10 are reported between .78 (Brummett, et al., 2006) and .85 (Cohen, et al., 1993). In the current study this measure of internal consistency was .90. The PSS-10 is brief and easy-to-administer and includes such items as “how often have you felt that you were unable to control the important things in your life?”. Responses range from ‘0’, never, to ‘4’ very often. The sum of all responses is used as a measure of the perception of stress in the time period specified in the instructions. Possible scores range from 0 to 40; higher scores indicate higher perception of stress. Participants in this study were asked to consider responses using a timeframe of the last month. The PSS continues to be considered a valid research tool for investigating stress-related health effects (Cole, 1999). It has recently been used in investigations of outcomes in surgical patients (Broadbent, Petrie, Alley, & Booth, 2003; Ellard, Barlow, Mian, & Patel, 2006) and is considered well-suited to studies of caregiver outcomes (Schwarz & Dunphy, 2003; Stowell, Kiecolt-Glaser, & Glaser, 2001). See Appendix A.

2.3.2 The Depression Anxiety Stress Scale

The DASS was developed to measure the negative emotional states of depression, anxiety and stress in the general population (Lovibond & Lovibond, 1995). The DASS items were devised to maximally separate these related but conceptually distinct states. The DASS depression sub-scale contains items to tap the core elements of
depression, including anhedonia and hopelessness. The DASS anxiety sub-scale items refer to respondent’s experience of panic and worry as well as somatic complaints. The DASS stress sub-scale items relate to symptoms of over-arousal that are related to an emotional state but not considered to indicate a stable trait. This last sub-scale is considered to provide a unique measure of non-specific chronic arousal (Lovibond & Lovibond, 1995). The DASS-21 is a short research version which contains seven items to tap each construct and is considered to be psychometrically equivalent to the full scale (Antony, Bieling, Cox, Enns, & Swinson, 1998).

DASS response options for all items range from ‘0’, “did not apply to me at all”, to ‘3’, “applied to me very much or most of the time”. For the DASS-21 the totals out of 21 are multiplied by two to enable comparisons with the complete DASS-42. Thus, the range of possible scores for each scale is 0 to 42. Reported internal reliabilities for the 7-item depression, anxiety and stress sub-scales are .81, .73 and .81 respectively (Lovibond & Lovibond, 1995). In the current study, the Cronbach alpha for each of these were .91, .78 and .89 respectively. DASS depression and anxiety scales have been found to correlate highly with the Beck scales for these constructs indicating good construct validity (Lovibond & Lovibond, 1995). See Appendix B.

2.3.3 The Personal Wellbeing Index

The PWI was developed to measure SWB or “the subjective dimension of quality of life” (International Wellbeing Group, 2006, p.5). Each item of the PWI is designed to tap one of seven life domains. These relate to standard of living, personal health, achieving in life, personal relationships, personal safety, community connectedness, and future security (International Wellbeing Group, 2006). Each domain is considered to represent “the first level of deconstruction of satisfaction with ‘Life as a Whole’,” (International Wellbeing Group, 2006, p.6). It is important to note that each domain is considered to be an indicator, but not a mediator, of
global SWB (International Wellbeing Group, 2006). Respondents are asked to indicate their level of satisfaction for each domain on an 11-point scale from ‘0’, ‘completely dissatisfied’, to ‘10’, ‘completely satisfied’. The average satisfaction across key domains then provides an overall measure of SWB (International Wellbeing Group, 2006). This can then be converted to a score on a 0 to 100 scale for ease of communication (Davern, et al., 2007). The higher the PWI score, the higher the level of life satisfaction. Australian norms are regularly updated for the PWI and appear to be very stable over time, with means ranging between 73.2 and 76.3 in samples taken over the last decade (Cummins, et al., 2012). The PWI also exhibits good internal consistency, with Cronbach’s alphas from .7 to .85 reported for the PWI (International Wellbeing Group, 2006). In the current study, Cronbach’s alpha was .88.

The PWI has been validated internationally and with many subpopulations and is considered to be a valid and psychometrically sound instrument for use with diverse demographic and cultural groups (International Wellbeing Group, 2006). It represents the distillation of a long-standing research project to develop a scale to measure both personal and community level quality of life (International Wellbeing Group, 2006). Indeed, the PWI can provide a key health outcome measure alongside information obtained through the DASS and clinical observations (Cummins, et al., 2004). Normative scores are available for the Australian population (Cummins, 2003) with suggested cut-off scores of 50 for individuals, or 70 for a sub-population, as indicative of a failure of SWB homeostasis (Cummins, 2005a). The PWI is also regarded as a valid measure for use with informal caregivers and, moreover, is considered to have potential as a measure of global carer outcomes (Cummins, et al., 2007). In the current study, an additional initial item asking about satisfaction with life as a whole, as suggested by Cummins (2005b), was also included. This broad item is purported to provide the best approximation of a homeostatically managed sense of self (Cummins, 2005b). See Appendix C.
2.3.4 The Work and Social Adjustment Scale

Social functioning has been identified by Lazarus (1999) as a key outcome of successful stress management. The Work and Social Adjustment Scale (WSAS) was chosen as a brief measure of this key outcome. It was designed to measure work and social functioning in psychiatric patients (Mundt, et al., 2002). According to its developers, it is a reliable and valid scale that provides a “simple measure of impairment in functioning” (Mundt, et al., 2002, p.461). It has also been found to be very sensitive to patient improvement (Mataix-Cols, et al., 2005; Mundt, et al., 2002; Shear, Frank, Houck, & Reynolds III, 2005) and to correlate well with data obtained in clinical interviews (Mataix-Cols, et al., 2005; Mundt, et al., 2002). While it was designed as a clinical tool it taps functioning in key life areas considered essential to healthy engagement in life. Thus, it was considered likely to be sensitive to the effects of the caregiving role on functioning within these key spheres. The WSAS displays good internal consistency, with Cronbach’s Alphas ranging from .7 to .95 (Mataix-Cols, et al., 2005; Mundt, et al., 2002). In this study, a modified version produced an alpha of .89.

The WSAS consists of five items pertaining to work, home management, leisure activities with others, private leisure activities, and close relationships. The items ask to what level the respondent’s particular mental health diagnosis has impaired their functioning in each area. In the current study, permission was obtained from Dr Isaac Marks (personal communication, February 8, 2007) to change the wording for use with a non-clinical population. Specifically, ‘my life circumstances’ was inserted into each item where the name of a particular disorder would otherwise occur. For example, the first item became “Because of my life circumstances, my ability to work is impaired”. This generic phrase was used instead of ‘caregiving’ so that the items would be applicable to both carers and non-carers. Feedback from carer participants indicated that these modified items were interpreted with reference to their carer role.
In the original WSAS, the response options ranged from 0, 'not at all impaired', to 8, 'very severely impaired'. Scores thus ranged from 0 to 40, with scores above 20 suggestive of moderate to severe pathology and scores between 10 and 20 associated with severe functional impairment but less severe clinical presentation (Mundt, et al., 2002). Another modification in the current study was to change to an 11-point response format, from 0, 'completely disagree', to 10, 'completely agree' regarding the level of impairment. While most users of the WSAS employ the original 9-point agreement scale (Mataix-Cols, et al., 2005; Mundt, et al., 2002; Shear, et al., 2005), an 11-point scale has also been utilised (Sheehan, 1983). According to Cummins (2003), 11 or more points provides a superior response option by allowing increased sensitivity, especially when distributions are likely to be skewed and limited to a narrow range. Since no carer, or even non-clinical, norms were available for comparison, alteration of the response options was not considered to be an issue for the current study. A further modification employed for ease of interpretation, was that total WSAS scores were reversed such that high scores would indicate increased functioning rather than increased impairment. Given that the current version allows a maximum of 10 points per item, the mid-point for the scale becomes 25 rather than 20. This mid-point was previously used as a clinical cut-point. Thus, a score in the current study of 25 or below would correspond to the previous cut-score for moderate to severe impairment in functioning. See Appendix D.

2.3.5 The Positive and Negative Events Scales

Daily hassles and uplifts, as well as major life events, have long been recognised as important determinants of both psychological (Bolger, DeLongis, Kessler, & Schilling, 1989; Lazarus & Folkman, 1989; Mroczek & Almeida, 2004) and physiological outcomes (McEwen & Seeman, 1999; Stone, et al., 1994; Turner Cobb & Steptoe, 1996). The Positive Events Scale (PES) and the Negative Events Scale (NES) were developed to provide a measure of these common sources of both distress and uplift.
Importantly, the PES and NES include measures of interpersonal events which, though significant sources of daily hassle and uplift, are commonly excluded from similar measures (Graham & Maybery, 2001; Maybery, 2003). The inclusion of interpersonal conflict is particularly important given that it is a salient source of daily stress and, moreover, has a complex relationship with emotional states (Bolger, et al., 1989). Another important feature of the NES and PES is that they allow measurement of both frequency and intensity of hassles and uplifts. This allows consideration of the impact of these distinct components within the hassle or uplift experience (Maybery, et al., 2006).

The NES has been found to be a valid and reliable measure of hassles among adults (Maybery, et al., 2007). The scale consists of 42 items relating to the experience of problems across a range of interpersonal (partner, children, parents, colleagues, employer) and other (health, work, household) life areas. Respondents are asked to indicate the frequency of occurrence of each item across the previous month from ‘0’, through frequency brackets from ‘1-3’, ‘4-6’, ‘7-9’ or ‘10+’ times with associated scores ranging from ‘0’ to ‘4’. Respondents are also asked to rate the level of hassle involved for each item, from ‘0’, ‘no hassle’, to ‘4’, ‘extreme hassle’. NES Frequency and NES Intensity scores may thus range from a minimum of 0 to a maximum of 168, with higher scores respectively indicating higher frequency and intensity of hassles. See Appendix E.

The PES is considered to be a valid and reliable measure of the experience of daily uplifts (Maybery, et al., 2006). Such an instrument is unusual given the traditional focus within psychology on the measurement of negative events and appraisals (Maybery, et al., 2006). The inclusion of the PES in the current study allowed measurement of regular positive experiences alongside negative ones. This was considered important due to the potential independence of effects from positive and negative affect (Folkman & Moskowitz, 2000; Pressman & Cohen, 2005). Use of the PES
in addition to the NES allowed consideration of any possible differential
effects for hassles and uplifts in the maintenance of SWB.

The PES was designed to tap the appraisal of positive events
across interpersonal, social and work domains (Maybery, et al., 2006). It
consists of 43 items with respondents again asked to indicate the
frequency and intensity of events. Response options reflect those for the
NES, with the exception that intensity responses reflect ‘uplift’ instead of
‘hassle’. Thus, the range of possible PES Frequency and Intensity scores
is 0 to 172, where higher scores indicate more frequent or more intense
uplifts respectively. See Appendix F.

Within the current questionnaire, the PES always appeared before
the NES. This was done to conform to the recommendation that positive
event scales precede negative ones due to potential unidirectional order
effects, because uplift scale scores tend to be diminished when preceded
by hassle scale items (Maybery, et al., 2002).

2.3.6 The Brief COPE

The Brief COPE provides a concise yet psychometrically sound
measure of coping that is well suited to populations experiencing high
levels of stress (Carver, 1997). The original 60-item COPE scale was
developed by Carver, Scheier and Weintraub (1989) to encompass both
Lazarus and Folkman’s (1984) model of stress and coping alongside their
own model of behavioural regulation. The Brief COPE contains 28 items
derived from the original. Respondents are asked to indicate their use of
each strategy from ‘0’, ‘I usually don’t do this at all’, to ‘3’, ‘I usually do this
a lot’. Responses can be combined to form 14 two-item subscales
designed to measure use of the following coping strategies: active coping,
planning, positive reframing, acceptance, humour, religion, using
emotional support, using instrumental support, self-distraction, denial,
venting, substance use, behavioural disengagement, and self-blame. See
Appendix G.
Mean scores for each subscale can be calculated with a higher score indicating greater use of that particular method. Coping subscales can also be subsumed into higher level categories, such as problem or emotion-focussed, if preferred although this method may not improve data interpretation (Carver, et al., 1989). In the current study, the Cronbach’s Alpha for the full scale was 0.89. Alphas for the subscales were similar to those reported by Carver et al. and generally acceptable for research purposes. Specifically, the alphas were: active coping .84; planning .85, positive reframing .6; acceptance .74, humour .83; religion .87; using emotional support .84; using instrumental support .85; self-distraction .67; denial .52; venting .6; substance use .94; behavioural disengagement .7; and self-blame .85.

2.3.7 The Composite Scale of Morningness

The Composite Scale of Morningness, CSM, is a 13-item scale which was designed to measure self-reported time of day preferences (Smith, et al., 1989). The first scale developed to measure individual differences in circadian preference was the Morningness-Eveningness Questionnaire, MEQ, by Horne and Ostberg (1976). While the MEQ remains a popular measure of diurnal preference (Caci, Deschaux, Adan, & Natale, 2009), the Composite Scale of Morningness, CSM, is a more psychometrically sound alternative with a tighter factor structure (Smith, et al., 1989). In addition, the CSM is more suited to research due to its shorter length and simpler scoring system (Caci, et al., 2009; Cavallera & Giudici, 2008; Smith, et al., 1989). Smith et al. (1989), created the CSM by combining what they deemed were the best items from the MEQ with items from other similar scales to create a brief psychometrically sound instrument. Unsurprisingly then, the CSM correlates highly (.9) with the MEQ (Caci, et al., 2009). It is also a reliable measure, with Cronbach’s alpha, as a measure of internal consistency, of .85 (Diaz-Morales & Sanchez-Lopez, 2008; Randler, 2008a) and .87 (Smith, et al., 1989) reported. In the current study Cronbach’s alpha was .90.
The CSM items ask respondents to consider their ‘feeling best’ rhythm, to report on their typical circadian patterns and to indicate the time they would choose for regular activities such as work or exercise. The response format uses an agreement scale from 1 to 4 (or 5) for each item, which is then summed to yield a total score. The CSM was originally developed for use with university students (Smith, et al., 1989) but has since been validated with other populations (Caci, et al., 2005; Diaz-Morales & Sanchez-Lopez, 2004). Documented rising and retiring times have been found to correlate well with self-reported preferences (Caci, Nadalet, Staccini, Myquel, & Boyer, 1999; Smith, et al., 1989). Additionally, CSM scores have been found to be stable over time (Caci, et al., 2000; Greenwood, 1994) and to remain unaffected by concurrent shift-work (Greenwood, 1994). Nevertheless, there has been some debate regarding the best CSM cutoff scores for chronotypes (see Caci, et al., 1999; Greenwood, 1994; Natale & Alzani, 2001). In the current study CSM scores were not used to categorise types but were treated as a continuous variable indicating relative morningness, with higher CSM scores indicating a greater tendency toward morning preference. See Appendix H.

2.3.8 Sleep Diary

A seven-day sleep diary, designed for the current study, asked participants to record their sleep patterns as well as report any symptoms of illness or use of alcohol, cigarettes, caffeine or other drugs (see Appendix I). Given that the most reliable and validated measure of sleep is total sleep time (Krystal & Edinger, 2008), the diary included several questions aimed at estimating sleep quantity based on those employed in previous studies (Carrier, et al., 1997; Horne & Ostberg, 1976; Sukegawa, et al., 2009). Questions were included to estimate wake time, bedtime, any sleep interruptions and the participants also provided their own estimation of sleep length. In addition, since the amount and quality of one’s sleep can be independent of one another (Krystal & Edinger, 2008) and sleep
quality is likely to be an important health-related variable (Sickel, Moore, Adler, Williams, & Jackson, 1999), the diary also included two questions targeting sleep quality. Specifically, participants were asked to rate both the quality of their previous nights sleep and their level of restedness on each of seven mornings. Such self-rated sleep quality is a very simple method that is nonetheless a popular research approach that is considered to provide a valid means of capturing aspects of sleep not possible to be assessed via objective data (Krystal & Edinger, 2008).

In addition, the sleep diary contained questions for each day regarding the quantity of alcohol, cigarettes, caffeine or other substances consumed. The diary also included a section for each of the seven days of data collection for participants to note any symptoms of ill health they may be experiencing.

2.3.9 T-Tec Data Loggers

T-Tec data loggers from Temperature Technology, Adelaide, Australia, were used to record core body temperature. In combination with the accompanying software, these loggers can be set to read a disposable sensor and will record hundreds of single data points over many hours. In the current study, the loggers were set to record temperatures at 2 minute intervals over a 24 hour period.

2.3.10 Saliva Sampling

Collection of saliva is a simple procedure compared to collection of blood as it is relatively stress-free and little training is required (Backhaus, et al., 2004; Hansen, et al., 2012; Pruessner, et al., 1999; Vedhara, et al., 1999). In fact, saliva sampling is considered to be the method of choice for stress research (Hellhammer, et al., 2009). It can also be done at times and places that suit both participants and researchers (Hellhammer, et al., 2009). Of particular note, saliva sampling can take place within the natural home environment, with minimal disruption to daily routines, and at natural waking and retiring times (Edwards, et al., 2003; Hansen, et al., 2012;
Provinciali, et al., 2004). Collection of saliva thus provides a convenient way to measure biomarkers at key times of the 24-hour day with minimal disruption for participants (Backhaus, et al., 2004; Pruessner, et al., 1999). Cortisol (Clow, 2004), sIgA (Hofman, 2001), and melatonin (Arendt, 2005; Voultsios, Kennaway, & Dawson, 1997) can all be easily detected in saliva. Saliva and serum levels are highly correlated for cortisol (Rosmond, et al., 1998) and melatonin (Voultsios, et al., 1997) and provide a good reflection of bioavailability (Arendt, 2005; Backhaus, et al., 2004). Of particular interest to the current study, salivary cortisol is considered to be the best available indication of HPA activation (Hellhammer, et al., 2009). In sum, saliva collection was seen as particularly well suited to the purposes of the current study. Instructions for collection of morning and evening samples were provided to participants. See Appendix J.

2.4 Procedure

All participants were visited in their own home. On the first visit a semi-structured interview was conducted and participation packs were delivered. The interviews provided an opportunity to gather relevant background information and qualitative data on the participants’ views regarding their own health and wellbeing. The interview also allowed participants to mention any particular concerns, such as sleep, lifestyle, or circumstances that they felt may be impacting them. The interview also allowed carer participants to provide details they felt were important to adequate consideration of their caregiving situation. See Appendix K for an overview of topics covered.

The participation packs included the scales, demographic questions, a 7-day sleep diary and sampling tubes with instructions for collection of un-stimulated saliva to be completed over a data-collection week. The general protocol followed was similar to that used in other studies of a community sample under regular (non-shiftwork) conditions, with collection of both morning and evening saliva samples (Adam & Gunnar, 2001; Corbett, Mendoza, Baym, Bunge, & Levine, 2008;
Edwards, et al., 2003; Pruessner, et al., 1999; Volkmann & Weekes, 2006). Participants were asked to provide morning and evening saliva samples over two to three consecutive days. Use of a minimum of two sampling days was considered likely to provide reliable baseline data (Edwards, et al., 2003; Hellhammer, et al., 2007; Weekes, et al., 2008), while avoiding undue burden for carer participants. However, only one morning sampling time-point, the estimated peak of the cortisol rhythm 30 minutes after waking (Pruessner, et al., 1997) was utilized, again in an effort to minimise burden and maximise compliance among carer participants.

Participants were asked to collect approximately 4ml saliva in three separate tubes approximately 30 minutes after waking (but before eating or brushing their teeth) and two tubes about 30 minutes before retiring for the night on two consecutive days. The use of passive saliva collection was chosen to reduce the influence of saliva flow (Volkmann & Weekes, 2006) and avoid use of materials, such as cotton in salivettes, that may influence biochemical determinations (Kozaki, Lee, Nishimura, Katsuura, & Yasukouchi, 2011; Shirtcliff, Granger, Schwartz, & Curran, 2001). Because cortisol rhythms are influenced by season (Laakso, Porkka-Heiskanen, Alila, Stenberg, & Johansson, 1994; Thorn, Hucklebridge, Evans, & Clow, 2009; Vreeburg, et al., 2009), participants were asked to complete all activities during one week chosen from a five week period during late Spring.

All specimens and documents were coded to allow data collation. Participants were asked to record the time and date of each sample and place tubes in their own freezer until collection. Samples were collected and transferred frozen to the laboratory where they were stored below minus 20°C. At collection, all participants indicated that they had followed the study protocol. However, five carer and five non-carer participants provided fewer samples due to only sampling over one day or providing insufficient saliva. To minimize loss of whole data sets and given that a single saliva sample may provide adequate baseline data (Carins & Booth,
2001; Da Roza Davis & Cowen, 2001; Ebrecht, et al., 2004) these individuals were retained. Overall, cortisol and melatonin data was available for 55 participants, 26 carers and 29 non-carers.

Those carers and non-carers who agreed to wear a self-administered rectal temperature sensor for 24 hours were also given a pre-set T-Tec logger, a disposable sensor and an instruction sheet based on an established research protocol (Devaney, et al., 2003). See Appendix L. Participants were asked to collect temperature data during one 24-hour period of their data collection week. Temperature loggers were either collected from the participant’s home or mailed back using a reply-paid postage pack provided. Data was downloaded from the loggers and analysed using version 10 of the T-Tec software. The total number of participants who provided temperature data was 20, including eight carers and twelve non-carers.

2.5 Biochemical Determinations

One of the coded waking samples was analysed locally by the chief investigator using facilities available in the JCU Health Psychology and Immunology Laboratory, Cairns to determine salivary immunoglobulin-A levels. After thawing, vials were centrifuged at 12,000g at 4°C for 5 minutes. Levels of s-IgA were determined using Dade Behring 12-well LC partigen immunodiffusion plates. Standards for preparation of the reference curve (with a known batch concentration of .101 g/L) were also provided by Dade Behring, Germany. In each run, 20 μL of serum standard (at concentrations of 10%, 25%, 50% and undiluted) or saliva (in triplicate for each sample) was pipetted into each well and let stand at room temperature for 24 hours. The precipitin ring was measured using digital calipers (accurate to .03mm). Thirteen participants either did not supply sufficient saliva or their samples produced rings outside (above or below) the standard profile and were excluded (see Dade Behring, 2003) resulting in comparison sIgA data being available for 53 cases.
The other evening and morning samples were packed with dry ice and sent by overnight transport to ARL Pathology, Melbourne, Australia. Thus, the coded saliva samples were analysed by an external independent biochemist. The laboratory reported that the contents of the insulated packages arrived at temperatures below minus 20°C. Cortisol levels were determined by competitive electrochemiluminescence immunoassay (ECLIA, Elecsys 2010, Roche Diagnostics) as described elsewhere (Vogeser, Durner, Seliger, & Auernhammer, 2006). The kit sensitivity was 6.9 nmol/L. Assay functional sensitivity was estimated at 5 nmol/L, with intra- and inter-assay coefficients of variation 6.9% and 10.6% respectively. Melatonin levels were determined using Direct Saliva Melatonin ELISA kits, a competitive immunoassay which employs a capture antibody technique (Buhlmann Laboratories AG, 2004). The kit sensitivity was 0.5 pg/mL. Assay functional sensitivity was 1.3 pg/ml and intra-assay and interassay coefficients of variability 6.5% and 11.3% respectively.

2.6 Statistical Analyses

Data analyses were conducted using SPSS-17. All variables used in parametric analyses were investigated with respect to normality, linearity, homogeneity, and the presence of outliers, with no serious violations observed. All statistical tests were two-tailed with a significance level of $\alpha=.05$ unless otherwise specified. Due to the low numbers of carers, Bonferroni corrections were not employed in the current study. It should be noted, however, that these multiple comparisons run the risk of family-wise error and results must be interpreted accordingly. Particular tests employed are described within the chapters reporting their respective results.

It should be noted that continuous variables within this study have been treated as such to avoid the recognised pitfalls of categorisation. Indeed, categorisation of continuous data has been described as an arbitrary process which is difficult to defend empirically and is likely to
reduce power, effect size and reliability (MacCallum, Zhang, Preacher, & Rucker, 2002; Naggara, et al., 2011; Sauerbrei & Royston, 2010). However, the current research has, at times, treated SWB as continuous while, at others, employed a binary approach to SWB. This latter strategy was used in order to explore the possible utility of an SWB threshold. In particular, Student t-tests (for uneven groups) and logistic regressions were employed to explore outcomes associated with SWB below 50% of scale maximum (i.e. dissatisfaction) or SWB at or above this cut-point (i.e. satisfaction).

Use of logistic regression is common in health research where the probability of health outcomes, such as life or death or the presence or absence of a specific medical condition, are of particular interest (Anderson, Jin, & Grunkemeier, 2003; Beagley, White, & Golomb, 2001). The use of logistic regression to determine the likelihood an individual will be categorised as healthy or not, is also frequently applied to clinical cut-offs for conditions that are measured using self-report scales, such as depression (Van den Bergh & Van Calster, 2009) and burnout (Brenninkmeijer & VanYperen, 2003). It is argued here that the same binary approach may be relevant to consideration of SWB and the possibility of failure of SWB homeostasis. Indeed, other studies have found categorization of patients according to whether or not they report dissatisfaction with life helpful in identifying associated health outcomes (Paunio, et al., 2008; Sinikallio, et al., 2009).

It is also noteworthy that logistic regression does not depend on assumptions of normality, linearity or equality of variance (Tabachnick & Fidell, 2007). Such flexibility may have relevance to the prediction of outcomes under circumstances of homeostatic failure, where variability is high (Cummins, 2010). Nevertheless, cut-points must always be used with caution (Naggara, et al., 2011). For this reason, whilst a 50% threshold was used to explore the possible utility of the concept of SWB failure, SWB was always treated as a continuous variable in the first instance.
2.7 Ethical Considerations

This research was conducted in accordance with NH&MRC ethical guidelines and approved by the James Cook University ethics committee (approval #H2703). All participants received a verbal explanation of the requirements of the study, an information sheet (see Appendix M) and gave written consent (see Appendix N for consent form).
Chapter 3 – Psychosocial Outcomes and Carer Subjective Wellbeing

3.1 Summary

Carers are at risk of poor health and wellbeing outcomes. This chapter examined the psychological and social variables included in the study to compare the outcomes for participating carers and non-carers. Analysis of the marked differences between these groups across stress, distress, coping, SWB and social functioning provided the psychosocial basis of the examination of carer SWB as well as the necessary foundation for the biological comparisons of later chapters. Such psychosocial evidence has the potential to inform policy approaches to the growing population of Australian carers as well as add to the developing literature on both chronic stress and subjective wellbeing.

“life as I knew it is gone”

(quote from carer participant)

3.2 Introduction

3.2.1 Carer Wellbeing – a Critical Outcome

As noted earlier, carers in this study provided care and support to a partner or child with a disability or chronic mental or physical illness. The time and energy demands of such a role are likely to far exceed those of typical partner or parent-child relationship (Schulz & Quittner, 1998). Yet, outcomes for such carers have tended to be overlooked (Commonwealth of Australia, 2010; Noon, 1999). Recently, increasing recognition of the extraordinary economic and social value of informal family care particularly given an ageing population and increasing longevity among those with disabilities has provided research and policy momentum (Access Economics, 2010; Cummins, et al., 2007). Caregiving often involves the
experience of severe and persistent stress (Schulz & Quittner, 1998) with potential for carers themselves to become a subsequent wave of healthcare need (Briggs & Fisher, 2000; Edwards & Higgins, 2009). As noted in Chapter 2, subjective wellbeing (SWB) is an enduring sense of feeling positive and enthusiastic about oneself and one’s life (Cummins, et al., 2004; Manderscheid, et al., 2010; Simsek, 2009). As such, SWB involves a global evaluation of quality of life (Diener, et al., 1998; Diener, et al., 1999; Schimmack, 2008). While a key part of the carer role is to maintain the wellbeing of those they care for (Cummins, 2005a), the cost to carers’ own wellbeing is likely to be extreme (Cummins, et al., 2007). Since stress, by definition, involves a threat to wellbeing (Lazarus & Folkman, 1984), wellbeing must be a key outcome of successful adaptation to stress (Lazarus, 1999). Thus, SWB appears to have great potential as an indicator of global carer outcomes (Cummins, et al., 2007). Numerous studies of carers have demonstrated more stress, distress, sleep problems, fatigue and physical health problems compared to non-carers (Briggs & Fisher, 2000; Pakenham, et al., 2005; Schulz & Beach, 1999; Shewchuk, Richards, & Elliott, 1998; Vitaliano, et al., 2003; Vitaliano & Young, 2004). To date, however, comparatively few studies have examined quality of life outcomes for carers (Kim, et al., 2012). Those that have, indicate carers are doing poorly in comparison to those without a caregiving role (Cummins, 2001; Cummins, et al., 2007; Pinquart & Sorensen, 2004; Schofield, 1997).

3.2.2 Carer Coping

The personal meaning and significance of an event and the presence of other concurrent or long-standing demands negatively impact the appraisal process (Lazarus, 1999). As previously discussed, caregiving is highly likely to involve both personally relevant and persistent stress and, thus, threat appraisal. It follows then that coping behaviours, which can provide emotion regulation (Lazarus, 1999) and stress amelioration (Toates, 1995), are likely to be important contributors to the
maintenance of SWB. Both problem-focused strategies, such as planning and problem-solving, and emotion-focused strategies, such as reframing, tolerance and acceptance, can be used to make a situation more manageable and can be equally effective in altering the person-environment transaction (Lazarus, 1999). However, strategies such as venting, disengagement, escape and avoidance tend to be associated with negative outcomes (Carver, et al., 1989; Vedhara, Shanks, Anderson, & Lightman, 2000). In the case of long-term caregiving, there is some evidence that proactive strategies may be associated with better psychological outcomes, though it should be noted that appraisals and strategy choices under chronic stress tend to be rather dynamic and change with time (Aldwin & Brustrom, 1997). Carer coping styles have been found to make a greater contribution to carer psychological health than the specific needs of the person they care for (Sander, High, Hannay, & Sherer, 1997). This appears to parallel Cummins’ (2001) finding that the disability of the recipient can be irrelevant to the effects of the carer role on quality of life.

3.2.3 Caregiving – a Natural Experiment in Chronic Stress

It is particularly noteworthy that, while coping strategies can mediate the relationship between stressor and outcome (Lazarus & Folkman, 1984), there is an inevitable upper limit to coping capacity (Somerfield & McCrae, 2000). The evidence to date on carer stress, coping and wellbeing, appears to provide support for a homeostatic model of SWB where surpassing a personal stress threshold is associated with a failure of homeostatic coping mechanisms and subsequent decrements in subjective wellbeing (Cummins, 2010). Thus, carer outcomes represent a unique opportunity to examine SWB under conditions of chronic challenge and, particularly, at the extremes of personal capacity. Low quality of life judgements under extreme life circumstances may reflect the natural limits of cognitive mechanisms that, under normal circumstances, maintain an optimal and normative sense of SWB (Cummins, 2003; Kim, et al., 2012).
As previously mentioned, the other key outcomes of successful adaptation, according to Lazarus and Folkman’s (1984) stress and coping model, are physical health and social functioning. Clearly these are also highly salient outcomes under prolonged challenge. While indicators of physical health, including sleep, immune and biochemical markers are discussed in subsequent chapters, carers’ social adjustment has been considered here alongside psychological outcomes as an indicator of global personal functioning (Mundt, et al., 2002). Indeed, it has been convincingly argued that a sense of wellbeing is both the foundation for adequate social functioning within one’s environment (Inui, 2003) as well as the product of such social interaction (Suurmeijer, Reuvekamp, & Aldenkamp, 2001).

It is noteworthy, however, that in the case of chronic stress, the social environment may not function as the buffer it tends to provide for acute stress. Rather, social relationships may exacerbate already fraught interactions (Lepore, 1997). For instance, the experience of ongoing stress is likely to increase relationship strain and/or isolate the individual, resulting in a cascade of interpersonal challenges and subsequent erosion of social support (Lepore, 1997). Furthermore, coping efforts may incur a psychological cost that can have flow-on effects, such as a reduced ability to deal effectively with other life events (Lepore, 1997). Indeed, burnout has been described as the result of failed coping in the face of prolonged stress (Melamed, et al., 1999). In the current study, inclusion of a measure of social functioning was considered to be essential to an holistic biopsychosocial approach (Hyypa & Maki, 2003; Inui, 2003) and to the multidimensional view needed to examine the complex dynamics of caregiver health (Raina, et al., 2005).

3.2.4 Aims

In sum, the aim of this chapter was to examine the relationships between stress, distress, social adjustment and quality of life. A further aim was to describe the key psychosocial outcomes among participating long-
term primary carers and compare these to those reported by participants without a caring role. Using information obtained through individual interview as well as the scales described in the previous section, this chapter reports on participants’ depression, anxiety, arousal stress, perceived stress, hassles, uplifts, coping strategies, subjective wellbeing and social functioning.

3.3 Method

Chapter 2 provides a detailed description of all variables and processes referred to in this chapter. As previously noted in Chapter 2, the choice of analyses were limited by the small sample size.

3.4 Results

3.4.1 Associations Between the Key Study Variables

Table 3.1 reports the correlations between the key psychosocial variables included in the study. As expected, there were significant positive associations between measures of stress and distress as well as significant negative associations between these measures and the key outcomes of subjective wellbeing and social functioning. Of particular interest is the strong inverse relationship between stress and SWB with increased perceived stress and increased chronic arousal (DASS stress) both associated with decreased SWB. Similarly, social functioning also displayed a significant negative association with perceived stress and chronic arousal stress.

Table 3.1 also provides the correlations between the key study variables and measures of hassles and uplifts. The frequency and intensity of hassles exhibited strong positive correlations with both perceived stress and chronic arousal stress. It is also noteworthy that the frequency and intensity of hassles were also strongly negatively correlated with SWB, as well as with social functioning, within this sample. However, with respect to the frequency and intensity of uplifts, there were significant moderate
correlations with DASS depression scores but no other significant associations were evident between uplifts and either stress and distress or social functioning and SWB.

Table 3.1

*Inter-correlations between the key psychosocial variables and the frequency and intensity of hassles and uplifts*

<table>
<thead>
<tr>
<th>Perceived Stress</th>
<th>Depression</th>
<th>Anxiety</th>
<th>Chronic Arousal</th>
<th>Subjective wellbeing</th>
<th>Social functioning</th>
<th>Hassles, frequency</th>
<th>Hassles, intensity</th>
<th>Uplifts, frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression</td>
<td>.654***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anxiety</td>
<td>.578***</td>
<td>.624***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chronic Arousal</td>
<td>.676***</td>
<td>.682***</td>
<td>.638***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjective wellbeing</td>
<td>-0.679***</td>
<td>-0.552***</td>
<td>-0.409***</td>
<td>-0.490***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social functioning</td>
<td>-0.608***</td>
<td>-0.720***</td>
<td>-0.508***</td>
<td>-0.635***</td>
<td>0.637***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hassles, frequency</td>
<td>0.513***</td>
<td>0.427***</td>
<td>0.546***</td>
<td>0.641***</td>
<td>-0.497***</td>
<td>-0.518***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hassles, intensity</td>
<td>0.595***</td>
<td>0.526***</td>
<td>0.645***</td>
<td>0.725***</td>
<td>-0.570***</td>
<td>-0.396***</td>
<td>0.784***</td>
<td></td>
</tr>
<tr>
<td>Uplifts, frequency</td>
<td>-0.131</td>
<td>-0.261*</td>
<td>-0.012</td>
<td>0.019</td>
<td>0.151</td>
<td>0.180</td>
<td>0.252*</td>
<td>0.267*</td>
</tr>
<tr>
<td>Uplifts, intensity</td>
<td>-0.155</td>
<td>-0.303**</td>
<td>-0.003</td>
<td>-0.032</td>
<td>0.113</td>
<td>0.140</td>
<td>0.238</td>
<td>0.294*</td>
</tr>
</tbody>
</table>

N = 66.
*p<.05. **p<.01. ***p<.001.

Table 3.2 reports the correlations between the 14 subscales of the Brief COPE and the main psychosocial study variables. Of particular note is the positive relationship between endorsement of disengagement and stress and distress and the negative relationship between use of this strategy and SWB and social functioning. This pattern was somewhat mirrored by the associations between self-blame and the same key variables, with the exception of anxiety and SWB.
From Table 3.3, it is clear that both planning and self-blame were positively associated with the frequency and intensity of hassles. The intensity of uplifts was positively correlated with the use of humour, seeking emotional support and self-distraction.

Table 3.2

<table>
<thead>
<tr>
<th>Coping Style</th>
<th>Perceived Stress</th>
<th>Depression</th>
<th>Anxiety</th>
<th>Chronic Arousal</th>
<th>Subjective Wellbeing</th>
<th>Social Functioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active coping</td>
<td>.116</td>
<td>-.014</td>
<td>.022</td>
<td>.155</td>
<td>-.075</td>
<td>-.093</td>
</tr>
<tr>
<td>Planning</td>
<td>.266*</td>
<td>-.035</td>
<td>.073</td>
<td>.246*</td>
<td>-.172</td>
<td>-.153</td>
</tr>
<tr>
<td>Reframing</td>
<td>-.088</td>
<td>-.103</td>
<td>-.043</td>
<td>-.083</td>
<td>.086</td>
<td>.118</td>
</tr>
<tr>
<td>Acceptance</td>
<td>.168</td>
<td>.190</td>
<td>.321*</td>
<td>.089</td>
<td>-.167</td>
<td>-.061</td>
</tr>
<tr>
<td>Humour</td>
<td>-.101</td>
<td>-.264*</td>
<td>.110</td>
<td>-.158</td>
<td>.127</td>
<td>.254*</td>
</tr>
<tr>
<td>Religion</td>
<td>.101</td>
<td>.116</td>
<td>.194</td>
<td>.089</td>
<td>-.098</td>
<td>-.140</td>
</tr>
<tr>
<td>Emotional Support</td>
<td>-.033</td>
<td>-.251*</td>
<td>.056</td>
<td>.02</td>
<td>.106</td>
<td>.152</td>
</tr>
<tr>
<td>Instrumental Support</td>
<td>.01</td>
<td>-.208</td>
<td>.027</td>
<td>-.049</td>
<td>.105</td>
<td>.175</td>
</tr>
<tr>
<td>Distraction</td>
<td>-.030</td>
<td>-.147</td>
<td>.041</td>
<td>.062</td>
<td>.060</td>
<td>.036</td>
</tr>
<tr>
<td>Denial</td>
<td>.035</td>
<td>.122</td>
<td>.107</td>
<td>.074</td>
<td>-.008</td>
<td>-.060</td>
</tr>
<tr>
<td>Venting</td>
<td>.122</td>
<td>.018</td>
<td>.110</td>
<td>.104</td>
<td>-.031</td>
<td>-.032</td>
</tr>
<tr>
<td>Substance Use</td>
<td>.119</td>
<td>.001</td>
<td>-.035</td>
<td>-.069</td>
<td>-.108</td>
<td>.103</td>
</tr>
<tr>
<td>Disengagement</td>
<td>.439***</td>
<td>.431***</td>
<td>.329**</td>
<td>.384**</td>
<td>-.439**</td>
<td>-.490***</td>
</tr>
<tr>
<td>Self-Blame</td>
<td>.355**</td>
<td>.282*</td>
<td>.143</td>
<td>.458**</td>
<td>-.219</td>
<td>-.276*</td>
</tr>
</tbody>
</table>

N = 66.
*p<.05. **p<.01. ***p<.001.
Table 3.3

Correlations between coping strategies (from the Brief COPE) and hassles and uplifts (NES and PES scales)

<table>
<thead>
<tr>
<th>Coping Style</th>
<th>Hassles, frequency</th>
<th>Hassles, intensity</th>
<th>Uplifts, frequency</th>
<th>Uplifts, intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active coping</td>
<td>.196</td>
<td>.185</td>
<td>.082</td>
<td>.159</td>
</tr>
<tr>
<td>Planning</td>
<td>.265*</td>
<td>.250*</td>
<td>.098</td>
<td>.124</td>
</tr>
<tr>
<td>Reframing</td>
<td>-.033</td>
<td>-.051</td>
<td>.116</td>
<td>.138</td>
</tr>
<tr>
<td>Acceptance</td>
<td>.221</td>
<td>.194</td>
<td>.091</td>
<td>.066</td>
</tr>
<tr>
<td>Humour</td>
<td>.042</td>
<td>.011</td>
<td>.242</td>
<td>.261*</td>
</tr>
<tr>
<td>Religion</td>
<td>.157</td>
<td>.074</td>
<td>-.104</td>
<td>.031</td>
</tr>
<tr>
<td>Emotional Support</td>
<td>.164</td>
<td>.079</td>
<td>.181</td>
<td>.322**</td>
</tr>
<tr>
<td>Instrumental Support</td>
<td>.107</td>
<td>.055</td>
<td>.168</td>
<td>.212</td>
</tr>
<tr>
<td>Distraction</td>
<td>.067</td>
<td>.077</td>
<td>.204</td>
<td>.360**</td>
</tr>
<tr>
<td>Denial</td>
<td>-.016</td>
<td>.007</td>
<td>-.100</td>
<td>.027</td>
</tr>
<tr>
<td>Venting</td>
<td>.111</td>
<td>.160</td>
<td>.210</td>
<td>.086</td>
</tr>
<tr>
<td>Substance Use</td>
<td>.072</td>
<td>.029</td>
<td>.174</td>
<td>.137</td>
</tr>
<tr>
<td>Disengagement</td>
<td>.133</td>
<td>.137</td>
<td>-.231</td>
<td>-.174</td>
</tr>
<tr>
<td>Self-Blame</td>
<td>.298*</td>
<td>.292*</td>
<td>.229</td>
<td>.138</td>
</tr>
</tbody>
</table>

N = 66.
*p < .05. **p < .01.

3.4.2 Carer and Non-Carer Demographics and Descriptives

Table 3.4 reports the demographics for carers and non-carers. There were no significant differences between the groups with respect to age, gender or relationship status. However, carers were significantly less likely than non-carers to have a tertiary qualification, with 42% compared to 85%, $\chi^2 (1, N=66)=13.3$, $p<.001$. With regard to finances, carers
reported less time in paid employment per week than non-carers did, $t(65)=-2.8, p=.007$, but did not rate their felt financial security significantly lower than did non-carers. It is perhaps noteworthy, however, that carers rating of financial security fell below the mid-point of the scale, within the insecure range.

Table 3.4

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Carer (n=31)</th>
<th>Non-Carer (n=35)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender, female (%)</td>
<td>87.5</td>
<td>85.7</td>
</tr>
<tr>
<td>Relationship status, single (%)</td>
<td>74.2</td>
<td>65.7</td>
</tr>
<tr>
<td>Education, tertiary (%)</td>
<td>42*</td>
<td>85</td>
</tr>
<tr>
<td>M SD</td>
<td>M SD</td>
<td></td>
</tr>
<tr>
<td>Age, yrs</td>
<td>54.56 15.25</td>
<td>55.46 14.05</td>
</tr>
<tr>
<td>Financial security, /10</td>
<td>4.3 2.9</td>
<td>5.4 2.5</td>
</tr>
<tr>
<td>(0='v insecure'; 10='v secure')</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paid work, hrs</td>
<td>3.5* 9.3</td>
<td>16.3 15.9</td>
</tr>
</tbody>
</table>

Table 3.5 provides data relating to questions of relevance to carers only. On average, responses to the interview question asking carers to rate their global ability to cope with their role lay above the scale midpoint. However, their mean rating of support received indicated dissatisfaction with available assistance. The mean rating with respect to the health of the person they cared for was above the neutral midpoint. However, the mean rating of the independence of their care recipient, at around 30% capacity, combined with the long weekly hours reported in the carer role, provide support for the view that the carers within the study provided substantial care. Despite this, and the fact that some carers had been in their caregiver role for decades, the mean number of hours of respite reported was proportionately low.
Table 3.5

Mean responses on carer-specific interview questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Range</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of carer role (yrs)</td>
<td>2 - 40 yrs</td>
<td>12.6</td>
<td>10.3</td>
</tr>
<tr>
<td>Intensity of carer role (hrs per wk)</td>
<td>20 - 156 hrs</td>
<td>127</td>
<td>56</td>
</tr>
<tr>
<td>Respite (hrs per wk)</td>
<td>0 - 20 hrs</td>
<td>3.4</td>
<td>5.8</td>
</tr>
<tr>
<td>Recipient capacity, /10</td>
<td>0 = ‘totally dependent’, 10 = ‘independent’</td>
<td>3.1</td>
<td>2.2</td>
</tr>
<tr>
<td>Recipient health, /10</td>
<td>0 = ‘very poor’, 10 = ‘excellent’</td>
<td>6.1</td>
<td>2.4</td>
</tr>
<tr>
<td>Support, /10</td>
<td>0 = ‘none’, 10 = ‘all I need’</td>
<td>3.9</td>
<td>3.3</td>
</tr>
<tr>
<td>Coping, /10</td>
<td>0 = ‘very poor’, 10 = ‘excellent’</td>
<td>6.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>

n = 31

Table 3.6 reports the relationships between specific aspects of carers’ experience and the psychosocial measures used in the study. It is noteworthy that there was a moderate negative correlation between carers’ levels of perceived stress and their subjective evaluation of support received. A similar relationship was also evident for their felt ability to cope with their role and perceived stress levels. Correspondingly, there was a large positive association between SWB and felt support, though no significant relationship between SWB and coping. Also noteworthy, there was no significant relationship between SWB and carers’ ratings of the health or independence of their care recipient. There were also no significant relationships between the experience of hassles or uplifts and any carer-specific factors.
Table 3.6

**Correlations between carer-specific variables and psychosocial variables**

<table>
<thead>
<tr>
<th>Carer Variable</th>
<th>Perceived Stress</th>
<th>Depression</th>
<th>Anxiety</th>
<th>Chronic Arousal</th>
<th>Subjective Wellbeing</th>
<th>Social Functioning</th>
<th>Hassles, frequency</th>
<th>Hassles, intensity</th>
<th>Uplifts, frequency</th>
<th>Uplifts, intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>-.311</td>
<td>-.172</td>
<td>-.137</td>
<td>-.350</td>
<td>.322</td>
<td>.283</td>
<td>-.159</td>
<td>-.275</td>
<td>-.075</td>
<td>-.039</td>
</tr>
<tr>
<td>Intensity</td>
<td>.120</td>
<td>.062</td>
<td>.028</td>
<td>.048</td>
<td>-.174</td>
<td>.027</td>
<td>.128</td>
<td>.133</td>
<td>.134</td>
<td>.116</td>
</tr>
<tr>
<td>Respite</td>
<td>-.428</td>
<td>-.084</td>
<td>-.101</td>
<td>-.263</td>
<td>.431</td>
<td>.209</td>
<td>-.207</td>
<td>-.261</td>
<td>-.008</td>
<td>.039</td>
</tr>
<tr>
<td>Recipient capacity</td>
<td>.148</td>
<td>.223</td>
<td>-.028</td>
<td>.181</td>
<td>-.157</td>
<td>-.297</td>
<td>.011</td>
<td>-.073</td>
<td>.036</td>
<td>.069</td>
</tr>
<tr>
<td>Recipient health</td>
<td>-.106</td>
<td>.097</td>
<td>-.101</td>
<td>.155</td>
<td>.107</td>
<td>-.146</td>
<td>.311</td>
<td>-.136</td>
<td>-.142</td>
<td>-.165</td>
</tr>
<tr>
<td>Support</td>
<td>-.433***</td>
<td>.223</td>
<td>-.028</td>
<td>-.181</td>
<td>.657***</td>
<td>.251</td>
<td>.246</td>
<td>.189</td>
<td>.300</td>
<td>.276</td>
</tr>
<tr>
<td>Coping</td>
<td>-.406*</td>
<td>-.392</td>
<td>-.111</td>
<td>-.309</td>
<td>.036</td>
<td>.08</td>
<td>.008</td>
<td>-.154</td>
<td>.310</td>
<td>.237</td>
</tr>
</tbody>
</table>

n = 31.
*p<.05. **p<.01. ***p<.001.

3.4.3 Carer and Non-Carer Psychosocial Comparisons

Table 3.7 provides comparison data for carers’ and non-carers’ on psychosocial outcomes. In order to compare carer and non-carer outcomes, independent t-tests were conducted on sets of variables relating to health and psychosocial functioning.

3.4.4 Carers’ and Non-Carers’ Illness and Distress

Carers reported significantly more doctors’ visits, regarding their own health, than non-carers did, \( t(65)=2.65, p=.012 \), and also rated their overall health lower than non-carers did, \( t(65)=-3.27, p=.002 \). The carer group also reported significantly higher perceived stress, \( t(65)=5.11, p<.001 \), depression, \( t(65)=4.31, p<.001 \), anxiety, \( t(65)=3.54, p=.001 \), and chronic arousal, \( t(65)=4.08, p<.001 \). The effect size for each of these significant differences is large. See Table 3.7.
The DASS depression score for carers at 16.6, 95% CI [12.5, 20.6] differed little from the carer mean of 16.1 reported by Cummins (2007). As Cummins did not use the DASS anxiety subscale, no comparison with Australian carer population data for DASS anxiety was possible. The mean DASS stress score for carers at 21.2, 95% CI [17.1, 25.4] was very similar to the mean of 20.8 reported by Cummins (2007). Additionally, the DASS stress score for non-carers, at 10.6, 95% CI [8.4, 14.0] closely matched the population norm of 10.1 (SD=7.9) reported in the DASS manual (Lovibond & Lovibond, 1995).

It is noteworthy that carers’ mean DASS subscale scores for depression, anxiety and chronic arousal stress placed sample carers within the moderate range for all three indicators of psychological distress, whereas non-carer means sat within the non-clinical range compared to Australian norms (Lovibond & Lovibond, 1995). Cross-tabulation using DASS cut-off scores corresponding to moderate clinical levels, with an adjusted alpha of .017, indicated that carers were significantly more likely to experience at least moderate levels of depression, at 75% compared to 25% of non-carers, $\chi^2(1, N=66)=12.7, p<.001$. Similarly, there were significant differences in the proportion of carers reporting at least moderate levels of chronic arousal, with 78.3% of carers compared to 28.7% of non-carers, $\chi^2(1, N=66)=13.9, p<.001$, with DASS stress scores above the normal range. With respect to anxiety, however, the pattern did not reach significance at $\alpha=.017$. Indeed the ratio was much lower, with 47% of carers compared to 23% of non-carers with anxiety in the moderate or greater range, $\chi^2(1, N=66)=4.1, p=.04$. 
### Table 3.7

**Comparison between carers and non-carers on key psychosocial variables**

<table>
<thead>
<tr>
<th></th>
<th>Carer (n=31)</th>
<th>Non-Carer (n=35)</th>
<th>Cohen's d</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Health Variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doctors visits, past year</td>
<td>8.8*</td>
<td>4.5</td>
<td>.65</td>
</tr>
<tr>
<td>Self-rated Health, /10, (0 = 'very poor'; 10 = 'excellent')</td>
<td>6**</td>
<td>7.5</td>
<td>-.92</td>
</tr>
<tr>
<td><strong>Psychometric Scales</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived Stress (PSS-10, max 40)</td>
<td>22.6***</td>
<td>14.8</td>
<td>1.37</td>
</tr>
<tr>
<td>Depression (DASS-Depression, max 42)</td>
<td>16.6***</td>
<td>6.3</td>
<td>1.06</td>
</tr>
<tr>
<td>Anxiety (DASS-Anxiety, max 42)</td>
<td>12.2**</td>
<td>5.5</td>
<td>.90</td>
</tr>
<tr>
<td>Chronic Arousal (DASS-Stress, max 42)</td>
<td>21.2***</td>
<td>10.4</td>
<td>1.14</td>
</tr>
<tr>
<td>Hassles, frequency (NES-f, max 184)</td>
<td>30.7**</td>
<td>20.9</td>
<td>.66</td>
</tr>
<tr>
<td>Hassles, intensity (NES-i, max 184)</td>
<td>34.3*</td>
<td>20.7</td>
<td>.73</td>
</tr>
<tr>
<td>Uplifts, frequency (PES-f, max 172)</td>
<td>57.4</td>
<td>68.6</td>
<td>-.41</td>
</tr>
<tr>
<td>Uplifts, intensity (PES-i, max 172)</td>
<td>60.3</td>
<td>69.4</td>
<td>-.31</td>
</tr>
<tr>
<td>Subjective Wellbeing (PWI, max 100)</td>
<td>51.0***</td>
<td>70.2</td>
<td>-1.14</td>
</tr>
<tr>
<td>Social Functioning (WSAS, max 50)</td>
<td>14.8***</td>
<td>29.7</td>
<td>-1.57</td>
</tr>
</tbody>
</table>

* p<.05, ** p<.01, *** p<.001.

### 3.4.5 Differences in Carer and Non-Carer Stress

Stepwise logistic regression was performed to examine whether stress levels were indeed able to discriminate carers from non-carers. Four stress-related variables were entered: perceived stress, chronic arousal, hassles frequency (NES-f) and hassles intensity (NES-i). The final model was significant, $\chi^2(1, N=66)=20.84$, $p<.001$, indicating that it was able to distinguish between carers and non-carers. This model was able to explain between 27.8% (Cox & Snell R Square) and 37.1% (Nagelkerke R Square) of the variance in carer status. However, only perceived stress
was retained in order to achieve this, with 75% of cases able to be correctly classified using this variable alone, $B=0.189$, $SE=0.049$, \( \text{Wald}=14.66, \text{df}=1, p<.001 \), odds ratio=$0.83$, 95% CI $[0.75, 0.91]$. Clearly, levels of perceived stress best differentiated carer participants.

There are no suggested norms for the PSS scale (Cohen, et al., 1983). The current sample non-carer mean at 14.8, 95% CI $[12.4, 16.3]$, is similar to the comparison age mean of 12.6 ($SD=6.1$) reported by Cohen and Williamson (1988) in their original sample and the mean of non-carer controls of 12.8 ($SD=7.4$) reported by Brummett et al. (2006). The study carer mean PSS-10 score at 22.6, 95% CI $[20.1, 25.1]$, was higher than that reported by either de Vugt et al. (2005), $M=15.3$, or Brummett et al. (2006), $M=17.6$ ($SD=7.4$). However, those studies did not report using primary carers only.

It is also noteworthy that the NES scores, indicating the number and impact of daily hassles, showed that carers reported hassles with significantly greater frequency, $t(65)=2.63$, $p=.01$, and intensity, $t(65)=3$, $p=.004$, than did non-carers.

### 3.4.6 Carer and Non-Carer Coping

Table 3.8 reports carers’ and non-carers’ endorsement of the strategies covered by the Brief COPE. A series of t-tests with a Bonferroni adjusted alpha of $0.003$ was employed to examine the differences between carers and non-carers across the 14 coping strategy subscales. There appeared to be a trend toward carers using religion more frequently, $t(65)=2.2$, $p=.03$, and humour less frequently, $t(65)= -2.3$, $p=.025$. However, the only comparison to reach significance was with respect to the use of disengagement, with carer participants endorsing this approach more often, $t(65)=4.34$, $p<.001$, than non-carers.
### Table 3.8

*Comparison of Brief COPE scores between carers and non-carers*

<table>
<thead>
<tr>
<th>Coping Strategy Subscale (max score = 6)</th>
<th>Carer (n=31)</th>
<th>Non-Carer (n=35)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Active coping</td>
<td>4.5</td>
<td>1.4</td>
</tr>
<tr>
<td>Planning</td>
<td>4.8</td>
<td>1.4</td>
</tr>
<tr>
<td>Reframing</td>
<td>3.8</td>
<td>1.5</td>
</tr>
<tr>
<td>Acceptance</td>
<td>4.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Humour</td>
<td>1.4*</td>
<td>1.4</td>
</tr>
<tr>
<td>Religion</td>
<td>3.1*</td>
<td>2.6</td>
</tr>
<tr>
<td>Emotional Support</td>
<td>2.6</td>
<td>1.7</td>
</tr>
<tr>
<td>Instrumental Support</td>
<td>2.6</td>
<td>1.8</td>
</tr>
<tr>
<td>Distraction</td>
<td>3.0</td>
<td>1.9</td>
</tr>
<tr>
<td>Denial</td>
<td>.6</td>
<td>.9</td>
</tr>
<tr>
<td>Venting</td>
<td>1.82</td>
<td>1.2</td>
</tr>
<tr>
<td>Substance Use</td>
<td>.76</td>
<td>1.3</td>
</tr>
<tr>
<td>Disengagement</td>
<td>1.1***</td>
<td>1.1</td>
</tr>
<tr>
<td>Self-Blame</td>
<td>2.6</td>
<td>1.9</td>
</tr>
</tbody>
</table>

*p<.05. **p<.01. ***p<.001.

#### 3.4.7 Social Functioning and Uplifts

There were no significant differences between carers and non-carers with respect to the frequency and intensity of uplifts reported. However, carers did report significantly poorer social functioning compared to non-carers, $t(65)=-6.38$, $p<.001$. Given that the WSAS was substantially modified, from a tool for assessment of outcomes with psychiatric patients for use with the general population in the current study, comparison with other populations was not possible. Nevertheless, examination of participants scoring above 25, the revised cut-off score for adequate social functioning (i.e. the mid-point of the new scale with maximum of 50), did reveal that carers were less likely to function well socially. Indeed, carers were significantly less likely to report social functioning above this
proposed cut-off, with 16% of carers compared to 69% of non-carers scoring 25 or above, $\chi^2(1, N=66)=18.3, p<.001$. In addition, examination of the responses to individual items clearly demonstrated that carers reported lower functioning across each of five key social spheres. It is also noteworthy that mean carer responses across these items fell below the neutral midpoint of the response scale. See Figure 3.1 below.

![Figure 3.1. Carer and non-carer 95% confidence intervals for social functioning across the five items (max score = 10) of the modified Work & Social Adjustment Scale (WSAS).](image)

3.4.8 Carer and Non-Carer SWB

The mean PWI score for non-carers in the current study, at 70.2, 95% CI [65.9,74.4], is below the norm of 75 (normal range 73.4 to 76.4) reported for the general Australian population (Cummins, et al., 2007). Cummins argues that populations with a mean below 70 contain wide variability indicative of a large proportion of individuals unable to sustain SWB. However, the sample’s non-carer PWI mean is just above this 70 point lower bound suggested for psychologically healthy populations.
(Cummins, 2005b) and was taken to denote a population still able to provide resistance to homeostatic defeat (see Cummins, 2003).

Of particular interest to the current study, carers reported significantly lower SWB, \( t(65) = -4.7, p < .001 \), than did non-carers. The mean PWI score for carers in the current study of 51, 95% CI [43.6,58.4], was in line with the PWI means in Cummins et al.’s (2007) study which reported mean PWI scores of 58.2 for all carers surveyed and 56.7 for carers who had spent 10 to 19 years in a caregiving role. The somewhat higher values reported by Cummins may be associated with the higher proportion of males in his sample (20% compared to 10% in the current sample) and, more particularly, with his inclusion of non-primary carers. The findings are also consistent with others which have observed low quality of life among informal carers (Cummins, 2001; Pinquart & Sorensen, 2004; Schofield, 1997).

Cross-tabulation comparing SWB among carers and non-carers indicated that a large proportion of carers had global SWB scores below 50% of the PWI scale maximum. This midpoint score is a critical cut-off suggested by Cummins (2005a) with respect to sustainable individual SWB. Scores below this point are indicative of dissatisfaction, rather than satisfaction, and represent personal homeostatic defeat as well as high risk of depression (Cummins, 2005a). In the current study, 48% of carers’ scores were in the dissatisfied range compared to 8% of non-carers, \( \chi^2(1, N=66) = 13.1, p < .001 \). It should be noted that cumulative population data shows that only 4.4% of the Australian population report SWB below 50% of scale maximum (Cummins, 2010).

Carer and non-carer responses to the individual items of the PWI show a clear separation with respect to most life areas. With the exception of the item regarding satisfaction with personal safety, the means for most carer responses were close to neutral or in the dissatisfied range. See Figure 3.2.
3.5 Discussion

3.5.1 Carer Outcomes

Overall, this study reveals a picture of poor psychosocial outcomes for long-term primary carers. Carers visited their doctor more, rated their health as poorer and reported greater stress and distress than non-carers. The current findings are clearly not in line with those studies that have found no differences between carers and non-carers (Provinciali, et al., 2004) or even enhanced outcomes for carers (Brown, et al., 2009). The results do, however, support a growing body of research that has found carers to be more likely to experience poor psychological health (Briggs & Fisher, 2000; Cummins, et al., 2007; Edwards & Higgins, 2009; Gill, et al., 2007; Hirst, 2005; Morimoto, Schreiner, & Asano, 2003; Pakenham, et al., 2005; Pinquart & Sorensen, 2003) as well as to report more physical
health decrements (Schulz & Beach, 1999; Vitaliano, et al., 2003; Vitaliano & Young, 2004).

Crucially, the observed differences between carers and non-carers in this sample were not indicative of minor disparities but, rather, reflected large discrepancies across most psychosocial indicators measured. Mean carer results for depression anxiety and arousal stress corresponded with moderate clinical levels (Lovibond & Lovibond, 1995) also indicated poor psychological outcomes for carers in the study. Indeed, the experience of long-term primary caregiving appears to be characterised by perceived stress, depression, chronic arousal and anxiety, as well as frequent and intense hassles. Put another way, the role of long-term family caregiver seems likely to result in individuals feeling overwhelmed, down, agitated, anxious and hassled. In particular, levels of subjective stress as measured by the perceived stress scale provided the clearest difference between carers and those not in a caregiving role, with carers clearly experiencing life as more “unpredictable, uncontrollable, and overloading” (Cohen, 1986, p. 717).

The extent of these group differences can perhaps best be illustrated by a few comments from the participants themselves. When asked during an interview to describe their life in general non-carers responded with such comments as “life’s just fine”, “I’m happy”, “I’m glad I’m alive”, “I have a good life and I know it” or, at minimum, “OK”. Carer responses to the same enquiry, on the other hand, included statements such as “life as I knew it is gone”, “deep inside you’re screaming”. “I’m coping, not enjoying”, “it’s hell on earth” and even “at least one day I’ll be dead”.

3.5.2 Carer and Non-Carer Representativeness

It is noteworthy that non-carer participants reported somewhat higher perceived stress (PSS-10) values than might be expected in the general population, indicating the possibility that sample non-carers had relatively high levels of personal stress. Indeed, at interview non-carer
participants reported experiencing many life difficulties during the period prior to data collection. Examples of recent stressful experiences included the cancer diagnosis of a close relative, adjusting to a new job and a legal dispute over a rental bond. Nevertheless, non-carers did not report ongoing life difficulties but, rather, instances of stressful life events.

Additionally, despite the similarities between the current carer sample and other larger research samples, anecdotal evidence suggests that carers who participate in surveys and research are well functioning by comparison with carers who do not (T. Cannon, Carers Queensland, personal communication, August 11, 2008). Further evidence to support this view was gathered during the current study. Carers who made contact but did not participate reported that they did so because they felt unable to take part due to their caring commitments, rather than because they preferred not to. Such individuals expressed interest but mentioned a range of difficulties which precluded their taking part such as: having so little sleep that they felt unable to do anything beyond the absolute basics; feeling unable to cope any longer and the care recipient going into formal care; extreme distress due to a dispute with a service provider; and feeling extremely overcommitted and unwilling to take on any more. This would appear to indicate that, despite low carer SWB scores, long-term carers in this sample may have had better SWB than non-participating long-term primary carers.

Thus, it should be acknowledged that research data on carers may well be skewed by a greater participation rate among individuals who are coping relatively well. Moreover, given that carers in the current study may represent the better-faring end of the spectrum of the caregiving experience and that participating non-carers appeared to be doing a little more poorly than might be expected, any observed differences are likely to be an underestimate of broader disparities between these populations.
3.5.3 Carer Uplifts, Subjective Wellbeing and Social Functioning

The lack of significant differences between the frequency and intensity of uplifts experienced by carers and non-carers was somewhat unexpected and appears to sit in contrast to the remaining psychosocial data. It may be that carers derive benefit and uplift due to finding the caregiver role rewarding and meaningful (Beach, et al., 2000; Folkman & Moskowitz, 2000; Grant, et al., 1998; Pakenham, et al., 2005) and these may compensate for other lost opportunities. Since positive experiences may coexist with negative ones (Murray, 2007; Steptoe, et al., 2005) it may also be that the key feature of informal family caregiving is the imbalance in the ratio of positive and negative events, with the latter outweighing the former. An alternative possibility is that the PES and NES scales, which were adapted for the adult population from versions designed for university students (Maybery, et al., 2006; Maybery, et al., 2007), were not sensitive to the nuances of the experiences of caregiving. If this were the case, there may yet be differences in levels of positive experience undetected by the current study. Given the lack of comparison data on uplifts among informal family carers, it was not possible to make any conclusions regarding these alternative explanations. Indeed, future studies examining everyday positive experiences among caregivers are recommended.

There were clear differences observed however with respect to SWB and social functioning on both the full scale scores as well as across most individual scale items. Of note, carers were more likely to report social functioning below the suggested cut-off for impaired functioning (Mundt, et al., 2002). Moreover, carers were more likely to report SWB below Cummins’ (2005a; 2010) suggested critical cut-off for SWB maintenance (50% of scale maximum). This suggests that carers are likely to be at risk of depression and other health decrements (Cummins, 2010; Diener, et al., 2006). Since the data is cross-sectional in nature, however,
it is not possible to determine causality for reduced SWB and social functioning among carers.

Given the large differences between the groups on the other psychosocial measures it may be that carers’ higher levels of stress and distress contribute to their poorer social functioning and this leads to subsequent SWB decrements. Alternatively, it may be that their reduced ability to engage across core social domains is a precursor to the failure to maintain their emotional health and, subsequently, their SWB. It should be noted that carer interview data appeared to support the latter interpretation. When asked to describe their life circumstances adjectives such as ‘restricted’, ‘demanding’, ‘routine’ and ‘frustrating’ were common. Carers described a lack of freedom due to always feeling ‘on call’ and unable to make plans of their own. Many mentioned giving up previous enjoyable pursuits as well as an inability to participate in paid work due to their caregiving role. Such social restraints may play an important part in any failure of SWB homeostasis.

3.5.4 Disengagement and Caregiving

In the current study, use of the coping strategy ‘disengagement’ displayed strong links to stress and SWB. In particular, disengagement was positively correlated with the experience of both perceived stress and chronic arousal stress as well as depression and anxiety. This is in line with previous findings regarding links between strategies such as disengagement and poor psychological outcomes (Carver, et al., 1989; Vedhara, et al., 2000). Given that the disengagement subscale of the Brief COPE consists of two items which refer to ‘giving up trying to cope’ and ‘giving up trying to deal with it’, endorsement likely indicates that the limits of coping capacity have been reached. A disengagement response is consistent with Lazarus and Folkman’s (1984) transactional stress model, where the situation has been appraised as having exceeded available resources and, thus, wellbeing is indeed under serious threat. Further, the pattern of relationships with disengagement and other key variables fits
Cummins’ (2005b; 2010) notion of exceeding a personal stress threshold, beyond which personal SWB is unable to be maintained and risk of depression is heightened. The fact that carers in the current study used disengagement more than non-carers, alongside the data on psychological outcomes for carers, would be consistent with this interpretation. This is also consistent with the notion that many individuals are already at the upper limit of their adaptive capacity (Somerfield & McCrae, 2000). Indeed, the tendency for carers to employ disengagement more frequently and for this strategy to be associated with stress and distress may provide insight into the broader effects of the experience of prolonged challenge. This will be explored further in subsequent chapters.

The negative associations between disengagement and the adaptive outcomes of social functioning and SWB may point to this strategy as a potential marker of chronic stress effects. Indeed, this result is entirely consistent with a cognitive appraisal model since both these outcomes are considered key indicators of successful adaptation in the face of challenge (Lazarus, 1999; Lazarus & Folkman, 1984). In the case of disengagement, where the strategy of choice is, in fact, no strategy, it is perhaps predictable that an individual would be unable to either defend their own wellbeing or enhance it through social interaction. Furthermore, the inverse relationship between use of disengagement and both social functioning and SWB also supports Cummins’ (2010) model of wellbeing homeostasis. Indeed, the maintenance of a positive mood state through active cognitive strategies is seen as advantageous in an evolutionary sense whereas a failure to do so in the face of chronic and overwhelming challenge is a predictable contributor to clinical depression.

3.5.5 Conclusion

Outcomes for carers were markedly poorer than for non-carers across all key psychosocial variables. With respect to the experience of stress, carers reported higher stress levels than non-carers both as perceived stress and as symptoms of chronic arousal. Of particular
interest to the current study, carers were more likely to experience SWB at levels indicative of homeostatic failure. The current results appear to support the notion that “the sometimes twenty-four hour nature of the caring role multiplied across days and years cannot be underestimated in terms of the potentially negative effects on carers’ health” (O’Connell, et al., 2003, p.84).

“I’m coping, not enjoying”

(quote from carer participant)
Chapter 4 – Feeling Flat: Cortisol Rhythms, Wellbeing Homeostasis and sIgA Under Chronic Stress

4.1 Summary

Chronic stress is associated with poor SWB and, possibly, with levels outside the normative homeostatic range. Prolonged stress is also likely to be associated with a physiological imbalance known as allostatic load. The links between these may provide insight into the biopsychosocial costs of exposure to prolonged stress. In this component of the current study, the relationships between SWB, circadian cortisol patterns and sIgA levels were investigated among individuals experiencing chronic caregiver stress. Saliva suitable for cortisol and sIgA analysis was obtained from 26 informal primary carers and 29 non-carer controls on waking and retiring. These were compared to self-report measures of stress and SWB. There was a significant negative relationship between both waking cortisol and the diurnal cortisol amplitude and perceived stress, chronic arousal and the intensity of daily hassles across the whole sample. There was a corresponding significant positive association between these two cortisol measures and SWB. There were no significant differences between carers and non-carers on waking cortisol, diurnal cortisol amplitude or sIgA levels. However, participants whose SWB lay in the dissatisfied range were found to have significantly lower waking cortisol levels and flatter diurnal cortisol profiles compared to those in the satisfied SWB range. These findings point to physiological dysregulation as a likely correlate of SWB dysregulation. Further investigation of these links with diurnal cortisol patterns are needed to determine the potential utility of a homeostatic model of SWB to the understanding of global outcomes under chronic stress.
“deep inside you’re screaming”

(quote from carer participant)

4.2 Introduction

4.2.1 Cortisol, Subjective Wellbeing and Stress

As previously noted, stress involves the perception of a threat to personal wellbeing (Lazarus & Folkman, 1984) but is also described as perception of a threat to physiological homeostasis (Chrousos, 2009; McEwen, 2000b). If SWB is accepted to have a biological basis (Davern, et al., 2007) these definitions may not differ markedly. Indeed, given that HPA functioning is acknowledged to be vital to the maintenance of homeostasis (Fries, et al., 2009; Tsigos & Chrousos, 2002), it could be argued that cortisol regulation has considerable potential for understanding the links between subjective wellbeing and stress. As the end-product of the threat response and its associated HPA axis activity, cortisol is already considered to be an ideal biomarker of stress (Clow, 2004; Hellhammer, et al., 2009; O'Connor, et al., 2000), although the exact nature of this relationship remains elusive (Chrousos, 2009). While, greater perceptions of stress tend to be associated with increased cortisol production (Pruessner, et al., 1999; Rosmond, et al., 1998; Volkmann & Weekes, 2006), depleted cortisol levels have also been linked to increased stress, particularly under chronic conditions (Kudielka, et al., 2009; Miller, et al., 2007).

The circadian rhythm of cortisol appears to offer particular potential for improved understanding of global stress effects and possible links to global SWB. It has been suggested that lifestyle choices while under stress may contribute to cortisol dysregulation (McEwen, 2008) and, as noted in the Introduction, positive psychological states have also been linked to lower daily cortisol output (Ryff, et al., 2004; Steptoe, et al., 2005)
though not necessarily to quality of life (Provinciali, et al., 2004; Ryff, et al., 2004). Given that healthy HPA axis functioning is associated with a pattern of high morning and low evening cortisol levels (Rosmond, et al., 1998), changes in cortisol rhythmicity have potential as indicators of long-term consequences. Again, however, mixed effects are reported in the literature. For example, the morning cortisol rise has been found to be positively associated with general life stress and job stress but negatively correlated with chronic stress (Chida & Steptoe, 2009; Fries, et al., 2009). Decreased cortisol rhythm amplitude has been observed under conditions of prolonged stress as both reduction in the morning zenith and elevation of the evening nadir (Barker, et al., 2012; Chrousos & Gold, 1998; Izawa, et al., 2012; Rosmond, et al., 1998). The nature of a cortisol rise may also be open to interpretation, such as in the case of long-term temporary employees where a high morning rise results not from rising to high levels but because of a very low baseline (Gustafsson, et al., 2012). With regard to carers, results on cortisol rhythms are mixed, with some studies reporting higher waking cortisol (de Vugt, et al., 2005) and others higher evening nadirs (Da Roza Davis & Cowen, 2001). Yet other carer studies have found no differences in morning cortisol levels between carers and controls (Lovell, et al., 2012; Provinciali, et al., 2004; Rohleder, et al., 2009; Vedhara, et al., 2003; Wahbeh, Kishiyama, Zajdel, & Oken, 2008).

4.2.2 Immunity and Stress

A well-functioning immune system is also essential to homeostasis (Rabin, 1999) and good health (Kiecolt-Glaser, McGuire, Glaser, et al., 2002). As noted earlier, the experience of acute stress tends to enhance immunity while chronic stress tends to be associated with immune decrements (Cohen, Miller, & Rabin, 2001; Herbert & Cohen, 1993; Kiecolt-Glaser, McGuire, Glaser, et al., 2002; Kim & Maes, 2003; McEwen, 2000b; Rabin, 1999). Indeed, prolonged stress is associated with immune suppression no matter what immune marker is investigated (Segerstrom & Miller, 2004) and elevated cortisol levels may play a role in immune
suppression (Cohen, et al., 2001). Indeed, it appears that chronic stress may be linked to problems maintaining a well-functioning immune system (Burns, et al., 2003). For example, dementia carers exhibit decreasing immunity over time rather than immune adaptation (Lutgendorf & Costanzo, 2003), although this may be confounded by the effects of ageing. Indeed, older caregivers have been found to show poorer cellular immune responses compared to non-caregivers but this was not associated with differences in humoral activity (Wong, et al., 2012) yet younger carer groups have been shown to exhibit elevated cytokine levels (Lovell, et al., 2012).

The antibody sIgA is considered to play a critical role in maintaining good health (Woof & Kerr, 2006) and it can be used to provide a simple yet reliable estimate of immune function (Hofman, 2001; Tsujita & Morimoto, 1999). Indeed, given that sIgA can be affected by stressful life events (Phillips, et al., 2006; Valdimarsdottir & Stone, 1997), exam stress (Deinzer, et al., 2000) and general stress perceptions (Ng, et al., 1999; Yang, et al., 2002) it appears to be an ideal choice as a marker of stress effects among carers. However, carer sIgA has rarely been investigated. The one study reported indicates that low sIgA appears to be associated with increased carer burden (Gallagher, et al., 2008). Of particular interest here, previous studies have not simultaneously investigated the links between SWB, cortisol and sIgA nor have they examined these relationships under conditions of chronic stress. While previous work has been limited and inconsistent (Pressman & Cohen, 2005), clarification of these relationships appears to have great potential for understanding global outcomes under chronic stress.

4.2.3 Subjective Wellbeing and Homeostatic Thresholds

As proposed in the introductory chapter, Cummins’ (2010) notion of a wellbeing threshold for conceptualising chronic stress effects may have particular relevance for considering any associated physiological changes. For example, the suggested threshold of 50% scale maximum (the neutral
point between satisfaction and dissatisfaction) may provide a useful criterion for consideration of indications of allostatic load, such as circadian dysregulation and altered immune functioning. It appears that previous reports of inter-individual differences in quality of life outcomes have not recognised the possibility of a SWB homeostat. However, a few studies have used an SWB cut-point to good effect, finding dissatisfaction with life was linked to poorer post-surgery outcomes (Sinikallio, et al., 2009) and was linked to sleep quality below a minimum level (Paunio, et al., 2008). Studies of the relationship between the experience of stress and ultimate health and wellbeing outcomes, may benefit from the use of this binary approach involving a relatively simple division of participants into satisfied and dissatisfied SWB groups.

4.2.4 Aims and Hypotheses

This component of the current study aimed to take a biopsychosocial approach to examining chronic stress effects by investigating the relationship between SWB, cortisol patterns and sIgA levels. A further aim was to explore the possible utility of a SWB cut-point. It was expected that long-term primary carers, who have been shown in the previous chapter to report poorer SWB than non-carers, would also display cortisol dysregulation and lower sIgA. It was predicted that individuals reporting SWB in the dissatisfied range (i.e. below 50% scale maximum) would be particularly likely to exhibit cortisol dysregulation and lower sIgA compared to individuals with SWB in the satisfied range.

4.3 Method

Chapter 2 provides a description of all psychological and physiological measures relevant to this chapter. Appendices J and K give information on the saliva collection instructions and interview topics. The reader is reminded that only a subset of the original participant group provided saliva samples suitable for analysis so that the sub-sample providing cortisol data was reduced to 55. Participants were asked to
collect all data within one week, including information on any symptoms of illness and any substance use. They collected morning and evening saliva samples over two consecutive days during that week and kept them in their own freezer until collection.

4.4 Results

4.4.1 Statistical Analyses

Pearson correlation coefficients were employed to examine the relationships between psychological measures of stress and SWB and the physiological markers of diurnal cortisol patterns and sIgA. Chi-square tests of independence were employed to test for differences between carers and non-carers and between satisfied and dissatisfied SWB groups on categorical measures. A series of independent t-tests were conducted to examine group differences on continuous variables. Student t-tests were used to compare carer and non-carer groups while unequal variance t-tests were used to compare satisfied and dissatisfied SWB groups due to the differences in group size (see Ruxton, 2006). The influence of the carer role on the relationship between the psychological variables and sIgA was examined using moderated multiple regression as recommended by Aguinis et al. (2005).

4.4.2 Stress, Subjective Wellbeing and Cortisol

The correlations between the key variables of interest are provided in Table 4.1. Waking cortisol and the diurnal cortisol amplitude were significantly negatively correlated with perceived stress and with chronic arousal. Waking cortisol also exhibited a significant negative relationship with the intensity rating of daily hassles. Of particular interest to the current study, waking cortisol levels and cortisol amplitude were both significantly positively correlated with SWB. The correlation between sIgA and anxiety approached significance, $r = -.235$, $p = .085$. 
### Table 4.1

**Correlations between cortisol, slgA and key psychological measures**

<table>
<thead>
<tr>
<th></th>
<th>Waking cortisol</th>
<th>Bedtime cortisol</th>
<th>Cortisol amplitude</th>
<th>slgA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waking cortisol</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedtime cortisol</td>
<td>.426***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cortisol amplitude</td>
<td>.945***</td>
<td>.106</td>
<td></td>
<td></td>
</tr>
<tr>
<td>slgA</td>
<td>.001</td>
<td>.093</td>
<td>-.134</td>
<td></td>
</tr>
<tr>
<td>Perceived Stress</td>
<td>-.320*</td>
<td>-.006</td>
<td>-.307*</td>
<td>-.073</td>
</tr>
<tr>
<td>Depression</td>
<td>-.199</td>
<td>-.054</td>
<td>-.169</td>
<td>-.093</td>
</tr>
<tr>
<td>Anxiety</td>
<td>-.213</td>
<td>-.214</td>
<td>-.138</td>
<td>-.235</td>
</tr>
<tr>
<td>Chronic Arousal</td>
<td>-.319*</td>
<td>-.075</td>
<td>-.304*</td>
<td>-.125</td>
</tr>
<tr>
<td>Hassles, frequency</td>
<td>-.213</td>
<td>.026</td>
<td>-.193</td>
<td>-.169</td>
</tr>
<tr>
<td>Hassles, intensity</td>
<td>-.289*</td>
<td>-.109</td>
<td>-.246</td>
<td>-.174</td>
</tr>
<tr>
<td>Disengagement</td>
<td>-.179</td>
<td>-.073</td>
<td>-.177</td>
<td>-.130</td>
</tr>
<tr>
<td>Uplifts, frequency</td>
<td>.098</td>
<td>-.015</td>
<td>.055</td>
<td>.044</td>
</tr>
<tr>
<td>Uplifts, intensity</td>
<td>.095</td>
<td>-.067</td>
<td>.09</td>
<td>.051</td>
</tr>
<tr>
<td>Subjective Wellbeing</td>
<td>.287*</td>
<td>-.059</td>
<td>.268*</td>
<td>.041</td>
</tr>
<tr>
<td>Social Functioning</td>
<td>.145</td>
<td>-.066</td>
<td>.189</td>
<td>.091</td>
</tr>
</tbody>
</table>

\( n = 55. ^* n = 53. ^* p < .05. ^** p < .01. ^*** p < .001. \)

#### 4.4.3 Carers’ and Non-Carers’ Health and Health Behaviours

Table 4.2 provides comparison data for carers’ and non-carers’ on age, self-rated health, endorsement of key health behaviours and use of common substances. There were no significant differences between the groups on age. However, they did differ significantly with respect to health perceptions, with carers rating their health as significantly poorer, \( t(54) = -2.6, p = .015 \). Nevertheless, chi-square tests of independence did not indicate any significant differences between carers and non-carers regarding their endorsement of regular exercise, maintaining a balanced diet or having regular medical checkups. There were also no significant differences between the groups with regard to 7-day diary means for intake of nicotine, caffeine or alcohol.
Table 4.2

Comparison of age & health behaviour variables for carers and non-carers

<table>
<thead>
<tr>
<th></th>
<th>Carer (n=26)</th>
<th>Non-Carer (n=29)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female (frequency)</td>
<td>23 (88%)</td>
<td>26 (89%)</td>
</tr>
<tr>
<td>Age, years</td>
<td>54.23 15</td>
<td>52.03 12.1</td>
</tr>
<tr>
<td>Self-rated Health, /10</td>
<td>6.3** 1.9</td>
<td>7.5 1.1</td>
</tr>
<tr>
<td>Health Habits (endorsement frequency)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regular exercise routine</td>
<td>17 (65%)</td>
<td>21 (72%)</td>
</tr>
<tr>
<td>Balanced diet</td>
<td>24 (92%)</td>
<td>25 (86%)</td>
</tr>
<tr>
<td>Regular medical checkups</td>
<td>15 (58%)</td>
<td>17 (59%)</td>
</tr>
<tr>
<td>Daily Substance Use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nicotine</td>
<td>1.6 6.0</td>
<td>1.3 3.5</td>
</tr>
<tr>
<td>Caffeine</td>
<td>1.6 1.1</td>
<td>2.1 1.2</td>
</tr>
<tr>
<td>Alcohol</td>
<td>1.0 1.1</td>
<td>1.4 1.1</td>
</tr>
</tbody>
</table>

*1 unit = 1 cigarette, 1 cup coffee or 1 standard drink (or equivalent)

Table 4.3 provides comparison data for the carer and non-carer groups on the physiological measures. There were no significant differences in sIgA levels. There were also no significant differences between the groups for waking cortisol, bedtime cortisol or the daily cortisol amplitude.
Table 4.3
Comparison of sIgA and cortisol levels for carers and non-carers

<table>
<thead>
<tr>
<th>Immune Marker</th>
<th>Carer (n=26)</th>
<th>Non-Carer (n=29)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sIgA¹, pg/mL</td>
<td>.040 ± .028</td>
<td>.049 ± .027</td>
</tr>
<tr>
<td>Cortisol Analyses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waking cortisol, nmol/mL</td>
<td>14.19 ± 7.51</td>
<td>16.64 ± 10.72</td>
</tr>
<tr>
<td>Bedtime cortisol, nmol/mL</td>
<td>5.32 ± 3.65</td>
<td>5.12 ± 2.53</td>
</tr>
<tr>
<td>Cortisol amplitude, nmol/mL</td>
<td>8.87 ± 6.84</td>
<td>11.51 ± 9.88</td>
</tr>
</tbody>
</table>

¹ N = 53 (n = 26 & 27 respectively)

4.4.4 Caregiving and a Subjective Wellbeing Threshold

As previously noted, a global PWI score below the mid-point of 50 represents a score within the dissatisfied range of the scale (i.e. below the neutral midpoint). Cummins (2005a; 2010) has suggested that such scores indicate a failure to maintain SWB homeostasis. This cut-score was used to re-examine the proportion of carers, in the reduced sample who provided saliva samples, were more likely to experience SWB below this point. A Chi-square test of independence again revealed a significant difference between the two groups, with 11 carers (42%) compared to 2 non-carers (7%) reporting PWI scores below 50, \( \chi^2 (1, N=55)=9.52, p<.01 \).

In order to investigate these differences further, sample participants were categorised into two (uneven) groups according to this PWI cut-off and compared across the key study variables. Tables 4.4, 4.5 and 4.6 report comparisons between these satisfied and dissatisfied SWB groups.

From Table 4.4 it is clear that individuals with SWB in the dissatisfied range reported significantly higher scores for perceived stress, \( t(54)=3.9, p<.001 \), depression, \( t(54)=6.54, p<.001 \), and chronic arousal stress, \( t(54)=3.92, p<.001 \). The groups also differed significantly with respect to the experience of hassles, with both frequency, \( t(54)=2.75, p<.001 \), and
By definition, SWB levels between the groups differed, with those reporting dissatisfaction indicating significantly lower levels than those not, $t(54)=-9.7, p<.001$. Social functioning was also significantly lower among those who reported SWB in the dissatisfied range, $t(54)=-4.8, p<.001$. 

Table 4.4

Comparison of psychological variables for groups with SWB above and below Cummins’ wellbeing threshold

<table>
<thead>
<tr>
<th>Psychometric Scales</th>
<th>SWB Range</th>
<th>“Dissatisfied”</th>
<th>“Satisfied”</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$(n=13)$</td>
<td>$(n=42)$</td>
<td></td>
</tr>
<tr>
<td>Perceived Stress (PSS-10, max 40)</td>
<td></td>
<td>24.3**</td>
<td>16.5</td>
<td>1.73</td>
</tr>
<tr>
<td>Depression (DASS-Depression, max 42)</td>
<td></td>
<td>22.7***</td>
<td>6.1</td>
<td>1.31</td>
</tr>
<tr>
<td>Anxiety (DASS-Anxiety, max 42)</td>
<td></td>
<td>13.2</td>
<td>6.1</td>
<td>.76</td>
</tr>
<tr>
<td>Chronic Arousal (DASS-Stress, max 42)</td>
<td></td>
<td>25.2**</td>
<td>12.5</td>
<td>1.23</td>
</tr>
<tr>
<td>Hassles, frequency (NES-f, max 184)</td>
<td></td>
<td>35.6*</td>
<td>21.5</td>
<td>.86</td>
</tr>
<tr>
<td>Hassles, intensity (NES-i, max 184)</td>
<td></td>
<td>40.1**</td>
<td>22</td>
<td>.92</td>
</tr>
<tr>
<td>Disengagement, (BriefCOPE scale, max 6)</td>
<td></td>
<td>1.2</td>
<td>.4</td>
<td>3.61</td>
</tr>
<tr>
<td>Uplifts, frequency (PES-f, max 172)</td>
<td></td>
<td>57.1</td>
<td>65.8</td>
<td>-.31</td>
</tr>
<tr>
<td>Uplifts, intensity (PES-i, max 172)</td>
<td></td>
<td>61.4</td>
<td>66.6</td>
<td>-.18</td>
</tr>
<tr>
<td>Subjective Wellbeing (PWI, max 100)</td>
<td></td>
<td>37.5***</td>
<td>70</td>
<td>-3.01</td>
</tr>
<tr>
<td>Social Functioning (WSAS, max 50)</td>
<td></td>
<td>12.8**</td>
<td>26.4</td>
<td>-1.31</td>
</tr>
</tbody>
</table>

*p<.05. **p<.01. ***p<.001

$p=.012$, and intensity, $t(54)=3.1$, $p=.006$, higher for those in the lower SWB group. However, the use of disengagement as a coping strategy was not significantly different for those with SWB in the dissatisfied range, although the difference did approach significance, $t(54)=2.1, p=.058$. Levels of anxiety were also not significantly different between the SWB groups, although, once again, the difference between the means did approach significance, $t(54)=2.12, p=.052$. 

Table 4.4

Comparison of psychological variables for groups with SWB above and below Cummins’ wellbeing threshold

<table>
<thead>
<tr>
<th>Psychometric Scales</th>
<th>SWB Range</th>
<th>“Dissatisfied”</th>
<th>“Satisfied”</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$(n=13)$</td>
<td>$(n=42)$</td>
<td></td>
</tr>
<tr>
<td>Perceived Stress (PSS-10, max 40)</td>
<td></td>
<td>24.3**</td>
<td>16.5</td>
<td>1.73</td>
</tr>
<tr>
<td>Depression (DASS-Depression, max 42)</td>
<td></td>
<td>22.7***</td>
<td>6.1</td>
<td>1.73</td>
</tr>
<tr>
<td>Anxiety (DASS-Anxiety, max 42)</td>
<td></td>
<td>13.2</td>
<td>6.1</td>
<td>.76</td>
</tr>
<tr>
<td>Chronic Arousal (DASS-Stress, max 42)</td>
<td></td>
<td>25.2**</td>
<td>12.5</td>
<td>1.23</td>
</tr>
<tr>
<td>Hassles, frequency (NES-f, max 184)</td>
<td></td>
<td>35.6*</td>
<td>21.5</td>
<td>.86</td>
</tr>
<tr>
<td>Hassles, intensity (NES-i, max 184)</td>
<td></td>
<td>40.1**</td>
<td>22</td>
<td>.92</td>
</tr>
<tr>
<td>Disengagement, (BriefCOPE scale, max 6)</td>
<td></td>
<td>1.2</td>
<td>.4</td>
<td>3.61</td>
</tr>
<tr>
<td>Uplifts, frequency (PES-f, max 172)</td>
<td></td>
<td>57.1</td>
<td>65.8</td>
<td>-.31</td>
</tr>
<tr>
<td>Uplifts, intensity (PES-i, max 172)</td>
<td></td>
<td>61.4</td>
<td>66.6</td>
<td>-.18</td>
</tr>
<tr>
<td>Subjective Wellbeing (PWI, max 100)</td>
<td></td>
<td>37.5***</td>
<td>70</td>
<td>-3.01</td>
</tr>
<tr>
<td>Social Functioning (WSAS, max 50)</td>
<td></td>
<td>12.8**</td>
<td>26.4</td>
<td>-1.31</td>
</tr>
</tbody>
</table>

*p<.05. **p<.01. ***p<.001
There were no significant differences, however, on the frequency or intensity of uplifts experienced by the two groups.

Table 4.5 provides further information on the differences between the two SWB groups. It should be noted that individuals with SWB in the dissatisfied range were significantly younger than those in the satisfied group, \( t(54) = -2.63, p = .013 \). As previously noted, this group also comprised a disproportionately large number of carers and all were female. Additionally, those dissatisfied with their life rated their health as significantly worse than those with PWI scores in the satisfied range, \( t(54) = -3.2, p = .003 \). Chi square tests for independence did not reveal any significant differences regarding endorsement of health habits nor did the t-tests indicate any differences in the use of nicotine or caffeine. However, the difference between the groups on use of alcohol was significant, \( t(54) = -2.5, p = .019 \), with those in the dissatisfied group tending to use less alcohol.

As shown in Table 4.6, there were no significant differences in bedtime cortisol values or for sIgA levels. However, waking cortisol levels were significantly lower among those with PWI scores in the dissatisfied range, \( t(54) = -2.6, p = .013 \), and the diurnal cortisol amplitude was significantly flatter in the dissatisfied group, \( t(54) = -2.5, p = .016 \).
Table 4.5

Comparison of age and health behaviour variables for groups with SWB above and below Cummins' wellbeing threshold

<table>
<thead>
<tr>
<th>SWB Range</th>
<th>“Dissatisfied” (n=13)</th>
<th>“Satisfied” (n=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carer role (frequency)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>11 (85%)</td>
<td>15 (36%)</td>
</tr>
<tr>
<td>Female (frequency)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>13 (100%)</td>
<td>36 (86%)</td>
</tr>
<tr>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Age, years</td>
<td>46.23*</td>
<td>9.52</td>
</tr>
<tr>
<td>Self-rated Health, /10</td>
<td>5.8**</td>
<td>1.6</td>
</tr>
<tr>
<td>Health Habits (endorsement frequency)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regular exercise routine</td>
<td>9 (69%)</td>
<td>29 (69%)</td>
</tr>
<tr>
<td>Balanced diet</td>
<td>11 (85%)</td>
<td>38 (90%)</td>
</tr>
<tr>
<td>Regular medical checkups</td>
<td>7 (54%)</td>
<td>25 (60%)</td>
</tr>
<tr>
<td>Daily Substance Use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nicotine</td>
<td>1.5</td>
<td>3.40</td>
</tr>
<tr>
<td>Caffeine</td>
<td>2.0</td>
<td>1.49</td>
</tr>
<tr>
<td>Alcohol</td>
<td>0.7*</td>
<td>.6</td>
</tr>
</tbody>
</table>

*1 unit = 1 cigarette, 1 cup coffee or 1 standard drink (or equivalent)
*p<.05. **p<.01

Table 4.6

Comparison of sIgA and cortisol levels for groups with SWB above and below Cummins’ wellbeing threshold

<table>
<thead>
<tr>
<th>SWB Range</th>
<th>“Dissatisfied” (n=13)</th>
<th>“Satisfied” (n=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immune Marker</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sIgA, pg/mL</td>
<td>.034</td>
<td>.026</td>
</tr>
<tr>
<td>Cortisol Analyses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waking cortisol, nmol/mL</td>
<td>11.38*</td>
<td>4.91</td>
</tr>
<tr>
<td>Bedtime cortisol, nmol/mL</td>
<td>4.67</td>
<td>3.51</td>
</tr>
<tr>
<td>Cortisol amplitude, nmol/mL</td>
<td>6.71*</td>
<td>4.51</td>
</tr>
</tbody>
</table>

N=53 (n=13 & 40 respectively)
*p<.05.
4.4.5 Immunity, Chronic Stress and Subjective Wellbeing

In order to examine whether the carer role moderated the relationship between sIgA and the psychological variables, a series of moderated regressions was conducted. No effect was observed with respect to the possible moderating effect of the carer role on the relationship between sIgA and SWB, perceived stress, anxiety or depression. However, for chronic arousal stress the interaction approached significance, with lower sIgA concentrations observed in carers with higher chronic arousal (see Tables 4.7 and 4.8).

Table 4.7
Results of the hierarchical moderated multiple regression analysis of chronic arousal stress, carer role and their interaction on sIgA

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>$R^2$</th>
<th>adjusted $R^2$</th>
<th>$\Delta R^2$</th>
<th>$F\Delta$</th>
<th>df</th>
<th>signif of $F\Delta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>DASS stress</td>
<td>.016</td>
<td>.008</td>
<td>.008</td>
<td>.663</td>
<td>1,49</td>
<td>.420</td>
</tr>
<tr>
<td>DASS stress &amp; Carer role</td>
<td>.019</td>
<td>.029</td>
<td>.011</td>
<td>.397</td>
<td>2,48</td>
<td>.675</td>
</tr>
<tr>
<td>DASS stress, Carer role &amp; DASS stress-Carer Interaction</td>
<td>.159</td>
<td>.096</td>
<td>.06</td>
<td>2.524</td>
<td>3,47</td>
<td>.071</td>
</tr>
</tbody>
</table>

Table 4.8
Contributions of DASS stress, carer role and their interaction to the final model

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>$\beta$</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>DASS stress</td>
<td>.001</td>
<td>.510</td>
<td>1.784</td>
<td>.082</td>
</tr>
<tr>
<td>Carer role</td>
<td>.023</td>
<td>.432</td>
<td>1.702</td>
<td>.097</td>
</tr>
<tr>
<td>DASS stress X Carer</td>
<td>-.002</td>
<td>-1.02</td>
<td>-2.582</td>
<td>.014</td>
</tr>
</tbody>
</table>

$R^2 = .159$. Adj $R^2 = .096$. $F(3,47)=2.524$. SE=.025.
4.5 Discussion

4.5.1 Cortisol and sIgA Patterns in Carers and Non-Carers

Overall, the results did not support the prediction that, compared to non-carers, carers would exhibit disturbed cortisol patterns, in the form of differences in morning peak or evening nadir values or in daily cortisol amplitude. This was despite clear evidence that carers experienced poorer outcomes, with significantly lower SWB and correspondingly high levels of depression, anxiety and stress. These results on these physiological markers stand in contrast to the results reported in the previous chapter, where psychological outcomes for carers were significantly lower across all indicators. Indeed, the current findings are not consistent with the view that carers are more likely to demonstrate physiological decrements or that biological changes are the inevitable sequelae of chronic stress.

Thus, the current findings do not support previous findings of higher cortisol values among caregivers (Da Roza Davis & Cowen, 2001; de Vugt, et al., 2005; Vedhara, et al., 1999). The current results are, rather, consistent with reports of comparable morning cortisol levels between non-spousal dementia carers and controls (Provinciali, et al., 2004), although the current results do not show similar levels of life satisfaction as that study did. The findings of the current study are perhaps most consistent with findings of no differences in daily cortisol production between carers and non-carers despite large differences in measures of stress and distress (Gonzalez-Bono, et al., 2011; Vedhara, et al., 2003). The results also align with Schwarz and Dunphy’s (2003) finding of no link between caregivers’ perceived stress and cortisol levels as well as comparable neuroendocrine reactivity among carers and non-carers (Cacioppo, et al., 2000). It is noteworthy, however, that carers and non-carers did not differ on lifestyle measures, such as regular exercise and the use of caffeine which have been proposed as a potential pathway of chronic stress effects (McEwen, 2008; O’Connor, et al., 2009).
With respect to immunity, the prediction that carers would exhibit lower levels of sIgA was not supported. This finding appears to be congruent with Volkman and Weekes’ (2006) report of no effect on sIgA due to exam stress. However, it was not in line with other studies of sIgA decrements due to prolonged exam effects (Deinzer, et al., 2000) or negative life events (Phillips, et al., 2006). The current results also stand in contrast to previous reports of lower sIgA among nurses reporting high levels of perceived stress (Yang, et al., 2002) and, in particular, findings of decrements in other immune markers found among caregivers (Cacioppo, et al., 1998; Kiecolt-Glaser, et al., 1987; Provinciali, et al., 2004; Vedhara, et al., 1999). Nevertheless, the current findings are consistent with the only study to date of sIgA in caregivers, where there was no overall difference between carers and non-carers for sIgA (Gallagher, et al., 2008).

Thus, despite the role of sIgA as a first line of defence against pathogens (Woof & Kerr, 2006) and related evidence that carers tend to have longer episodes of flu (Provinciali, et al., 2004) and increased risk of respiratory infection (Kiecolt-Glaser, Dura, Speicher, Trask, & Glaser, 1991; Vitaliano, et al., 2003), there was no evidence of immune decrements among participating carers. It is important to note however that sIgA comparisons were based on a somewhat reduced sample of participants. Additionally, the moderated regressions provided some indication that the experience of chronic arousal among caregivers may be related to sIgA decrements and this would be worthy of further investigation. It is also notable that only one previous study on carers has used sIgA as an immune marker wherein it seemed particularly sensitive to ageing (Gallagher, et al., 2008). It may be that sIgA in younger individuals experiencing ongoing stress do not follow this trend. Indeed, the current results could be seen as lending support to Stowell et al.’s (2001) and Bosch et al.’s (2001) conclusions regarding cellular immunity, that immune outcomes appear to depend on a complex inter-relationship between perceived stress and coping patterns. In that case, multiple factors, including basal and reactive immunity may determine current levels.
4.5.2 Cortisol, Stress and Distress

The correlational results do however, provide support for the prediction that lower SWB would be associated with reduced variability of cortisol rhythms, specifically lower values for the morning rise and less amplitude in the daily rhythm. Indeed, higher reported stress was associated with lower morning cortisol peaks and a flatter diurnal decline, supporting previous similar findings regarding the relationship between chronic stress and waking cortisol (Edwards, et al., 2003; O'Connor, et al., 2009) and diurnal cortisol (Chrousos & Gold, 1998; Rosmond, et al., 1998; van Cauter, et al., 1996). The current results are also consistent with evidence of flattened cortisol rhythms being associated with allostatic load (Abercrombie, et al., 2004; McEwen, 2000a) as well as those showing a negative relationship between morning cortisol levels and outcomes such as exhaustion, fatigue and burnout (Chida & Steptoe, 2009; Pruessner, et al., 1999). However, they stand in contrast to reports of a positive relationship between morning cortisol values and perceived stress (Pruessner, et al., 1999; Volkmann & Weekes, 2006) including among caregivers (de Vugt, et al., 2005). These discrepancies may be due to the use of relatively young samples in studies reporting positive links between cortisol and stress. They may also be related to some studies inclusion of individuals who had experienced relatively short-term challenge and were likely to be still operating within their adaptive capacity.

Indeed, methodological differences may explain the contrast between the current findings and those of Vugt et al., since the dementia carers in their sample did not appear to be comparable to the primary carers in either the current study or other recent Australian reports (Cummins, et al., 2007). De Vugt et al. investigated individuals who had been providing care for an average of 31 months but some had had as little as three months in a carer role and some only had contact with their care recipient once per week. This latter point is consistent with the large differences in scores for perceived stress between carers in de Vugt et
al.’s study, with a PSS mean of 15.3, and the current study, with a mean carer PSS score of 22.1, 95% CI [19.26,24.9] (de Vugt, et al., 2005).

Thus, the current finding that stress ratings were negatively correlated with waking cortisol values runs counter to some recent conclusions on more general stress effects (Fries, et al., 2009), but sits well with other findings of decreased morning cortisol with prolonged stress (Fries, et al., 2009) as well as evidence that the direction of the stress-cortisol relationship may depend on situational factors, including duration of exposure (Chida & Steptoe, 2009; Hellhammer, et al., 2009; Kudielka, et al., 2009).

The immune marker sIgA was not correlated with stress or SWB as had been expected, but there was evidence of a non-significant modest negative correlation with anxiety. This finding may be consistent with Rohrmann et al.’s (2000) report that anxiety was predictive of sIgA levels but is not in line with other reports that negative affect per se is associated with lower sIgA levels (Carins & Booth, 2001; Pressman & Cohen, 2005; Stone, Cox, Valdimarsdottir, Jandorf, & Neale, 1987). Indeed, the current study failed to replicate the results of Ng et al. (1999) and Yang et al. (2002) where stress levels were inversely related to sIgA levels but, rather, appears more in line with Deinzer et al.’s (2000) finding of no clear relationship between sIgA and self-reported stress.

4.5.3 Cortisol Patterns and sIgA Below the Subjective Wellbeing Threshold

The current results supported the prediction that SWB below the critical threshold suggested by Cummins (2005a) would be associated with cortisol dysregulation. However, the prediction that SWB in the dissatisfied range would also be associated with reduced immune function as indicated by sIgA levels was not supported. Thus, the current findings appear to be consistent with a model of dysregulation of circadian rhythmicity under conditions of prolonged demand (Chrousos & Gold,
not with the parallel prediction of reduced antibody levels.

Of particular interest to the current study was the finding that SWB above Cummins’ proposed critical threshold was related to greater diurnal cortisol amplitude and higher waking cortisol values. While this does not appear to be consistent with previous findings that positive affect (Evans, et al., 2007; Pressman & Cohen, 2005; Steptoe, et al., 2005) and subjective wellbeing (Evans, et al., 2007) were inversely related to the production of cortisol, it is nevertheless in line with other reports that wellbeing (defined as self-development and engagement) was inversely related to basal cortisol (Ryff, et al., 2004). Furthermore, the current results are clearly congruent with previous reports of flatter cortisol rhythms associated with allostatic load due to the experience of chronic stress (Abercrombie, et al., 2004; McEwen, 2000a; van Cauter, et al., 1996).

It is noteworthy that a larger proportion of carers in the current study reported SWB levels below Cummins’ (2005a) critical threshold than did non-carers. However, there were no obvious differences between SWB groups in the brief measures of health habits or diary records of substance use. There was also no evidence of lower sIgA in those with SWB dissatisfaction, although it should be noted that this data was only available for a subset of participants.

The finding that circadian cortisol patterns may be related to critical levels of SWB speak to the potential utility of Cummins’ model of subjective wellbeing maintenance in understanding the physiological implications of psychological health.

4.5.4 Study Limitations

The current results must be interpreted with caution due to the methodological limitations of the study, particularly the relatively small sample size, the limited frequency of saliva sampling and the inherent lack of control regarding chronic carer stress. Thus, while caregiving is
recognized as an archetypal chronic stressor (Vitaliano & Young, 2004) which provides one of the few valid avenues to study chronic stress (Schulz & Quittner, 1998), it is nevertheless still not possible to examine causation due to a necessarily cross-sectional design. However, one strength of the current design is the extremely wide range across which the relationships between stress, distress and SWB were able to be investigated. A longitudinal approach would, nevertheless, be likely to provide more robust and detailed information on chronic stress and any potential mediating variables, though the logistics of such a longitudinal approach from both the researcher and caregiver perspective are likely to be formidable. The use of a larger sample would improve the robustness of the results, particularly given the possibility that one tenth of a sample may lack a typical diurnal pattern (Stone, et al., 2001). Additionally, an activity diary may help to control for any substantive behavioural variations such as napping and exercise that may impact cortisol, sIgA and/or SWB, though this latter suggestion would increase participant burden.

An issue worthy of consideration is that carer participants in the current study, while similar on key psychological variables to recent Australian data (Cummins, et al., 2007), may under-represent the true effects of chronic stress. During recruitment a number of carers mentioned that they felt unable to participate due to already feeling overloaded. Indeed, it may be that researchers in this area invariably tend to include carers who are, as evidenced by their volunteering and participating in research, relatively well-functioning. Thus, a failure to detect biochemical differences between carers and non-carers in the current study should be interpreted in light of the potential for underestimation of the full impact of caregiving due to barriers to participation for individuals most affected. While the current study attempted to reduce participant burden as much as possible and to deliver and collect all items from participant’s homes it did require commitment over a full week. Future work in the area may need to examine research demands more closely to promote wider participation. Sleep diaries may be able to be simplified or actigraphy used instead.
Additionally, recruitment strategies should aim to increase awareness and participation rates among carers most at risk of health effects. For instance, provision of additional respite (such as provided through funding initiatives that allow carers to attend personal development workshops) may be able to be negotiated and would seem very likely to increase participation among carers most at risk of negative outcomes.

Additionally, while SWB is not thought to be impacted by the specifics of care once a high level of care is required (Cummins, 2001), it may be that use of a less diverse carer group may provide clearer data on stress effects. If the carers had more similar daily patterns and experiences, for example providing care for children with epilepsy, it may be that there would be decreased variability in cortisol and sIgA levels which could make comparisons clearer. Also, the examination of specific types of stressors, such as a need for constant vigilance, may provide additional insights into the effects of particular aspects of chronic demand relevant to wellbeing. However, it would also be important to recognize likely confounds associated with use of particular carer groups, such as ageing among Alzheimer’s carers.

It should be noted also that, despite no significant correlations between sIgA and any of the key psychological variables and no significant differences between carer or SWB groups for sIgA, there did appear to be a pattern of reduced sIgA among those under difficult circumstances. Indeed, both carers and individuals reporting SWB dissatisfaction tended toward lower values. Further work is needed here.

4.5.5 Conclusion

The experience of chronic stress appears to be associated with reduced variability in circadian cortisol rhythms. However, a flatter diurnal cortisol pattern does not seem to be associated with a parallel reduction in immunity although this may be moderated by chronic arousal. Greater SWB, on the other hand, appears to be associated with increased variability in the circadian cortisol profile. Furthermore, while caregiving
per se does not seem to be associated with flatter cortisol patterns, failure to indicate some positive satisfaction with life does. Indeed, rating one’s SWB in the dissatisfied range may provide a simple indicator of a failure to maintain both psychological and physiological homeostasis. Further research is needed into this notion of a critical wellbeing threshold beyond which physiological changes associated with allostatic load may be more likely to occur. Use of simple instruments such as the 7-item PWI may allow better targeting of health messages and programs as well as greater awareness of physical health risks. A fuller understanding of the construct of personal wellbeing where physical and psychological load can be considered simultaneously would seem likely to have potential for an holistic and truly biopsychosocial approach to health.

“we try to keep our heads above water”

(quote from carer participant)
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Chapter 5 – Worn Out: The Links Between Carers’ Sleep, Melatonin and Temperature Rhythms, and Subjective Wellbeing

“nodding – it’s what carers do”

(quote from carer participant)

5.1 Summary

The aim of this component of the current study was to further explore the biopsychosocial effects of chronic stress by examining the relationships between SWB and, circadian patterns of melatonin, temperature, sIgA and sleep among individuals experiencing chronic caregiver stress. Saliva samples suitable for melatonin analysis were collected on waking and retiring by 26 informal primary carers and 29 non-carer controls in their home environment. Participants also kept a 7-day diary of their sleep-wake patterns (see Appendix I). An additional sub-set of participants, 8 carers and 12 non-carers, agreed to wear a rectal temperature sensor for one 24 hour period within the data-collection week which provided one full circadian cycle of core body temperature data (see Appendix L). Across all participants, waking melatonin levels and the daily amplitude of melatonin showed significant negative correlations with sleep quality. Sleep quality, in turn, showed strong negative correlations with all psychological measures of stress and distress as well as strong positive relationships with subjective wellbeing, social functioning, and self-reported health. The daily amplitude of core body temperature showed moderate negative correlations with depression and anxiety, as well as a moderate positive correlation with social functioning. While there were no significant differences between carers and non-carers in the timing or amount of sleep per night, carers reported much poorer sleep quality. Moreover, carers’ waking melatonin levels were significantly higher than those for
non-carers. Of note, the differences in amplitude for carers and non-carers daily melatonin and core body temperature approached significance. In regression analyses, carers were able to be distinguished from non-carers from melatonin data alone. The addition of sleep quality significantly improved the prediction of carer status. However, SWB in the dissatisfied range was not able to be predicted from melatonin but was weakly predicted by sleep quality. The results support the view that disturbance of both melatonin and sleep rhythms are likely outcomes in chronic caregiver stress. However, the findings also point to a complex interplay between circadian outcomes and the maintenance of SWB homeostasis.

The best bridge between despair and hope is a good night's sleep.

E. Joseph Cossman

5.2 Introduction

5.2.1 Sleep, Melatonin, and Core Body Temperature

As noted in the Introduction, melatonin is the key regulator of circadian rhythmicity (Cardinali & Golombeck, 2009; Pierpaoli & Maestroni, 1987). It codes for darkness and, in humans, promotes sleep (Cajochen, et al., 2003; Cardinali, 2000; Moore, 2007; Stehle, et al., 2003). It is, therefore, an excellent circadian biomarker (Benloucif, et al., 2005; Cardinali & Golombeck, 2009; Selmaoui & Touitou, 2003). In healthy individuals, melatonin levels begin to rise sharply at nightfall, remain high throughout the night, and decline rapidly around dawn, with negligible values throughout the day (Benloucif, et al., 2005; Czeisler, et al., 1999). The pattern of core body temperature reflects an inverse relationship with melatonin, such that it is also an important marker of circadian rhythmicity (Brown, et al., 2000; Cagnacci, et al., 1992; Refinetti, 2006).

Melatonin is not only considered to be vital to healthy sleep, however, but can influence mood, reproductive health and immune functioning (Brzezinski, 1997; Cardinali, 2000; Claustrata, Brun, & Chazot, 2005; Dubocovich, 2007; Macchi & Bruce, 2004; Masetroni, 1993).
Indeed, melatonin has the capacity to act on most cells and tissues throughout the body (Reiter, et al., 2007; Tan, et al., 2010). Mood disorders have long been associated with altered melatonin patterns (Cardinali, 2000; Duncan, 1996; Germain & Kupfer, 2008; Norman, 2009; Shafii, et al., 1996; Souetre, et al., 1989). Furthermore, melatonin has recognised roles as a powerful antioxidant (Kiarostami, et al., 2006; Macchi & Bruce, 2004; Srinivasan, Cardinali, Srinivasan, et al., 2011; Tan, et al., 2010), immune system enhancer (Cikler, et al., 2005; Cutando, et al., 2003; Kato, et al., 1997; Masetroni, 1993) and neuro-protective agent (Srinivasan, Cardinali, Srinivasan, et al., 2011; Tosini, et al., 2012). Moreover, it has been described as an anti-stress hormone (Kato, et al., 1997; Kopp, Vogel, Rettori, Delagrange, & Misslin, 1999; Pierpaoli & Maestroni, 1987). Importantly, melatonin is considered likely to play a role in reducing chrono-disruption (Erren & Reiter, 2009), possibly by reducing the HPA axis’ responsiveness to stress (Baxi, et al., 2010; Konakchieva, Mitev, Almei, & Patchev, 1997). It has further been suggested that melatonin may be a key part of a homeostatic system designed to protect against disruption due to chronic stress (Kopp, et al., 1999) and that high melatonin levels during the hours of darkness may provide a key indicator of health and vitality (Tan, et al., 2010).

5.2.2 Melatonin, Sleep Dysregulation and Subjective Wellbeing

Melatonin is not impervious to the effects of stress. Animal studies have shown that elevated cortisol can reduce melatonin synthesis during times of stress (Lutterschmidt & Mason, 2010; Nikaido, et al., 2010), although the initial stress response appears to be associated with increased melatonin (Lutterschmidt & Mason, 2010). In other animal studies, chronic sleep deprivation has been observed to lead to deterioration of the circadian rhythm of melatonin (Persengiev, et al., 1991). While the relationship between stress and sleep is, surprisingly, not well studied in humans (Akerstedt, 2006), there is growing interest in this topic (Benham, 2010; Brand, et al., 2010) as well as growing evidence of
the importance of sleep characteristics to both physical and mental health (Friedman, 2011; Gorwood, 2010; Orzel-Gryglewska, 2010). Indeed, as noted in the Introduction, pathological effects in humans are predicted from any desynchrony of circadian rhythms (Landgraf, et al., 2012; Vitaterna, et al., 2001).

Thus, despite melatonin’s key role in maintaining circadian fitness and its secretion being under direct control of the SCN (Moore, 2007), its own rhythmicity nevertheless depends on a complex interplay of genetic and physiological influences (Pandi-Perumal, et al., 2008; Tan, et al., 2010; Tosini, et al., 2012). Melatonin rhythms may be disrupted via many physiological events, including inflammation and stroke (Claustrata, et al., 2005) and recent animal studies are beginning to point to SCN changes after chronic stress (Jiang, et al., 2011). Thus, sleep and melatonin seem likely candidates for indicators of long-term circadian stress effects. Moreover, melatonin dysregulation is thought to have potentially serious consequences for human health (Arendt, 2005; Claustrata, et al., 2005; Erren & Reiter, 2009; Wirz-Justice, 2003) with sleep quality seen as vital to psychological and physical health (Sickel, et al., 1999). Additionally, the consequences of poor sleep have been shown to be cumulative (Orzel-Gryglewska, 2010), with clear implications for the experience of long-term adversity.

While the sleep-wake cycle and the melatonin rhythm operate independently, they remain closely linked (Dijk & Lockley, 2002; Landgraf, et al., 2012). Many studies have shown that endogenous melatonin is implicated in the timing and duration of sleep (Arendt, 2005; Benloucif, et al., 2005; Cagnacci, et al., 1992; Cajochen, et al., 2003; Lewy, Cutler, & Sack, 1999; Liu, et al., 2000), but less is known about the relationship between endogenous melatonin and sleep quality. Much of the evidence regarding melatonin’s relationship with sleep quality comes from research of its exogenous administration (Cajochen, et al., 2003; Cardinali & Golombeck, 2009; Fischer, et al., 2003; Guénolé, et al., 2011; Lemoine, Nir, Laudon, & Zisapel, 2007; Srinivasan, Cardinali, Srinivasan, et al., 2001).
Interestingly, some studies in natural settings have failed to find a relationship between endogenous melatonin profiles and subjective sleep ratings (Carlson, Campbell, Garland, & Grossman, 2007; Redwine, et al., 2000). It is clear that the nature of melatonin’s role in the relationship between sleep and stress is not yet fully understood (Arendt, 2005; Dubocovich, 2007).

Sleep has strong links to SWB (Howell, et al., 2008; Ronneberg, et al., 2007; Yokoyama, et al., 2008; Zammit, et al., 1999) and can provide a stress-buffering effect (Hamilton, et al., 2007). It seems likely that poor sleep, more than being a mere side effect of stress, represents a potential path to health decrements through circadian disturbance (Benham, 2010; Kashani, et al., 2012). Indeed, sufficient good quality sleep has been proposed as vital to offsetting allostatic load (Hamilton, et al., 2007), and unrefreshing sleep has been implicated in metabolic disturbance (Troxel, et al., 2010). Correspondingly, recent studies indicate that there may be links between melatonin disruption and metabolic syndrome (Cardinali, et al., 2011; Kate, et al., 2012; van Cauter, et al., 2008). Given that metabolic syndrome symptoms, such as glucose insensitivity, are recognised indicators of allostatic load (Juster, et al., 2010; McEwen, 2000a, 2008) melatonin dysregulation may also indicate that allostatic processes are, or are in danger of, being overwhelmed. Evidence of increased cancer rates associated with circadian disturbances due to shift-work and jetlag highlights the potentially critical health effects of circadian disruption (Bovbjerg, 2003; Wang, et al., 2011).

5.2.3 Melatonin Rhythmicity and Carers’ Sleep and Subjective Wellbeing

While evidence that melatonin is vital to human health and wellbeing is increasing, the nature of its role in health and disease and the mechanisms of its action remain unclear (Cardinali, et al., 2011; Claustrata, et al., 2005; Erren & Reiter, 2009; Stephenson, et al., 2012; Vogel, et al., 2012). Of particular interest to the current study is
melatonin’s potential as a stress-protector (Brotto, et al., 2001; Kopp, et al., 1999; Persengiev, et al., 1991; Reiter, 1991) and upregulator of the immune system (Macchi & Bruce, 2004; Masetroni, 1993; Pierpaoli & Maestroni, 1987). For chronically stressed carers whose sleep is often poor (Brummett, et al., 2006; Carter, 2002), melatonin appears to be a circadian biomarker of great potential relevance. Given that melatonin rhythmicity has been suggested to provide an indication of vitality (Tan, et al., 2010) and health (Arendt, 2005; Claustrata, et al., 2005) endogenous melatonin patterns would seem particularly germane to the study of carer SWB. Yet, to date, no studies have investigated the links between SWB and melatonin patterns or between circadian melatonin and chronic caregiver stress.

5.2.4 Aims and Hypotheses

The aim of this component of the current study was to investigate the relationship between distress, SWB, sleep and melatonin patterns under conditions of chronic stress. It was predicted that long-term primary carers, who have previously demonstrated very low levels of SWB, would show signs of circadian dysregulation with respect to sleep and melatonin compared to patterns observed in on-carers. It was further predicted that individuals reporting SWB in the dissatisfied range (i.e. below 50% scale maximum) would exhibit dysregulation of sleep and melatonin rhythms compared to those within the satisfied range.

5.3 Method

Chapter 2 provides the full description of the psychological and physiological measures relevant to this chapter. Appendices I to K provide related information, namely a sample participant sleep diary page, the saliva collection instructions, interview topics and temperature sensor instructions. The reader is reminded that only a subset of the original participant group provided saliva samples suitable for analysis so that the sub-sample with both melatonin and psychological data was reduced (55
out of the original 66). A further subset of 20 participants provided core body temperature data.

In brief, participants were asked to collect all data over one week in late spring. All participants collected data within a four week window to ensure that any seasonal affects on melatonin would be minimized (Laakso, et al., 1994; Wehr, 1991, 1997). They completed a 7-day sleep diary each morning, indicating the timing of their sleep (bedtime, rising, waking during the night), their ratings of the quality of the previous nights sleep, any symptoms of illness and any substance use. They were also asked to provide morning and evening saliva samples over two consecutive days during that week. A further subset of participants (20) provided 24 hours of temperature data according to the instructions set out in Appendix L.

5.4 Results

5.4.1 Statistical Analyses

Pearson correlation coefficients were employed to examine the relationships between psychological measures of stress and SWB and the physiological markers of core body temperature and melatonin. This involved grouping carer and non-carer data together which provided an extended range for the psychological and physiological measures. Student t-tests were used to compare carer and non-carer groups while unequal variance t-tests were used to compare satisfied and dissatisfied SWB groups due to the differences in group size (see Ruxton, 2006).

Disengagement, a coping strategy found to be more common among carers than non-carers and to have strong relationships with stress-related variables (see Chapter 3), was included to allow examination of its possible relationship with sleep and melatonin. Correlations between melatonin and sleep related variables and morningness scores were included to allow exploration of the influence of diurnal preference. Additionally, correlations with diurnal cortisol variables
were also included in order to examine the links between cortisol and melatonin rhythmicity. Sequential logistic regression analyses (as per Tabachnick & Fidell, 2007) were employed to test whether melatonin and/or sleep quality or duration could distinguish carers from non-carers. Linear regression was employed to explore the prediction of SWB from melatonin and sleep variables. A repeat of the logistic regression analyses was conducted to explore whether melatonin and sleep variables differed according to whether individuals reported SWB below the proposed 50% threshold (Cummins, 2010).

### 5.4.2 Stress, Subjective Wellbeing, and Sleep-related Rhythms

Table 5.1 provides the correlations between the key variables of interest for this chapter. These represent the relationships between variables for all participants who provided saliva samples suitable for analysis, carers and non-carers included. Given that the carer group tends to represent the extremes of stress and wellbeing-related measures (see Chapter 3) this was considered to allow the relationship between the variables to be explored across a wide range of values and, thus, to allow a more robust view of the inter-variable relationships than is generally possible in low-stress samples. Due to the very high correlation between mean sleep quality and mean morning restedness \((r=.89, p<.001)\), only sleep quality was retained in subsequent analyses.

Waking melatonin levels were significantly negatively correlated with mean sleep quality values from the 7-day diary. The relationship between diary means for sleep quality and sleep duration approached significance. A negative association between bedtime melatonin levels and amount of sleep also approached significance. Of special interest to this study, the mean amplitude of daily melatonin was significantly positively correlated with mean sleep quality ratings. However, none of the melatonin variables (waking, bedtime, or amplitude) was significantly correlated with any of the measures of stress and distress though there were indications of a positive trend between disengagement and waking
melatonin levels ($r=.233, p=.089$). By contrast, sleep quality exhibited significant negative correlations with all measures of stress (perceived stress, chronic arousal, and the frequency and intensity of daily hassles) as well as depression and anxiety. Additionally, and of particular interest to the current study, sleep quality was found to be significantly positively correlated with subjective wellbeing, social functioning and self-rated health.

The data from the subset of participants who wore a rectal temperature sensor for 24-hours, showed significant negative correlations between temperature amplitude (peak to trough), depression and anxiety. Correspondingly, there was a significant positive correlation between social functioning and core body temperature amplitude. Other non-significant negative relationships between core body temperature amplitude and stress measures are reported here due to the emerging pattern when considered together: namely perceived stress ($r=-.389, p=.09$), chronic arousal stress ($r=-.389, p=.089$) and the felt intensity of daily hassles ($r=-.417, p=.067$). Similarly the non-significant positive relationship between morningness and temperature amplitude ($r=.399, p=.082$) may point to support for this trend, despite low numbers providing temperature data.

Mean sIgA levels did not show associations with any of the other physiological or psychological measures, although a positive relationship between sIgA and mean sleep duration approached significance ($r=.263, p=.061$).

With regard to cortisol values, the waking levels and the amplitude of diurnal cortisol showed significant positive correlations with waking melatonin levels. The direction of these associations appears to be anomalous with the remaining inter-correlations, an issue which will be discussed further in the concluding chapter.
### Table 5.1

*Correlations between melatonin, sleep, cortisol, core body temperature and the psychological measures for carers and non-carers*

<table>
<thead>
<tr>
<th></th>
<th>Waking melatonin</th>
<th>Bedtime melatonin</th>
<th>Melatonin amplitude</th>
<th>Temperature Amplitude</th>
<th>Sleep amount</th>
<th>Sleep quality</th>
</tr>
</thead>
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<td>Waking melatonin</td>
<td>.348**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedtime melatonin</td>
<td>.304*</td>
<td>.787***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melatonin amplitude</td>
<td>-.304*</td>
<td></td>
<td>.787***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature amplitude‡</td>
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<td>-.105</td>
<td>.165</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep, amount</td>
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<td>-.016</td>
<td>-.051</td>
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<tr>
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<td>.361**</td>
<td>.068</td>
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<tr>
<td>Waking cortisol</td>
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<td>.069</td>
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<tr>
<td>Bedtime cortisol</td>
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<td>.091</td>
<td>.048</td>
<td>.191</td>
<td>-.060</td>
<td>-.150</td>
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<tr>
<td>Cortisol amplitude</td>
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<td>-.005</td>
<td>.209</td>
<td>-.202</td>
<td>.092</td>
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<tr>
<td>CSM (morningness) score</td>
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<td>-.031</td>
<td>.164</td>
</tr>
<tr>
<td>sIgA◊</td>
<td>.112</td>
<td>.190</td>
<td>.181</td>
<td>.062</td>
<td>.263</td>
<td>.077</td>
</tr>
<tr>
<td>Perceived Stress</td>
<td>-.066</td>
<td>-.081</td>
<td>-.016</td>
<td>-.389</td>
<td>.043</td>
<td>-.599***</td>
</tr>
<tr>
<td>Depression</td>
<td>-.066</td>
<td>.051</td>
<td>.125</td>
<td>-.491*</td>
<td>.100</td>
<td>-.426**</td>
</tr>
<tr>
<td>Anxiety</td>
<td>-.096</td>
<td>-.011</td>
<td>-.077</td>
<td>-.512*</td>
<td>-.011</td>
<td>-.424**</td>
</tr>
<tr>
<td>Chronic Arousal</td>
<td>-.165</td>
<td>-.123</td>
<td>-.012</td>
<td>-.389</td>
<td>.102</td>
<td>-.409***</td>
</tr>
<tr>
<td>Hassles, frequency</td>
<td>-.042</td>
<td>.027</td>
<td>.047</td>
<td>-.140</td>
<td>-.170</td>
<td>-.433***</td>
</tr>
<tr>
<td>Hassles, intensity</td>
<td>-.199</td>
<td>-.032</td>
<td>.101</td>
<td>-.417</td>
<td>-.090</td>
<td>-.381**</td>
</tr>
<tr>
<td>Disengagement</td>
<td>.233</td>
<td>-.045</td>
<td>-.156</td>
<td>-.211</td>
<td>.205</td>
<td>-.168</td>
</tr>
<tr>
<td>Uplifts, frequency</td>
<td>-.011</td>
<td>-.084</td>
<td>-.033</td>
<td>.278</td>
<td>-.051</td>
<td>.112</td>
</tr>
<tr>
<td>Uplifts, intensity</td>
<td>-.012</td>
<td>-.101</td>
<td>-.074</td>
<td>.285</td>
<td>-.097</td>
<td>.192</td>
</tr>
<tr>
<td>Subjective Wellbeing</td>
<td>-.064</td>
<td>.056</td>
<td>-.066</td>
<td>.354</td>
<td>.015</td>
<td>.484***</td>
</tr>
<tr>
<td>Social Functioning</td>
<td>-.004</td>
<td>.093</td>
<td>.061</td>
<td>.462*</td>
<td>-.073</td>
<td>.502***</td>
</tr>
<tr>
<td>Self-rated Health</td>
<td>-.091</td>
<td>-.091</td>
<td>-.081</td>
<td>.160</td>
<td>.135</td>
<td>.539***</td>
</tr>
</tbody>
</table>

\(n=55\) \(n=53\) \(n=20\)

*\(p<.05\) **\(p<.01\) ***\(p<.001\).
5.4.3 Carers and Non-Carers’ Sleep, Melatonin and Core Body Temperature

Table 5.2 provides comparisons for carers and non-carers on key sleep diary data. There were no significant differences for mean waking or bedtimes, nor were there any significant differences in the time spent awake overnight or the mean number of hours spent sleeping. However, mean sleep quality ratings were significantly lower among carers, $t(54)=-6.4$, $p<.001$.

Table 5.3 provides the mean melatonin levels and core body temperature data for carers and non-carers. There were no significant differences between the subsets of carers and non-carers who provided core body temperature data. It should be noted, however, that the difference between the groups for temperature amplitude did approach significance, $t(19)=-1.8$, $p=.08$. Of particular interest to the current study, waking melatonin levels were significantly higher among carers, $t(54)=2.72$, $p=.009$, and the difference between carers’ and non-carers’ mean melatonin amplitude also approached significance, $t(54)=1.82$, $p=.074$.

Table 5.2

<table>
<thead>
<tr>
<th></th>
<th>Carer ($n=26$)</th>
<th>Non-Carer ($n=29$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Waking time, diary mean, dec hrs</td>
<td>6.26</td>
<td>1.0</td>
</tr>
<tr>
<td>Bedtime, diary mean, dec hrs</td>
<td>22.63</td>
<td>.98</td>
</tr>
<tr>
<td>Waking overnight, diary mean, dec hrs</td>
<td>.54</td>
<td>.4</td>
</tr>
<tr>
<td>Sleep, amount, diary mean, dec hrs</td>
<td>6.55</td>
<td>1.0</td>
</tr>
<tr>
<td>Sleep, self-rated quality, /10</td>
<td>4.0***</td>
<td>1.7</td>
</tr>
</tbody>
</table>

***$p<.001$.

Note: Sleep times are in decimal hours; night waking is subsumed into sleep totals.
Table 5.3

Comparison of core body temperature and melatonin between carers and non-carers

<table>
<thead>
<tr>
<th></th>
<th>Carer (n=8)</th>
<th>Non-Carer (n=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( M )</td>
<td>( SD )</td>
</tr>
<tr>
<td>Lowest logged temperature (in 24hr cycle)</td>
<td>36.51</td>
<td>.26</td>
</tr>
<tr>
<td>Highest logged temperature (in 24hr cycle)</td>
<td>37.84</td>
<td>.28</td>
</tr>
<tr>
<td>Temperature amplitude</td>
<td>1.36</td>
<td>.34</td>
</tr>
</tbody>
</table>

Melatonin

<table>
<thead>
<tr>
<th></th>
<th>Carer (n=26)</th>
<th>Non-Carer (n=29)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( M )</td>
<td>( SD )</td>
</tr>
<tr>
<td>Waking melatonin, pg/mL</td>
<td>11.74*</td>
<td>11.2</td>
</tr>
<tr>
<td>Bedtime melatonin, pg/mL</td>
<td>17.7</td>
<td>15.4</td>
</tr>
<tr>
<td>Melatonin amplitude, pg/mL</td>
<td>6.64</td>
<td>13.1</td>
</tr>
</tbody>
</table>

* \( p<.05 \).

5.4.4 Sleep, Melatonin and Core Body Temperature above and below the SWB Threshold

Table 5.4 provides comparison data from participants’ sleep diaries according to the SWB groups (dissatisfied or satisfied) explored in the previous chapter. There were no significant differences between the groups for wake time, bedtime, overnight waking, or amount of sleep. However, sleep quality ratings for those with SWB in the dissatisfied range were significantly lower than for those in the satisfied range, \( t(54)=-2.97, p=.005 \).

Table 5.5 gives the melatonin and core body temperature data according to dissatisfied and satisfied SWB groups. There were no significant differences between those with SWB in the satisfied compared to dissatisfied range. It should be noted that there were only 13 individuals in the dissatisfied range, with even fewer (six) providing temperature data.
Table 5.4
Comparison of sleep and activity diary data for groups with SWB above and below Cummins’ wellbeing threshold

<table>
<thead>
<tr>
<th>SWB Range</th>
<th>“Dissatisfied” (n=13)</th>
<th>“Satisfied” (n=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Waking time, diary mean, dec hrs</td>
<td>6.58</td>
<td>.8</td>
</tr>
<tr>
<td>Bedtime, diary mean, dec hrs</td>
<td>22.81</td>
<td>.77</td>
</tr>
<tr>
<td>Waking overnight, diary mean, dec hrs</td>
<td>.49</td>
<td>.45</td>
</tr>
<tr>
<td>Sleep Amount, hrs</td>
<td>6.78</td>
<td>1.2</td>
</tr>
<tr>
<td>Sleep, self-rated quality, /10</td>
<td>4.1**</td>
<td>1.2</td>
</tr>
</tbody>
</table>

* p<.05. ** p<.01. *** p<.001.
Note: Sleep times are in decimal hours; night waking is subsumed into sleep totals.

Table 5.5
Comparison of melatonin and core body temperature for groups with SWB above and below Cummins’ wellbeing threshold

<table>
<thead>
<tr>
<th>SWB Range</th>
<th>Core Body Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lowest logged temperature (in 24hr cycle)</td>
</tr>
<tr>
<td>SWB Range</td>
<td>“Dissatisfied” (n=6)</td>
</tr>
<tr>
<td></td>
<td>M</td>
</tr>
<tr>
<td>Lowest logged temperature</td>
<td>36.5</td>
</tr>
<tr>
<td>Highest logged temperature</td>
<td>37.8</td>
</tr>
<tr>
<td>Temperature amplitude</td>
<td>1.31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SWB Range</th>
<th>Melatonin</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWB Range</td>
<td>“Dissatisfied” (n=13)</td>
</tr>
<tr>
<td></td>
<td>M</td>
</tr>
<tr>
<td>Waking melatonin, pg/mL</td>
<td>8.48</td>
</tr>
<tr>
<td>Bedtime melatonin, pg/mL</td>
<td>19.56</td>
</tr>
<tr>
<td>Melatonin amplitude, pg/mL</td>
<td>12.78</td>
</tr>
</tbody>
</table>
5.4.5 Differentiating Carers using Melatonin And Sleep Variables

A sequential logistic regression analysis was performed to determine whether carer status (carer or non-carer) could be predicted on the basis of 1) melatonin levels and 2) sleep-related variables. The three melatonin predictors were the mean waking melatonin, mean bedtime melatonin and mean melatonin amplitude. The two sleep-related predictors were sleep quality and sleep amount. Temperature data was not included due to the much lower number of participants who took part in that component.

There was a good model fit on the basis of the melatonin variables. The model was significant, $\chi^2(1, N=55)=7.120$, $p=.028$, indicating that it was able to distinguish carers from non-carers. This model was able to explain between 12.1% (Cox & Snell R Square) and 16.2% (Nagelkerke R Square) of the variance in carer status. However, melatonin amplitude was not in the final equation. Indeed, 60% of all cases (75.9% of carers, 42.3% of non-carers) were able to be correctly classified using waking melatonin levels, $B=.128$, $SE=.059$, $Wald=4.646$, $df=1$, $p<.031$, odds ratio=1.14, 95% CI [1.01,1.28] and bedtime melatonin levels, $B=-.038$, $SE=.026$, $Wald=2.141$, $df=1$, $p=.143$, odds ratio = .963, 95% CI [.915,1.013]. Thus, melatonin values were able to distinguish carer from non-carer participants.

In the second step, the addition of the sleep-related variables showed statistically significant improvement in the model, $\chi^2(1,N=55)=20.927$, $p<.001$, with improved ability to distinguish between carers and non-carers. This model was able to explain between 39.9% (Cox & Snell R Square) and 53.3% (Nagelkerke R Square) of the variance in carer status. Table 5.6 presents the contributions of the four variables in the full model. In this final model, 81.8% of all cases were correctly classified (86.2% of carers, 76.9% of non-carers). Notably, sleep quality was the sole individual predictor of carer from non-carer participants in the full model.
Table 5.6

Contributions of the four variables in the final logistic regression model of carer role from melatonin and sleep data

<table>
<thead>
<tr>
<th>Predictor</th>
<th>B</th>
<th>SE</th>
<th>Wald</th>
<th>df</th>
<th>p</th>
<th>odds ratio</th>
<th>95% CI (lower bound)</th>
<th>95% CI (upper bound)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waking melatonin</td>
<td>.107</td>
<td>.079</td>
<td>1.83</td>
<td>1</td>
<td>.176</td>
<td>1.113</td>
<td>.953</td>
<td>1.3</td>
</tr>
<tr>
<td>Bedtime melatonin</td>
<td>-.013</td>
<td>.031</td>
<td>.159</td>
<td>1</td>
<td>.690</td>
<td>.99</td>
<td>.93</td>
<td>1.05</td>
</tr>
<tr>
<td>Sleep, quality</td>
<td>-.922</td>
<td>.26</td>
<td>12.544</td>
<td>1</td>
<td>&lt;.001</td>
<td>.398</td>
<td>.239</td>
<td>.663</td>
</tr>
<tr>
<td>Sleep amount</td>
<td>-.183</td>
<td>.445</td>
<td>.168</td>
<td>1</td>
<td>.682</td>
<td>.99</td>
<td>.83</td>
<td>1.99</td>
</tr>
</tbody>
</table>

5.4.6 Predicting Subjective Wellbeing from Melatonin and Sleep Variables

While the small sample size would not support robust conclusions, an hierarchical multiple regression analysis was conducted as an exploratory analysis to see whether there was any indication that SWB might be associated with 1) melatonin levels and 2) sleep-related variables. The three melatonin predictors were the mean waking melatonin, mean bedtime melatonin and mean melatonin amplitude. The two sleep-related predictors were sleep quality and sleep amount. Core temperature data was not included due to the much lower number of participants who took part in that component of the study.

Melatonin levels did not predict SWB, F(2,52)=.115, p=.892. However, the addition of sleep quality and duration led to a significant model, R² = .178, Δ R²=.258, F(4,50)=2.72, p=.04, adj R² = .113. Nevertheless, the only significant individual predictor of SWB was sleep quality, β=.54, p<.001. It is noteworthy that the contribution of melatonin amplitude within this model approached significance, β=-.234, p<.09.

5.4.7 Predicting SWB Failure from Melatonin and Sleep Variables

In order to further explore the utility of the proposed SWB 50% cut-point, a sequential logistic regression analysis was performed to determine whether SWB group membership (satisfied or dissatisfied) could be predicted on the basis of 1) melatonin levels and 2) sleep-related
variables. The three melatonin predictors were the mean waking melatonin, mean bedtime melatonin and mean melatonin amplitude. The two sleep-related predictors were sleep quality and sleep amount. Again, temperature was not included due to the much lower number of participants who provided data.

The model from the first step using melatonin variables was not significant, \( \chi^2 (1, N=55)=.696, p=.706 \), and did not distinguish the SWB groups. In the second step, the addition of the sleep-related variables led to a significant model, \( \chi^2 (1, N=55)=11.593, p=.021 \), showing it was able to distinguish between participants in the satisfied and dissatisfied SWB ranges. Table 7 presents the contributions of the four variables to the final model. This model was able to explain between 19\% (Cox & Snell R Square) and 28\% (Nagelkerke R Square) of the variance in SWB group membership. In this final model, 83.6\% of all cases were able to be correctly classified. However, only 50\% of the dissatisfied group, compared to 95.1\% of the satisfied group, were correctly classified. Again, sleep quality was the only significant individual predictor of wellbeing status (as satisfied or dissatisfied).

Table 5.7

*Contributions of the four variables in the final logistic regression model of SWB group (satisfied or dissatisfied) from melatonin and sleep data*

<table>
<thead>
<tr>
<th>Predictor</th>
<th>B</th>
<th>SE</th>
<th>Wald</th>
<th>df</th>
<th>( p )</th>
<th>odds ratio</th>
<th>95% CI (lower bound)</th>
<th>95% CI (upper bound)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waking melatonin</td>
<td>-.040</td>
<td>.031</td>
<td>1.66</td>
<td>1</td>
<td>.198</td>
<td>.961</td>
<td>.905</td>
<td>1.021</td>
</tr>
<tr>
<td>Bedtime melatonin</td>
<td>.094</td>
<td>.061</td>
<td>2.34</td>
<td>1</td>
<td>.126</td>
<td>1.098</td>
<td>.97</td>
<td>1.24</td>
</tr>
<tr>
<td>Sleep, quality</td>
<td>.562</td>
<td>.224</td>
<td>6.3</td>
<td>1</td>
<td>.012</td>
<td>1.75</td>
<td>1.13</td>
<td>2.72</td>
</tr>
<tr>
<td>Sleep, amount</td>
<td>.750</td>
<td>3.650</td>
<td>1.58</td>
<td>1</td>
<td>.208</td>
<td>1.66</td>
<td>.83</td>
<td>1.99</td>
</tr>
</tbody>
</table>
5.5 Discussion

5.5.1 Relationships Between Stress, Subjective Wellbeing, Sleep and Melatonin

The results did not provide support for a direct relationship between melatonin levels and any of the study measures of psychological distress, stress or SWB in the combined sample. This was despite the wide range of values observed in the psychological measures which were expected to enhance detection of any such relationships. Nevertheless, these results are in line with previous findings of a lack of relationship between melatonin and measures of psychological distress (Carlson, et al., 2007). Of particular note is the lack of association between any melatonin measure and sIgA or self-rated health. This appears to be in direct contrast to reports of melatonin’s immune-enhancing properties (Cikler, et al., 2005; Kato, et al., 1997; Masetroni, 1993). However, the lack of association with sIgA may be congruent with a biphasic melatonin effect on immunity, as can be the case with chronic illness (Cutando, et al., 2003) or possible distinct effects for cell-mediated compared to humoral immune responses (Wong, et al., 2012), which would include sIgA antibodies. It is also noteworthy that morningness did not appear to be related to sleep or melatonin related variables yet, within the temperature data subset, a trend toward a positive relationship between morningness and temperature amplitude was observed.

Nevertheless, mean waking melatonin was negatively, and daily melatonin amplitude positively, associated with sleep quality in the full sample. In turn, sleep quality (as morning restedness) showed strong negative associations with perceived stress, depression, anxiety, chronic arousal stress and the frequency and intensity of daily hassles among study participants. There was no relationship observed, however, between disengagement, which emerged as a coping strategy related to low SWB, and sleep or melatonin variables. Sleep quality also displayed strong
positive associations with social functioning, subjective wellbeing and self-reported health across the sample. Thus, the current results are not in line with previous reports of no relationship between melatonin rhythmicity and sleep quality (Carlson, et al., 2007; Redwine, et al., 2000). Rather, the sleep quality correlations align with other previous findings of negative relationships between sleep quality and stress (Akerstedt, 2006; Benham, 2010; Hamilton, et al., 2007; Kashani, et al., 2012; Sickel, et al., 1999; van Cauter, et al., 2008) and depression (Brand, et al., 2010; Srinivasan, Cardinali, Pandi-Perumal, et al., 2011). They are also consistent with studies that have found a positive relationship between sleep quality and SWB (Howell, et al., 2008; Roenneberg, et al., 2007; Yokoyama, et al., 2008; Zammit, et al., 1999), self-reported health (Pilcher, et al., 1997; Vitaterna, et al., 2001) and social engagement (Friedman, et al., 2005).

5.5.2 Melatonin and Sleep in Chronic Caregiver Stress and SWB

Defeat

The current findings provided support for the prediction that carers would be more likely to experience disrupted sleep and melatonin patterns. Indeed, carers’ sleep diary data revealed poorer mean sleep quality ratings, though not reduced sleep quantity, and their saliva determinations provided evidence of higher waking levels of melatonin compared to non-carers with a trend toward decreased amplitude of the melatonin rhythm. These findings align with previous reports of poor sleep quality among carers (Brummett, et al., 2006; Carter, 2002; Sato, et al., 2002) but not with findings of reduced sleep quantity (Carter, 2002; Lee & Thomas, 2011). Nor do the current findings appear to align with reports of a positive link between SWB and the amount of sleep (Birchler-Pedross, et al., 2009; Cummins, et al., 2012; Yokoyama, et al., 2008). Given that carers’ also had significantly lower self-reported health, the findings of the current study may lend support to previous reports of health decrements in the face of circadian dysregulation (Bovbjerg, 2003; Chrousos & Gold, 1998; Landgraf, et al., 2012; Vitaterna, et al., 2001). While there are no
known studies of caregiver melatonin patterns for comparison, the results are consistent with studies of altered melatonin patterns in mood disturbance (Germain & Kupfer, 2008; Shafii, et al., 1996; Wirz-Justice, 2003) as well as observed melatonin dysregulation in animals under stress (Jiang, et al., 2011; Lutterschmidt & Mason, 2010; Nikaido, et al., 2010; Persengiev, et al., 1991). The results also provide support for the broader view that circadian dysregulation is likely under conditions of prolonged adversity (Arendt, 2005; Pandi-Perumal, et al., 2008; Tan, et al., 2010) and that melatonin rhythmicity may be impacted by chronic stress (Claustrata, et al., 2005; Jiang, et al., 2011).

That melatonin levels were able to distinguish carers from non-carers provides support for the proposition that circadian dysregulation is a potential, serious outcome of chronic caregiver stress (Persengiev, et al., 1991; Stewart, et al., 1990). The differences in carer melatonin may point to rhythm disruption under conditions of chronic adversity which, in turn, may be associated with wider stress effects due to melatonin’s central role as primary rhythm regulator (Claustrata, et al., 2005; Lupien, et al., 2009). The pattern of differences for melatonin patterns and psychological stress and distress between carer and non-carer participants are consistent with melatonin having an important role in vitality (Tan, et al., 2010) and health (Arendt, 2005; Claustrata, et al., 2005).

With regard to SWB homeostasis, however, the results provided only very limited support for the prediction that SWB in the dissatisfied range would also be associated with dysregulation of sleep and melatonin rhythms. Individuals who reported SWB in the dissatisfied range did not report poorer sleep quality or quantity or exhibit differences in melatonin levels. Moreover, SWB group could not be predicted from melatonin data although sleep quality did have some predictive power with respect to the SWB group.
5.5.3 Study Limitations

Once again, the results of the current study must be interpreted with caution due to the relatively small sample size, the cross-sectional design and the inherent lack of control regarding the stress experiences of the carer group. Nevertheless, caregiver samples are regarded as one of the few valid means to investigate chronic stress effects in humans (Lupien, et al., 2009; Schulz & Quittner, 1998; Vitaliano & Young, 2004) and carer melatonin has not been explored. The use of a larger sample would improve the robustness of melatonin results. Other improvements might involve more days of saliva collection so as to provide additional samples for melatonin determination as well as more time-points for collection each day to allow more evening, nighttime and morning data-points for plotting an individual’s melatonin rhythm. Additionally, a more detailed sleep-activity diary which included information concerning such behaviours as napping and exercise would possibly assist with interpretation of melatonin and sleep patterns. Future studies would also be improved by inclusion of a measure of the sleep patterns of the individual requiring care, in order to investigate the influence of this variable on carer outcomes. It should be noted, however, that such suggestions run the risk of increasing participant burden in an already highly stressed population. A longitudinal approach, such as yearly data collection by long-term carers, would also be useful to examine chronic stress effects on melatonin and sleep among caregivers, although once again, due to the potential burden of prolonged participation, may not be feasible.

As mentioned in the previous chapter, it is highly possible that carer participants in the current study may represent the more functional end of a caregiving continuum. It is also possible that the timing of their data collection was chosen to coincide with a period of lesser demand. Though similar to recent Australian carer norms (Cummins, et al., 2007) on key psychological variables, carer participants, by definition, had the capacity to take part in research, whilst several potential carer participants reported
that taking part in this study would be too burdensome. This is likely to be a problem for carer research in general, where, due to participation by those with fewer limitations, samples (and thus normative data) risk being unrepresentative. Thus, the current findings may provide an underestimate of the differences between carers and non-carers for melatonin levels, particularly given that one of the key potential barriers to participation for individuals most affected by the carer role is poor sleep. The current study attempted to minimize participant effort by delivering and collecting all study items but personal reports indicated that even a week of diary keeping and a few days of saliva collection were burdensome. As suggested in the previous chapter, future recruitment strategies should aim to increase participation rates among some of the most effected carers through such measures as provision of additional respite and/or support. The use of measurement strategies such as actigraphy may also alleviate burden by providing objective indicators of sleep and activity to supplement or replace self-report and biochemical data.

It should be noted that a particular strength of this component of the current study was the determination of salivary melatonin in a population in which this has not previously been studied but for whom melatonin rhythmicity, with its implications for circadian dysregulation, is likely to be of vital importance. A further strength of this component was the inclusion of sleep quality data alongside endogenous melatonin levels which allowed the exploration of the complex, but clearly critical, link between these two. This element of the current study also touched new ground by examining potential links between SWB and melatonin.

5.5.4 Conclusion

Reduced sleep quality and melatonin dysregulation appear to be associated with the experience of prolonged demand. While carers and non-carers did not differ significantly with regard to sleep duration, their subjective evaluations of sleep differed markedly and this was accompanied by a possible trend toward blunting of temperature and
melatonin rhythms. However, SWB, while positively linked to sleep quality, was not found to be associated with melatonin rhythmicity and neither was being in the satisfied SWB range. Yet it seems that caregiving and its associated stresses are key factors in sleep disturbance and changes in the endogenous melatonin rhythm. Perhaps this link represents the first step in a potential cascade of neuroendocrine changes that may eventually result in multi-system dysregulation, allostatic load and the subjective sense of poor subjective wellbeing. Alternatively, it may be that internal monitoring of SWB homeostasis, may be more sensitive to feelings of energy, as may be provided by the morning cortisol rise, than with sensations associated with rest and recuperation, as may be linked to melatonin. Further work is needed to tease out these possibilities. The identification of physiological changes that may provide a basis for subjective evaluations of SWB has the potential to improve models of personal wellbeing and our understanding of the biological correlates of quality of life. This, in turn, may provide a framework for programs toward supporting individuals such as carers who are experiencing severe and/or chronic life stress and improving their quality of life. Recognition of the crucial role of circadian influences would help to build a truly holistic understanding of subjective wellbeing which incorporates all key contributors, not least of them sleep.

“when we were trying to line up respite they'd ask me what I'd want to do and I said 'I'd like to go to sleep' and they're going 'what, don't you want to do this and that?' and I went 'no, I would just like to be able to stop and sleep'...”

(quote from carer participant)
Chapter 6 – Wellbeing Under Chronic Stress and the Potential Advantage of Morningness

6.1 Summary

This chapter is based on a published article which examined the interaction between diurnal preference and subjective wellbeing among carers. Excerpts are provided here with permission from the publisher, John Wiley & Sons (see Appendix P). Please note that data presentation in this chapter follows the style of the original article. The complete article is provided in Appendix O. This particular area of investigation was prompted by findings of an unexpected link between a morning preference and the personality trait of agreeableness (Randler, 2008b) as well as SWB (Randler, 2008a). These tendencies for morningness to be associated with positive psychological states have been explained in terms of ‘social jetlag’ (Wittman, et al., 2006, p.499) whereby those with a preference for sleeping late must contend with disadvantage if they are to fit in with conventional work and other schedules (Wittman, et al., 2010). The current sample, which showed a wide range of psychological stress, distress and wellbeing, was considered likely to provide an opportunity to explore these links further. The current findings showed a moderate positive association between SWB and morningness as well as negative relationships between a morning preference and all study measures of stress and distress. Further examination revealed that the relationship between morningness and wellbeing was moderated by the carer role and, thus, morningness may provide a buffering effect. Correspondingly, chronic arousal (DASS) stress was lower in carers with a preference for morningness pointing to a possible link between diurnal preference and physiological vulnerability under adverse conditions. Since publication, morningness has been linked to a higher cortisol awakening response
(Randler & Schaal, 2010) though others have not found this to be the case (Dockray & Steptoe, 2011; Toda, et al., 2012).

6.2 Abstract

This study investigated whether morningness was associated with quality of life in individuals experiencing chronic stress. Thirty-one informal primary carers and 35 non-carers completed self-report measures of time-of-day preference, stress and wellbeing. The data were collected as part of a broader study of circadian rhythmicity under conditions of prolonged stress. There was a significant interaction between diurnal preference and caregiving, with morningness associated with better wellbeing outcomes in those providing long-term home care. It appears that chronic arousal, but not perceived stress, plays a role in this morningness-carer interaction, with lower arousal levels also evident in carers with a greater preference for morningness. These results point to a possible role for circadian influences in the relationship between stress and subjective wellbeing.

6.3 Introduction

Morningness has been found to be associated with enhanced wellbeing (Howell, et al., 2008; Randler, 2008a). Yet subjective wellbeing is considered to be relatively stable due to maintenance by behavioural and cognitive mechanisms that keep it within an adaptive range. Nevertheless, if conditions become extremely stressful such wellbeing maintenance may be overwhelmed (Cummins, 2005a). This study sought to examine whether stress would influence the relationship between morningness and wellbeing. To this end, the link between quality of life and morningness was examined among informal carers, a group acknowledged to be chronically stressed (Vitaliano & Young, 2004).

Individual differences in time-of-day preferences for rest and activity within the circadian (24-hour) cycle are recognized as stable individual traits (Klei, et al., 2005; Smith, et al., 1989) under the control of endogenous factors such as genetics and ageing (Paine, et al., 2006;
Indeed, circadian preferences are mirrored by corresponding differences in physiological, psychological and behavioural variables such as core body temperature, subjective alertness and task performance (Cavallera & Giudici, 2008; Schmidt, et al., 2007; Smith, et al., 1989). Many studies recognise extreme Morning and Evening chronotypes (Horne & Ostberg, 1976; Smith, et al., 1989) however, morningness-eveningness may be better viewed as a continuous characteristic (Caci, et al., 2005; Caci, et al., 2000; Mecacci & Rocchetti, 1998; Natale & Cicogna, 2002; Roberts & Kyllonen, 1999).

Unsurprisingly, circadian preferences are found to be related to sleep patterns (Carrier, et al., 1997), with an evening preference associated with sleep inertia, problems falling asleep and sleepiness on waking (Taillard, Philip, Chastang, Diefenbach, & Bioulac, 2001; Taillard, Philip, Coste, Sagaspe, & Bioulac, 2003). Morningness, on the other hand, is linked to increased reporting of sleep problems, including nocturnal waking, extreme early waking and daytime sleepiness (Taillard, et al., 2001). Evening types appear to accumulate a sleep debt when working regular hours and to compensate for this by sleeping late on free days (Roenneberg, et al., 2003). They also seem to adapt better to shift work than Morning types (Griefahn, 2002; Khaleque, 1998), who appear to have poorer sleep flexibility (Cavallera & Giudici, 2008). Phase differences in the endogenous rhythms of key physiological variables, such as core body temperature, and subsequent differences in synchronisation with environmental demands have been proposed as an explanation for the sleep effects associated with time of day preferences (Kerknof & van Dongen, 1996; Selvi, Gulec, Agargun, & Besiroglu, 2007).

Evening types have also been found to be up to 2.5 times more likely to report they were not in good health (2006). Furthermore, eveningness has also been found to be associated with greater levels of depression (Hirata, et al., 2007) and anxiety (Diaz-Morales & Sanchez-Lopez, 2008; Vardar, Vardar, Molla, Kaynak, & Ersoz, 2008) among university students. Indeed, Evening types have been found to score
higher on neuroticism (Tonetti, Fabbri, & Natale, 2009) and stress-prone behaviours (Mecacci & Rocchetti, 1998) whereas morningness has been found to be positively correlated with agreeableness, conscientiousness and emotional stability (DeYoung, Hasher, Dijkic, Criger, & Peterson, 2007; Hogben, Ellis, Archer, & von Schantz, 2007). Moreover, as previously noted, recent indications are that morningness has a positive association with measures of life satisfaction (Randler, 2008a) and global wellbeing (Howell, et al., 2008).

One possible explanation for these differences is ‘social jetlag’, or the misalignment of biological and social clocks (Wittman, et al., 2006). It has been suggested that, under many work and study schedules, eveningness may be associated with problems synchronizing internal and external timing, whereas morningness may confer an advantage (Wittman, et al., 2006). Another possible explanation involves psychophysiological differences in arousal levels and stress reactivity. From this perspective, morningness may be associated with greater central nervous system adaptability which allows the individual to cope better with both intense, prolonged environmental demand as well as rapidly changing environmental conditions (Mecacci, Zani, Rocchetti, & Lucioli, 1986).

Subjective wellbeing, SWB, is described as “a stable sense of feeling positive about one’s self and one’s life” (Cummins, et al., 2004, p.415). Such measures of quality of life are increasingly recognised as essential components of any broad conceptualisation of health (Diener, et al., 1998; Lazarus, 1999). SWB is generally considered to be robust due to protective cognitive and behavioural mechanisms that maintain it within a narrow healthy range (Cummins, 2005b). Nevertheless, according to the wellbeing homeostasis model, once an individual experiences stress beyond a personal threshold, their personal resources can be overwhelmed and, subsequently, wellbeing will fail (Cummins, 2005a). It may be that individual differences along the morningness-eveningness dimension play a role in the relationship between stress and wellbeing. Furthermore, since chronic stress appears to be a particularly debilitating
form of stress (Lepore, 1997; O'Connor, 2005), the relationship between quality of life and diurnal preferences in a chronically stressed group appears likely to provide unique insights.

A group that stands out as experiencing both chronic stress and exceptionally poor SWB is informal carers (Cummins, et al., 2007; Schwarz & Dunphy, 2003; Stowell, et al., 2001; Vedhara, et al., 1999). An informal carer is defined as someone who provides long-term in-home care for a parent, partner, child, other relative or friend who has a disability, is frail aged or who has a chronic mental or physical illness (Gill, et al., 2007). Informal caregiving has been described as a prototypic chronic stressor (Vitaliano & Young, 2004) involving continuous, prolonged demand (Pearlin, et al., 1990; Schulz & Quittner, 1998). It is this chronic stress that is proposed to overwhelm many carers’ ability to maintain SWB levels within the normal range (Cummins, et al., 2007). Cummins (2001) notes that mean SWB for Australian carers falls far below the narrow normative range found in the general population. There is much other evidence to support findings of reduced quality of life among carers with high levels of depression, anxiety (Pakenham, et al., 2005; Schulz & Quittner, 1998), fatigue, physical health problems (Briggs & Fisher, 2000; Shewchuk, et al., 1998; Vitaliano & Young, 2004), and poor sleep quality (Carter, 2002; Sato, et al., 2002; Teel & Press, 1999) commonly reported.

While previous studies have indicated that time-of-day preferences may be associated with differences in personal wellbeing (DeYoung, et al., 2007), the potential role of stress in this relationship has not been investigated. It may be that morningness provides a particular advantage with respect to wellbeing under stressful conditions. The current study was part of a broader study investigating the relationship between circadian rhythms, chronic stress and subjective wellbeing. Examination of the relationship between quality of life and circadian preferences under conditions of chronic stress has the potential to provide insights into the more general role of circadian preferences in maintaining wellbeing. To our knowledge, these links have not yet been examined. The aim of the
present study was to explore the relationship between subjective wellbeing and morningness among individuals experiencing chronic stress. It was predicted that 1) in line with recent reports, morningness would be associated with higher levels of subjective wellbeing and 2) morningness would be associated with an additional wellbeing advantage in those who were coping with chronic stress.

6.4 Method

Chapter 2 provides the relevant methodological information.

6.5 Results

6.5.1 Overview

Table 6.1 reports the results for carers and non-carers for demographic and psychological variables. With regard to wellbeing, the PWI score for non-carers in the sample at 70, 95% CI [65.9,74.4], is significantly below the Australian norm but not yet below the suggested cut-off for a group experiencing homeostatic defeat (see Cummins, 2003). The mean PWI score of 51 for carers in the current study, 95% CI [43.6,58.4], was in line with the PWI means of 58.2 for all carers and 56.7 for carers who had spent 10 to 19 years in a caregiving role in Cummins et al.'s (2007) report. The somewhat higher values reported by Cummins may be related to the higher proportion of males in his sample (20% compared to 10% in this sample) and, more particularly, to his inclusion of non-primary carers.

Regarding perceived stress, the mean PSS-10 of the non-carer group at 14.8, 95% CI [12.4,16.3], is similar to the comparison mean of 12.6 (SD=6.1) reported by Cohen and Williamson (1988) in their original sample and the non-carer mean of 12.8 (SD=7.4) recently reported by Brummett et al. (2006). The variability in sample non-carer scores would indicate that some individuals were experiencing considerable stress. While several non-carers did report stressful life events during the data
collection period, none reported ongoing life stress. The current carer mean PSS-10 score at 23.3, 95% CI [20.2,25.0], is higher than that recently reported by either de Vugt et al. (2005), $M=15.3$, or Brummett et al. (2006), $M=17.6$ ($SD=7.4$). However, these differences also appear consistent with the selection of long-term primary carers in the present study.

Mean DASS depression, anxiety and stress scores were within the moderate range for participating carers and within the normal range for sample non-carers (Lovibond & Lovibond, 1995). The DASS depression score for carers, at 16.4, 95% CI [12.4,20.4], was very similar to the carer mean of 16.1 reported by Cummins (2007). Similarly, the carer DASS stress score in the current study, at 21.2, 95% CI [16.9,25.2], was very similar to the mean of 20.8 also reported by Cummins. No carer DASS anxiety subscale or CSM morningness scores were available for comparison.

In sum, sample carers and non-carers appeared to be typical of their respective populations on the variables of interest. Furthermore, as reported in Table 6.1, there were no significant differences for gender, marital status, age or consumption of caffeine, nicotine, or alcohol. Nor were there significant differences in morningness, sleep duration or the timing of sleep between the two groups. There was, however, a significant difference with respect to education, with a greater percentage of non-carers having a tertiary education, $\chi^2(1, N=66)=13.3, p<.001$.

### 6.5.2 Differentiating Carers from Non-Carers

A series of two-tailed t-tests were conducted on the psychological, sleep and substance use measures using a Bonferroni adjusted alpha of .01 to control for Type 1 error. As can be seen from Table 6.1, the groups differed significantly on sleep quality and morning restedness, with carers experiencing poorer sleep than non-carers. The two groups also differed significantly on all stress and wellbeing variables with carers reporting significantly poorer subjective wellbeing. Correspondingly, carers had
significantly higher scores for perceived stress, depression, anxiety, and chronic arousal (as indicated by DASS stress), with very large effect sizes.

In order to check that stress was a key differentiating factor, stepwise logistic regression was performed to determine which of the psychological variables best predicted whether or not participants were in a carer role. All five psychological variables were used: subjective wellbeing, perceived stress and the three DASS scales for depression, anxiety and stress. The final model was significant, \( \chi^2 (1, N=66) = 27.1, p<.001 \), indicating that it was able to distinguish between carers and non-carers. This model was able to explain between 35.4% (Cox & Snell R Square) and 47.2% (Nagelkerke R Square) of the variance in carer status. However, only perceived stress was retained in order to achieve this, with 82.3% of cases able to be correctly classified using this variable alone, \( B=.234, SE=.057, Wald=16.71, df=1, p<.001 \), odds ratio = 1.26, 95%CI [1.13,1.41]. Clearly, perceived stress was the best discriminator of the two groups.

6.5.3 Morningness and Sleep

The correlations between CSM morningness scores and sleep time variables are provided in Table 6.2. Significant negative correlations between morningness and average bedtimes and average wake times indicate that earlier rising and retiring was, as expected, associated with increasing morningness. From Table 6.3, however, it can be seen that there were no significant correlations between morningness and mean amount of sleep per night, sleep quality ratings or estimates of morning restedness. Nevertheless, the positive correlation between morningness and restedness did approach significance.
Table 6.1
*Means and standard deviations for carer and non-carer groups on demographic and study variables*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Carer (n=31)</th>
<th>Non-carer (n=35)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender, female</td>
<td>87.5</td>
<td>85.7</td>
</tr>
<tr>
<td>Marital status, single</td>
<td>74.2</td>
<td>65.7</td>
</tr>
<tr>
<td>Education, tertiary</td>
<td>42</td>
<td>85***</td>
</tr>
<tr>
<td><strong>M</strong></td>
<td><strong>SD</strong></td>
<td><strong>M</strong></td>
</tr>
<tr>
<td>Age (years)</td>
<td>54.56</td>
<td>55.46</td>
</tr>
<tr>
<td></td>
<td>15.25</td>
<td>14.05</td>
</tr>
<tr>
<td><strong>Daily substance use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nicotine</td>
<td>2.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Caffeine</td>
<td>1.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Alcohol</td>
<td>1.0</td>
<td>1.3</td>
</tr>
<tr>
<td><strong>M</strong></td>
<td><strong>SD</strong></td>
<td><strong>M</strong></td>
</tr>
<tr>
<td><strong>Sleep &amp; Activity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSM morningness (max 55)</td>
<td>40.8</td>
<td>43.5</td>
</tr>
<tr>
<td>Wake time (dec hrs)</td>
<td>6.3</td>
<td>6.3</td>
</tr>
<tr>
<td>Bed time (dec hrs)</td>
<td>22.6</td>
<td>22.5</td>
</tr>
<tr>
<td>Sleep time (dec hrs)</td>
<td>6.6</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Sleep quality (max 10)</strong></td>
<td>4.2</td>
<td>6.1***</td>
</tr>
<tr>
<td><strong>Morning restedness (max 10)</strong></td>
<td>3.9</td>
<td>6.3***</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Stress &amp; Distress</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PWI wellbeing (max 100)</td>
<td>51.0</td>
<td>70.2***</td>
</tr>
<tr>
<td>PSS-10 perceived stress (max 40)</td>
<td>23.3</td>
<td>14.8***</td>
</tr>
<tr>
<td>DASS depression (max 42)</td>
<td>16.4</td>
<td>6.3***</td>
</tr>
<tr>
<td>DASS anxiety (max 42)</td>
<td>12.2</td>
<td>5.1***</td>
</tr>
<tr>
<td>DASS stress (max 42)</td>
<td>21.2</td>
<td>10.4***</td>
</tr>
</tbody>
</table>

* ***p<.001 (2 tailed t-tests);  
  d = Cohen’s d (effect size)*

*a one unit equals one cigarette; one cup coffee (two of tea or one Coke); and one standard alcoholic drink

*Note: times are given in decimal hours; time awake during night has been subtracted for total sleep time*
Table 6.2

Correlations between morningness (CSM scores) and sleep variables
(mean values from sleep diary)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pearson’s r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wake time</td>
<td>-.489***</td>
</tr>
<tr>
<td>Bed time</td>
<td>-.469***</td>
</tr>
<tr>
<td>Waking during night</td>
<td>.063</td>
</tr>
<tr>
<td>Sleep time</td>
<td>.031</td>
</tr>
</tbody>
</table>

N=66. ***p<.001.

Table 6.3

Intercorrelations between the main study variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>CSM morningness</th>
<th>PWI wellbeing</th>
<th>PSS-10 (perceived stress)</th>
<th>DASS depression</th>
<th>DASS anxiety</th>
<th>DASS stress (chronic arousal)</th>
<th>Sleep quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSM morningness</td>
<td></td>
<td>.360**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PWI wellbeing</td>
<td></td>
<td></td>
<td>-.258*</td>
<td>-.679***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSS-10 (perceived stress)</td>
<td>-.299*</td>
<td>-.556***</td>
<td>.653***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DASS depression</td>
<td>-.266*</td>
<td>-.449***</td>
<td>.570***</td>
<td>.611***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DASS anxiety</td>
<td>-.421**</td>
<td>-.513***</td>
<td>.691***</td>
<td>.674***</td>
<td>.683***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DASS stress (chronic arousal)</td>
<td>-.113</td>
<td>.393***</td>
<td>-.538***</td>
<td>-.329**</td>
<td>-.405**</td>
<td>-.404**</td>
<td>.867***</td>
</tr>
<tr>
<td>Sleep quality</td>
<td>.226Δ</td>
<td>.484***</td>
<td>-.599***</td>
<td>-.425**</td>
<td>-.406**</td>
<td>-.429***</td>
<td></td>
</tr>
<tr>
<td>Morning restedness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N=66. Δ p = .072. * p<.05. ** p<.01. ***p<.001.

6.5.4 Morningness and Wellbeing

Table 6.3 gives the correlations between morningness, sleep ratings and the key psychological variables. There were significant negative correlations between morningness and perceived stress, depression and anxiety. Of particular interest was the significant moderate negative correlation between morningness and chronic arousal (DASS
stress) and the significant moderate positive correlation between morningness and subjective wellbeing.

### 6.5.5 Morningness and the Carer Role

Table 6.4 reports the results of a hierarchical moderated regression used to investigate the moderating effect of the carer role on the relationship between morningness and subjective wellbeing. In the first step, morningness accounted for 11.6% of wellbeing. The addition of carer role accounted for a further 18.6%. The final step which included the interaction between morningness and carer role accounted for an additional 11%. The full model was significant, $F(3,63)=15.93$, $p<.001$, accounting for 41.2% of the variance in subjective wellbeing. While being a carer was a significant predictor of wellbeing in the final model, the contribution of morningness was no longer significant. Nevertheless, the interaction term remained a significant predictor, with morningness associated with better wellbeing outcomes in the carer group. In the current study caregiving had a relatively large moderating effect on the relationship between morningness and wellbeing, $f^2=0.203$ (see Aguinis, et al., 2005).

Table 6.4 also reports the results of two further hierarchical moderated regressions performed for both stress types, perceived stress and chronic arousal. These were conducted in an attempt to examine the effect of the carer role on the relationship between morningness and the experience of stress. The full model was significant, $F(3,63)=12.41$, $p<.001$, and accounted for 34.8% of the variance in perceived stress. However, in this final model, only the carer role remained a significant independent predictor of perceived stress with morningness and the interaction term no longer contributing significantly.

With respect to chronic arousal, the final model was significant, $F(3,63)=15.44$, $p<.001$, explaining 40.7% of the variance in chronic arousal. However, once again, morningness was no longer a significant predictor of arousal stress in the full model. Both the carer role and the
carer-morningness interaction remained significant predictors in the full model. Thus, the carer role appeared to have a substantial moderating effect on the relationship between morningness and chronic arousal, $f^2=0.104$ (see Aguinis, et al., 2005), with morningness associated with fewer symptoms of chronic arousal among carers.

Table 6.4

Results of the hierarchical moderated multiple regression analyses of morningness, carer status and their interaction, on subjective wellbeing, perceived stress and chronic arousal (DASS stress) respectively

<table>
<thead>
<tr>
<th>Variables</th>
<th>Wellbeing</th>
<th>Perceived Stress</th>
<th>Chronic Arousal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta$</td>
<td>$\Delta\text{adj}R^2$</td>
<td>$\beta$</td>
</tr>
<tr>
<td>Morningness</td>
<td>.36***</td>
<td>.116**</td>
<td>-.258*</td>
</tr>
<tr>
<td>Morningness</td>
<td>.284***</td>
<td>.186***</td>
<td>-.164</td>
</tr>
<tr>
<td>Carer role</td>
<td>-.447***</td>
<td>.554***</td>
<td>.554***</td>
</tr>
<tr>
<td>Morningness</td>
<td>-.065</td>
<td>.11**</td>
<td>-.04</td>
</tr>
<tr>
<td>Carer role</td>
<td>-2.392***</td>
<td>1.246*</td>
<td>1.246*</td>
</tr>
<tr>
<td>Morningness X Carer role</td>
<td>1.946**</td>
<td>-.693</td>
<td>-.693</td>
</tr>
</tbody>
</table>

* $p<.05$   ** $p<.01$   *** $p<.001$

6.6 Discussion

Firstly, the current study provides further support for previous findings that carers are more likely to be experiencing stress and distress than non-carers. (Briggs & Fisher, 2000; Pakenham, et al., 2005; Schulz & Quittner, 1998; Shewchuk, et al., 1998). Indeed, there were significant differences on all psychological variables with perceived stress the best discriminator between the two groups. The results also support past findings that chronic stress (Vitaliano & Young, 2004) and extremely low subjective wellbeing characterise informal caregivers (Brummett, et al., 2006; Cummins, 2001; Cummins, et al., 2005) particularly those providing long-term care (Cummins, et al., 2007). The results were also in line with
previous findings of poor sleep quality among carers (Carter, 2002; Sato, et al., 2002; Teel & Press, 1999).

Secondly, with regard to morningness, the current findings are in line with previous reports of positive correlations between morningness and subjective wellbeing (Howell, et al., 2008; Randler, 2008a). The results also supported previous findings of an inverse relationship between morningness and anxiety (Diaz-Morales & Sanchez-Lopez, 2008; Vardar, et al., 2008) and depression (Hirata, et al., 2007). Further, the results indicate a negative relationship between morningness and perceived stress and chronic arousal stress. This appears to be congruent with previous evidence of links between eveningness and difficulties coping with environmental and social demands (Mecacci & Rocchetti, 1998).

Finally, the results support the prediction that the relationship between morningness and wellbeing would be enhanced under conditions of chronic stress. Indeed, it is clear from the regression analysis that the carer role had a moderating effect on the relationship between circadian preference and wellbeing, with a morning preference associated with greater wellbeing only in the carer group. It would appear that wellbeing homeostasis may be easier to maintain under stressful circumstances for individuals with a greater tendency to morningness. It is noteworthy that both previous findings of a relationship between wellbeing and morningness have been conducted using samples of university students. It could be argued that student samples are likely to be experiencing high stress levels and subsequent wellbeing challenge. It may be that the observed effects are related to the impact of stress on those students with lower morningness scores.

The role of stress appears complex however. While lower levels of arousal were also associated with morningness in the carer group this interaction did not occur for perceived stress. This appears counter to the current finding that perceived stress was the key differentiating factor between the carer and non-carer groups. It would seem that morningness is associated with less physiological arousal due to the carer role, but not
with fewer perceptions of being overwhelmed by that role. This appears to challenge previous studies' reliance on measures of perceived stress as the key measure of stress among carers (Brummett, et al., 2006; de Vugt, et al., 2005) and points to distinct characteristics of the DASS stress scale. Indeed, wellbeing homeostasis may reflect a physiological homeostasis that is associated with fewer symptoms of chronic arousal. Indeed, the moderation of chronic arousal is in line with previous reports that morningness may be associated with behaviours that reflect increased central nervous system adaptability in the face of environmental demand. This aligns with the proposal that morningness may be associated with a stronger capacity for central nervous system inhibition leading to effective coping through reduction of behaviours that are no longer adaptive (Mecacci & Rocchetti, 1998). Clearly, more research is needed to clarify such stress effects.

The results of this study should be considered in light of several limitations. These include the use of a quasi-experimental design, a small sample size, the self-selection of carer participants and the heterogeneity of the carer group. However, this approach is arguably the only ethical and ecologically valid method of exploring the impact of chronic stress, which is an experience unable to be replicated experimentally. With regard to sample size, the current sample appeared to be adequate to detect the apparent large effect sizes. Nevertheless, the use of a larger sample in future studies would improve the robustness of the findings and provide an opportunity to further investigate the mediating and/or moderating effects of stress.

Despite these caveats, the current results would appear to indicate that the effect of morningness on wellbeing among caregivers is a strong one. Further research is needed to investigate the specific conditions for which this is so and to further explore the role of chronic arousal in wellbeing homeostasis. Such findings may provide insight into the regulation of personal wellbeing more generally and help to further elucidate the links between stress, health and chronobiological influences.
Chapter 7 – General Discussion

7.1 Summary

This study took a biopsychosocial approach to the examination of stress and its interactions among long-term primary carers. Taken together, the findings point to large discrepancies between carer and non-carer participants across multiple measures of stress, distress and SWB. However, the results did not provide unambiguous support for a direct relationship between chronic stress, SWB and circadian rhythmicity. The study carers, who were primary carers who had been in that role for a minimum of two years, appeared to provide a sobering natural example of the experience of prolonged stress. Indeed, carers fared much worse than non-carers on measures of psychological stress and distress and their scores for SWB and social functioning were also comparatively poor. Yet these stark contrasts did not translate into clear differences in the circadian patterns of all biochemical markers employed. Specifically, the prediction that primary carers would exhibit circadian rhythm dysregulation in the form of decreased cortisol amplitude was not supported. Similarly, the hypothesis that the carers’ core body temperature rhythm amplitude would be reduced was not supported, although the difference did approach significance despite the smaller sample for that component. Again, the predicted lower levels of immunity among carers was not found. Yet, the results did provide support for the prediction of reduced melatonin rhythm amplitude among informal caregivers.

Furthermore, with regard to the hypothesised relationship between circadian dysregulation and physical health in the form of immune markers, there was no evidence of a link between cortisol, melatonin or temperature rhythms and the immune measure of slgA antibody levels. There was, nevertheless, evidence to support the prediction that circadian dysregulation would be associated with decrements in psychological
health. Indeed, perceived stress, chronic arousal stress and the intensity of daily hassles exhibited a negative relationship with morning cortisol levels and cortisol amplitude, providing an indication that blunted cortisol patterns may be associated with increasing levels of these negative states. Furthermore, the findings also provided support for the prediction that circadian dysregulation would be linked to subjective wellbeing, with a positive relationship apparent between both waking cortisol and cortisol amplitude levels and SWB.

Of interest to the current study was the finding that carers were more likely than non-carers to experience SWB in the dissatisfied range. An examination of the relationship between SWB and cortisol rhythmicity using satisfied and dissatisfied SWB groups provided some illumination of the relationship between caregiving and cortisol dysregulation. Exploration of this possible SWB threshold (the midpoint between satisfaction and dissatisfaction on the PWI scale) appeared to provide a potential alternative approach for investigation of the relationship between cortisol and SWB. Participants who scored below that threshold and rated themselves as dissatisfied with life, were distinguishable on the basis of their comparatively lower morning cortisol levels and the subsequent blunting of their cortisol rhythm. Thus, it may not be caregiving per se but the downstream effect on SWB maintenance that was linked to cortisol dysregulation.

### 7.2 Chronic Stress, Subjective Wellbeing and Cortisol Dysregulation

The experience of stress clearly differed markedly between study carers and non-carers, with perceived stress best able to distinguish the two groups. Yet, despite such test scores and, moreover, evidence of substantial qualitative differences observed at interview - with most carers seeming overwhelmed and struggling and most non-carers reporting they were coping well with life challenges and goals - circadian cortisol patterns did not differ. It is hard to convey the extent of the dissimilarities between
the groups and, as has been previously explained, the caregiving situations observed had existed for a minimum of several years. That the carer group did not exhibit HPA dysregulation as had been predicted was not in line with a considerable body of evidence of altered cortisol patterns under conditions of chronic adversity (Clow, 2004; Goldman-Mellor, et al., 2012; Heim, Ehlert, & Hellhammer, 2000; Izawa, et al., 2012; Li, et al., 2007; McEwen, 2000a; O'Connor, et al., 2012; Pruessner, et al., 1999), including among carers (Barker, et al., 2012; Bella, et al., 2011; Da Roza Davis & Cowen, 2001; Davis, et al., 2004; Vedhara, et al., 1999; Wahbeh, et al., 2008). Nevertheless the finding of no differences in diurnal cortisol patterns does align with several other investigations of carers (Gonzalez-Bono, et al., 2011; Lovell, et al., 2012; Provinciali, et al., 2004; Rohleder, et al., 2009; Schwarz & Dunphy, 2003; Vedhara, et al., 2003) and other chronically stressed populations (Bellingrath, et al., 2008; Carlson, et al., 2007; Mommersteeg, Heijnen, Verbraak, & van Doornen, 2006; Sertoz, Binbay, & Elbi Mete, 2008). The results also align with studies indicating no significant relationship between perceptions of stress and cortisol levels (Davis, et al., 2004; Simpson, et al., 2008).

The current cortisol result seems unlikely to be able to be explained by any genuine lack of psychosocial differences between the groups, as may have been the case with carer studies who either did not employ primary carers (Provinciali, et al., 2004) or included carers whose time in that role was limited (de Vugt, et al., 2005; Rohleder, et al., 2009). However, as previously noted, the great inter- and intra-individual variability in cortisol levels (Gex-Fabry, et al., 2012; Kudielka & Wust, 2010; Miller, et al., 2007) as well as bi-directional actions and multiple interactions (Kudielka, et al., 2009; Sapolsky, 1994) often render interpretation difficult. Carers and non-carer differences may simply have been overshadowed by the large inherent variability in cortisol data. It is also possible that the diversity of caregiving circumstances of carer participants may have contributed to divergent effects on cortisol. For instance, it may be that differences in caregiving circumstances and tasks
presented equally diverse challenges, responses and subsequent bodily effects for the diverse group of participating carers. However, previous studies have discounted the influence of care specifics once truly substantial caregiving is required (Cummins, 2005b; Raina, et al., 2005).

It is also possible, given continued mixed results being reported for the relationship between HPA, chronic stress and cortisol (Frodl & O'Keane, 2012; Goldman-Mellor, et al., 2012; Gustafsson, et al., 2012; Hellhammer, et al., 2009; Kudielka & Wust, 2010; Lovell, et al., 2012; Lupien, et al., 2009; Moriguchi-Jeckel, et al., 2010), that many opposing changes in cortisol rhythmicity may have occurred, particularly for carer participants, making any comparisons fraught with difficulty. For instance, at different stages of the caregiver trajectory cortisol may display different circadian effects, as would be consistent with previous reports of high levels at times of particular demand (Cacioppo, et al., 2000; Davis, et al., 2004; O'Connor, 2005) followed by troughs in cortisol secretion during less stressful stages (Da Roza Davis & Cowen, 2001; Harris, et al., 2007; Lupien, et al., 2009). The single morning sample used, which was intended to measure the morning rise at its peak, may have been insufficient to capture atypical changes in cortisol release under conditions of chronic adversity and this may have precluded a clear picture of morning levels. Additionally, state conditions may have resulted in reactive surges associated with anticipation of upcoming tasks (Thorn, et al., 2009; Young, et al., 2004) and these may have masked circadian effects. Furthermore, the expected large variability of the morning cortisol rise (Gex-Fabry, et al., 2012; Kudielka & Wust, 2010), which is likely to be even greater in a sample under uncontrolled stressful conditions, may have precluded detection of differences. In sum, a simple comparison between carers and non-carers may not be sufficiently sensitive to possible nuances in cortisol dysregulation under chronic stress of many years duration.

Nevertheless, participants grouped according to Cummins (2005a) criteria into dissatisfied and satisfied SWB groups, did exhibit cortisol
rhythm differences and this would seem to offer a helpful avenue for interpreting the current results. This finding is consistent with others which have identified blunted cortisol rhythms associated with depression (Deuschle, et al., 1997; Groer & Morgan, 2007; Souetre, et al., 1989), chronic fatigue (Crofford, et al., 2004), and PTSD (Yehuda, et al., 1996). It appears that reference to a SWB threshold, beyond which the risk of depression and wellbeing failure is high (Cummins, 2005b), offers a plausible means to explain cortisol dysregulation. Since the great majority of those in the dissatisfied group were carers, failure of SWB homeostasis seems to be a likely, though not inevitable, consequence of long-term caregiving. It seems that it is likely to be this failure, rather than caregiving per se, which may then be associated with changes in cortisol rhythmicity. Such an interpretation would fit Cummins (Cummins, 2005a, 2005b, 2010) model of SWB homeostasis, where maintenance of SWB within a narrow adaptive range will withstand challenges up to a personal stress threshold, but beyond which rapid decline in SWB is predicted. Cummins’ (2010; Tomyn & Cummins, 2011) argument that such SWB maintenance involves, at its core, the protection of positive mood (HPM, homeostatically protected mood), is also consistent with the current findings. His proposal that, once the adaptive positive influence of SWB is overwhelmed and external and internal buffers have been exhausted, the control of mood will revert to external circumstances, would appear to match well with many study carers’ assessments of their personal circumstances and outlook.

Cummins’ approach also fits, of course, with the definition of stress employed in this study with its emphasis on a sense of threat to personal wellbeing (Lazarus & Folkman, 1984). It also fits with the conceptualisation of stress as a threat to homeostasis that includes the sense of a threat to physiological homeostasis (Chrousos, 2009; Goldstein, 2003). Indeed, it is from this viewpoint that the concept of subjective wellbeing as a reading of one’s core affective state (Davern, et al., 2007) may be relevant to cortisol dysregulation. Given the cross-sectional nature of the current study it is not possible to discuss causation. However, it is interesting to consider
whether a collapse of SWB preceded the physiological changes in cortisol regulation and represented the beginning of a cascade of physical system failures. An equally plausible alternative explanation worthy of consideration is that bodily awareness of the physiological effects of ongoing stress (allostatic load) which may have eroded the biological substrate of HPA in those in the dissatisfied group, led to a ‘reading’ of this as low positive mood and a sense of not being up to the task of coping with further threat.

### 7.3 Chronic Stress and Immunity

While perceived stress, did not exhibit a straightforward relationship with cortisol (Hellhammer, et al., 2009), despite being best able to differentiate carers from non-carers, chronic arousal stress appeared to provide some insight into the possible mechanism of chronic stress effects. Chronic arousal stress, with its emphasis on physiological symptomology (Lovibond & Lovibond, 1995) showed a tendency toward links with both sIgA and chronotype among carers. The influence of chronic arousal appears to point to chronic physiological activation as a core component of the deleterious nature of chronic stress. Such an understanding would fit with a view of stress as a threat to homeostasis (Chrousos, 2009; Goldstein, 2003) and is certainly consistent with current understandings of worry as involving prolonged physiological activation (Brosschot, 2010). Indeed, it is also congruent with findings of reduced limbic activation being associated with increased cortisol amplitude (Cunningham-Bussel, et al., 2009). Furthermore, a central role for chronic arousal would also fit with the concept of allostatic load, with the wear and tear of chronic activation a potential mechanism of cortisol effects and/or sIgA decrements. The current findings may also relate to a conceptualisation of allostatic load as marker of “subclinical disease” (Mathews & Gallo, 2011, p. 504). Moreover, the evidence from the current study that a morning preference may provide some physiological
advantage under circumstances of constant arousal would appear to add weight to the argument for a circadian influence in SWB maintenance.

The lack of evidence of comparative sIgA decrements among carers in the current study stands in contrast to a substantial PNI literature on the effects of stress on immunity (Bauer, 2008; Cohen, et al., 1993; Ellard, et al., 2006; Glaser & Kiecolt-Glaser, 2005; Landgraf, et al., 2012; McEwen & Gianaros, 2010; Segerstrom & Miller, 2004) including among informal caregivers (Cacioppo, et al., 1998; Kiecolt-Glaser, et al., 1991; Kuster & Merkle, 2004; Lovell, et al., 2012; Moriguchi-Jeckel, et al., 2010; Wong, et al., 2012). As a possible measure of health, the sIgA data also contrasted with carers’ own reports of their more frequent visits to the doctor as well as poorer self-rated health. At the same time, however, the current results are consistent with other studies which have failed to find clear associations between immune levels and psychological measures of stress and/or wellbeing (Deinzer, et al., 2000; Kiecolt-Glaser, et al., 1987; Rohleder, et al., 2009; Stowell, et al., 2001; Volkmann & Weekes, 2006). Although it has been found useful with ageing caregivers (Gallagher, et al., 2008), it may be that sIgA is not well suited to detection of changes under chronic conditions where older age is not a factor. Indeed, much previous PNI work has employed markers of cellular-immunity or inflammation rather than humoral measures such as sIgA (Lovell, et al., 2012; Provinciali, et al., 2004; Rohleder, et al., 2009; Vedhara, et al., 1999; Wong, et al., 2012). The results may simply be in line with previous mixed findings for studies of the effects of stress on physical health parameters, with reports of both up-regulation and down-regulation of immunity (Cacioppo, et al., 1998; Fan, et al., 2009; Rohleder, et al., 2009; Segerstrom & Miller, 2004). The current findings also appear to speak to arguments that recognise the role of other highly influential factors besides stress in the complex determination of physical health outcomes (Lazarus, 1999). However, as noted earlier, the potential for interaction between sIgA and chronic arousal (as measured by the DASS stress scale) may provide more insight and requires further investigation.
7.4 Chronic Stress, Sleep, and Melatonin Dysregulation

With regard to melatonin, carers were able to be clearly differentiated from non-carers by higher morning levels and decreased amplitude. The addition of sleep quality to these comparisons served to sharpen the distinction between the groups further. Evidence of sleep and melatonin dysregulation among carers matches well with carers' personal anecdotes as well as with past findings of poor sleep among informal caregivers (Access Economics, 2010; Brummett, et al., 2006; Sato, et al., 2002). However, carers and non-carers did not differ on sleep quantity, and this was an apparent divergence from past literature on sleep-health (Carter, 2002; Ferrara & De Gennaro, 2001; Rueggeberg, et al., 2012; Spiegel, 1999; van Cauter, et al., 2008) and sleep-wellbeing links (Cummins, et al., 2012; Groeger, Zijlstra, & Dijk, 2004).

However, the study findings with regard to sleep quality are in line with previous reports of qualitative sleep changes in the face of stress (Dedert, et al., 2012; McEwen, 2008; Persengiev, et al., 1991; Vandkerckhove & Cluydts, 2010) and particularly in cases of vital exhaustion (Nicholson & van Diest, 2000) and burnout (Akerstedt, 2006; Melamed, et al., 1999). In particular, this study adds weight to arguments of likely sleep dysregulation among carers (Sato, et al., 2002) and evidence of negative links between sleep problems and subjective wellbeing (Birchler-Pedross, et al., 2009; Cummins, et al., 2012). The strong relationships between sleep quality and all the psychological variables of interest to the current study (with the exception of uplifts) point to its having a central role in outcomes under chronic stress. This is in line with previous literature showing the importance of sleep for reducing distress and improving wellbeing (Sickel, et al., 1999; Vandkerckhove & Cluydts, 2010) and for buffering stress and negative emotional states (Hamilton, et al., 2007). It also converges with recent indications that sleep may be a restorative antidote to cortisol dysregulation (Rueggeberg, et al.,
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2012) and is consistent with an appreciation of adequate circadian functioning as the key prerequisite for health (Landgraf, et al., 2012).

The results from the limited core body temperature dataset are also worthy of consideration here. The difference in core body temperature amplitude between carers and non-carers, which approached significance, fits with the observed general trend toward a blunted circadian pattern for carers and is consistent with the decreased amplitude observed for melatonin. Indeed, temperature amplitude’s inverse relationships with depression and anxiety (with trends for perceived stress, chronic arousal and hassles intensity also in the same direction) add further support to this interpretation. Furthermore, temperature amplitude’s strong positive association with social functioning is congruent with adaptive outcomes being associated with healthy circadian rhythmicity. Taken together, the findings present a picture of blunted temperature rhythms under conditions of chronic stress and its likely sequelae. Interestingly, temperature amplitude also displayed a positive association with morningness that approached significance, adding further weight to the notion that morningness may confer an advantage under chronic stress.

The fact that differences in melatonin and sleep quality were evident between carers and non-carers but not between SWB groups is of special interest. It has been argued previously that excessive activation of the HPA axis may lead to resetting of HPA homeostatic set-points (Chrousos & Gold, 1998; Engelmann, Landgraf, & Wotjak, 2004; Kudielka, et al., 2006; Tsigos & Chrousos, 2002; Uschold-Schmidt, et al., 2012), with subsequent negative impacts on other systems including sleep (McEwen & Gianaros, 2010; Nicholson & van Diest, 2000; O’Connor, et al., 2009). Indeed, the current findings could be seen as lending support to the notion of stress-induced melatonin disruption (Claustrata, et al., 2005), possibly as a result of an initial excess of reactive cortisol (Lutterschmidt & Mason, 2010; Nikaido, et al., 2010). However, the results of the current study would also, and perhaps better, fit an interpretation involving a different order of events where chronic stress interferes first with the capacity for
healthy sleep and melatonin rhythmicity, perhaps linked to chronic arousal. Such dysregulation may later be associated with flow-on effects to other circadian parameters including possible changes to the HPA axis (e.g. the morning cortisol rise) and ultimate effects on such parameters as mood and alertness. This would also be in line with melatonin’s proposed role in stabilising and synchronising other rhythms (Cajochen, et al., 2003; Claustrata, et al., 2005) and its proposed protective role in the face of adversity (Kopp, et al., 1999; Tan, et al., 2010). It would also be consistent with a view that awareness of physiological disruption leading to a shift in positive mood (the substrate of SWB) outside a homeostatically protected range (Davern, et al., 2007), may lead to a re-evaluation of one’s capacity to meet challenges and, eventually, to a perception of the collapse of personal wellbeing.

To revisit an apparent discrepancy identified in Chapter 5, the relationships with waking melatonin and both waking cortisol and cortisol amplitude were in the positive direction for the study sample. This was somewhat surprising given that high waking melatonin appeared to be linked to poorer outcomes and high waking cortisol to better outcomes within the current study. It was also in contrast to other findings in the current study, where only waking cortisol had significant relationships with measures of stress and SWB, whereas waking melatonin only displayed significant associations with sleep quality and disengagement. It also appears to contrast with other reports of cortisol blunting being associated with poor sleep (Lasikiewicz, et al., 2008) and melatonin’s apparent role in normalizing cortisol patterns (Fischer, et al., 2003) as well as findings of no relationships between cortisol, melatonin and sleep (Carlson, et al., 2007; Redwine, et al., 2000). It is important to note, however, that correlations across the whole sample would represent an amalgam of the many different tensions in the relationship between cortisol and melatonin, especially possible contrasting effects among carer and non-carer groups. The apparent positive links between waking melatonin and waking cortisol may simply point to a great complexity of inter-relationships between these
neuroendocrine markers. For instance, despite salivary cortisol being accepted as the most valid marker of HPA activation (Hellhammer, et al., 2009), it is likely that some elevations in cortisol were attributable to activation due to acute stress (Kudielka, et al., 2009; Previle, Zarit, Susman, Boulenger, & Lehoux, 2008). Thus, if enough acute stress episodes are occurring, rather than a sign of circadian health, morning elevations may represent anticipatory stress, which would alter interpretation of cortisol patterns. A further consideration is that ultradian pulsatility of cortisol may cloud interpretation of grouped cortisol data (Young, et al., 2004). Additionally, if rhythm abnormalities confer a greater vulnerability to stress, a subsequent spiral effect due to ongoing reciprocal reactions may result (Lupien, et al., 2009; Young, et al., 2004). Another possibility is that specific coping strategies such as disengagement may play a role in rhythm disruption, such as has been found in cancer patients where circadian dysregulation of rest-activity patterns has been linked to avoidance (Dedert, et al., 2012). It seems important at this point to acknowledge the dynamism and inter-connectedness of biological systems, particularly in response to stress (Rohleder, et al., 2009). Indeed, the current study supports a recognition of the inevitable complexity of the links between the perception of stress and physiological outcomes (Hellhammer, et al., 2009) as well as the likelihood of non-linear associations under chronic stress (Chatkoff, et al., 2010).

7.5 Study Limitations and Directions for Future Work

While the study limitations with respect to separate components have already been discussed in each chapter, it is perhaps appropriate to reiterate the key issues here. The most serious potential limitation of the current study was the small sample size. While this was due to the difficulty of obtaining participation from a group with serious constraints on their capacity to do so, an increased sample and improved robustness of results are needed to test whether the trends observed in this study hold. However, given that carers are a highly stressed and time-poor population,
this would likely require a co-ordinated project across a wide geographical area (such as a whole state) as well as provision of respite specifically for participation purposes in order to ensure a large enough pool from which to draw participants. Such an exercise, though costly, would be worthwhile, having as it does the potential to provide information on the experience of chronic stress unlikely to be obtainable otherwise. Larger numbers of carer and non-carer groups would also allow investigation of study variables within each separate group which may reveal further differences due to the carer role. While correlations in the current study were conducted using all participants, on the basis of this providing an extended range and improving chances of detection of relationships, it may be that extreme stress effects may benefit from alternative data management, including use of a wellbeing cut-off.

Another potential limitation of the current study involved the use of one time point only for measurement of morning cortisol values. Use of more time points to examine the cortisol awakening response may be needed if dysregulation leads to phase changes in the peak of waking cortisol. Furthermore, multiple time-points have been recommended to enhance examination of stress and circadian interactions (Lupien, et al., 2009). It must be stated again, however, that any such requests would very likely result in increased burden for participating caregivers and, given the experience of this study, a likely reduction in participation by the most stressed carers. Although study participants indicated that they had complied with directions and recorded their sampling accurately, the use of electronic devices such as caps that record time of opening of sample containers, would likely help to improve both compliance and data accuracy (Broderick, Arnold, Kudielka, & Kirschbaum, 2004) and would be worth consideration in future studies using saliva collection.

It may be that inclusion of previous carers would add to an understanding of any lasting chronic stress effects as well as increase the pool of potential participants. In the current study, a number of potential carer participants had recently relinquished care and had been keen to be
involved, remarking that they still felt affected by their previous role. It may be that use of carer, previous carer and never-carer groups may illustrate the longevity or otherwise of any psychological or physiological outcomes due to chronic demand. It is also probable that, over time, attrition will occur among carers by those individuals who are less able to deal with prolonged stress and/or circadian disturbance. Longitudinal studies of carer groups are needed to investigate such trends so that any systematic effects on carer outcomes, including SWB, may be taken into account.

The use of saliva collection appears to be suited to research involving caregivers, given its credibility as a biomarker of stress as well as its being a pain-free, non-invasive technique that can be accommodated into participants’ normal routine within their usual environment (Hansen, et al., 2012; Hellhammer, et al., 2009). Nevertheless, the use of newer technologies seems likely to provide avenues for obtaining more circadian data with even less burden or disruption. For instance, the use of hair sampling, a method that has been used previously for detection of cortisol trends over the space of months (Dettenborn, et al., 2010) as well as in comparisons between trauma victims and controls (Steudte, et al., 2011) may be useful in future studies. The use of temperature pill technology would appear to be a good choice for future core body temperature data collection over a circadian cycle (Casa, et al., 2007; Coyne, Kesick, Doherty, Kolka, & Stephenson, 2000), particularly as the cost barrier reduces. Additionally, simultaneous multi-channel monitoring of such variables as body temperature, heart and breathing rates, and rest-activity patterns alongside such key environmental information as ambient temperature and light intensity (Kolodyazhniy, et al., 2011) would appear to offer substantial improvements in data collection procedures. Investigations of genetic effects, such as telomere length (O'Donovan, et al., 2012), also appear to hold promise for understanding the full extent of coping with ongoing demand. These new strategies appear to have the potential to allow sampling that induces little burden and still takes place during the participants’ usual routine. Thus, they appear likely to have the
potential to radically improve both participation rates and data quality in studies of populations such as chronically stressed caregivers.

A possible improvement in future would be to take time of day into account when measuring SWB. Given that mood displays a circadian pattern (Murray, 2007), such changes may influence self-reported SWB and taking this into account may improve the robustness of results. A further improvement to future studies would be to consider the role of anti-depressants in circadian changes. While clinical changes have not been found to translate into changes in melatonin or cortisol values for individuals on anti-depressants (Monteleone, Catapano, Tortorella, Di Martino, & Maj, 1995), future work may wish to screen or monitor participants on this basis. Additionally, the current study’s consideration of possible seasonal effects on melatonin and sleep should be replicated in future, particularly in the face of concerns regarding circadian studies’ lack of concern for likely seasonal variations (Hansen, et al., 2012).

7.6 Practical Implications

This study adds to the growing body of research supporting the view that long-term caregiving is potentially associated with physical and psychological health decrements. Its findings thus add weight to arguments for the need to acknowledge the possible toll of long-term caregiving and ensure adequate support for individuals facing overwhelming demand. Such evidence is clearly needed to assist efforts to make sure such recognition and support is put in place (Commonwealth of Australia, 2010), since carers continue to demonstrate poor outcomes with few signs of positive adaptation over time (Bass, et al., 2012; Bella, et al., 2011; Edwards & Higgins, 2009; Kim, et al., 2012; Lambert, et al., 2012; Lovell, et al., 2012).

Use of a measure of subjective wellbeing in clinical or research work appears likely to improve understanding of chronic stress effects beyond that provided by typical measures of stress and distress alone. Clearly, SWB has a separate relationship with stress from such measures
and the possibility of an SWB threshold appears to have practical implications for the treatment of individuals who may be struggling to maintain SWB homeostasis. The consideration of a wellbeing cut-off may help to reconceptualise stress effects in at-risk populations. Furthermore, the current findings regarding the relationship between SWB and physiology point to the PWI as a potential indicator of allostatic load as well as SWB defeat. As a simple 7-item scale, the PWI may thus have great utility in identification of those individuals at risk of both mental and physical health decrements. The PWI may also be a useful tool for the measurement of support or program effectiveness as well as a possible way to identify those areas most in need of being addressed. For instance, the carers in the current study indicated most dissatisfaction with their health, life achievement and future security. Such information surely provides an opening for targeted interventions.

The current study also supports calls for the consideration of subjective wellbeing as vital to government policy (Rablen, 2012). Additionally, this study may help to reduce an apparent ignorance of the importance of circadian influences on health and wellbeing within the health sector, where most policies do not reflect an understanding of chronobiology (McEachron & Donnelly, 2012). It is imperative to continue to gather evidence that will promote better consideration of the influence of both circadian rhythmicity (e.g. the critical importance of quality sleep) and of possible circadian dysregulation (e.g. global effects due to melatonin dysregulation) for improving physical and psychological outcomes. For chronically stressed populations, a simple and obvious solution would seem to be to provide a level of support that reduces stress perceptions to within the range of the individual’s capacity for SWB maintenance. For example, provision of substantial respite care and measures to increase the level of felt support for carers, both variables clearly linked to SWB among participant carers, would doubtless increase caregiver SWB. While perhaps initially costly, such strategies seem likely to improve cortisol levels, sleep and wellbeing and, potentially, more distal outcomes such as
health across the lifespan, which would likely reduce costs in the longer term.

A less holistic but perhaps easier solution may lie with the use of exogenous melatonin or its agonists for the treatment of stress effects, an approach that appears to be gaining recognition and popularity (Cardinali & Golombeck, 2009; Hickie & Rogers, 2011; Norman, 2009; Reiter, et al., 2007; Srinivasan, Cardinali, Pandi-Perumal, et al., 2011; van Maanen, et al., 2011). Also, the acknowledgement of the importance of sleep to diurnal cortisol patterns and health (Rueggeberg, et al., 2012) may help to modify treatment and/or support approaches, such as providing an argument for regular overnight assistance for carers who feel they are ‘on duty’ 24/7. There is also potential for carer training in coping strategies that have been found to be linked to positive outcomes and improvement of cortisol profiles, such as problem engagement and seeking social support (O'Donnell, et al., 2008) as well as mindfulness techniques (Hsiao, et al., 2012; Lengacher, et al., 2012). Dissemination of such training may have implications for health promotion efforts among carers or any other chronically stressed population, including the long-term unemployed (Dettenborn, et al., 2010), those with precarious job security (Gustafsson, et al., 2012) or those with prolonged and debilitating grief (O'Connor, et al., 2012). In sum, the current results point to a wide range of practical directions for addressing the impact of chronic stress.

7.7 Theoretical Implications

The current findings sit well with the notion of a healthy stress response system being a fundamental contributor to SWB (Chrousos, 2009). Indeed, Lazarus and Folkman’s (1984) definition of stress appears to have provided an excellent framework. This study’s findings support their view that a threat to personal wellbeing is at the core of the stress experience, with many caregivers experiencing dissatisfaction with life. Such an understanding is congruent with the nature of the carer role, with its ‘other’ focus and the possibility of overwhelming demand experienced
over years on a largely 24/7 basis. However, the definition of stress as the perception of a threat to homeostasis (Chrousos, 2009) is also highly relevant to the findings of this study. These two conclusions tend to support the current contention that viewing these experiences as one and the same phenomenon is both valid and pragmatic. Indeed, as stated earlier, this study argues that a sense of positive wellbeing may be conceptualised as the subjective component of a state of physiological homeostasis and, correspondingly, that true ‘health and wellbeing’ may involve simultaneous balance of both psychological and physiological parameters. The current findings are also consistent with emotions as central to neuroendocrine functioning (Mathew & Paulose, 2011). Indeed, if SWB (interpreted here as core affect (Davern, et al., 2007)) is synonymous with physiological wellbeing, that may explain why it is considered a key determinant of health (Diener & Chan, 2011; Xu & Roberts, 2010).

This study’s investigation of the links between SWB and physiology also lends support to contentions of a link between circadian regulation and the maintenance of positive mood states (Nater, Hoppmann, & Klumb, 2010; Ong, et al., 2011; Simpson, et al., 2008). It points to the possibility of circadian rhythmicity being closely related to SWB maintenance. This fits with past arguments that conditions such as depression, which Cummins’ (2010) describes as the result of SWB failure, may be associated with a weakened coupling of circadian pacemakers leading to increased sensitivity to external events (Souetre, et al., 1989). More recent proposals that mirror this by arguing that the failure of core mood/affect homeostasis will precipitate a shift toward external control of mood (Cummins, 2010; Tomyn & Cummins, 2011) are also congruent with the current study. In sum, this study points to a truly biopsychosocial conceptualisation of SWB, with circadian synchronisation potentially underpinning one’s sense of ‘health and wellbeing’ and stress as a possible desynchroniser of such healthy rhythmicity.
It is argued here that a conceptualisation of SWB homeostasis as the subjective equivalent of physiological homeostasis could revitalise the usefulness of the original Lazarus and Folkman model. While their 1984 model did include physical, psychological and social outcomes as indicators of successful adaptation in the face of stress, it did not consider the unique problems associated with chronicity. Indeed, to the present time, chronic stress models are few and inadequate (Bhatia, et al., 2011; Gottlieb, 1997; Kudielka & Wust, 2010; Liu & Alloy, 2010). A renewed emphasis on challenge to wellbeing alongside clarification of current understandings of SWB may improve the utility of the Lazarus and Folkman model by allowing it to address changes in the defence of wellbeing over time. In particular, appreciation of the links between SWB and circadian processes could allow adequate consideration of the potentially corrosive nature of stress and the potential for ongoing reciprocal effects to overwhelm homeostatic efforts. Thus, when stress is not an episodic experience but more a fact of daily life, stress effects may, ultimately, be circadian/SWB effects. Indeed, as stated earlier, positive SWB may reflect an underlying biological state of preparedness to engage with the world which may also be interpreted as a ‘reading’ of circadian synchrony. Thus, inclusion of the notion of homeostatic control of SWB, with links to physiological outcomes, could improve the Lazarus and Folkman model's explanatory power in circumstances of chronic adversity.

A key question left unanswered by the current study is ‘why are some carers not exhibiting low SWB?’. It appears likely that physiological factors are at play in the maintenance of SWB homeostasis. Clearly, more investigation of wellbeing under chronic stress is needed. It has been argued that “understanding how stress, coping and health change over time within individuals (i.e., in a multi-level framework) will be a major advance for the field” (Segerstrom & O'Connor, 2012, p.128). Better illumination of the role of both subjective wellbeing and circadian dysregulation within that multi-level framework has the potential to improve our understanding of the psychological and physical processes involved in
the experience of prolonged stress. Such knowledge will surely promote 
better support and/or interventions for individuals experiencing adversity 
as well as enhanced appreciation of the critical role of circadian rhythmicity 
in health and quality of life.
References


CIRCADIAN RHYTHMICITY AND SUBJECTIVE WELLBEING


CIRCADIAN RHYTHMICITY AND SUBJECTIVE WELLBEING

(Thamnophis sirtalis). General and Comparative Endocrinology, 169, 11-17.


CIRCADIAN RHYTHMICITY AND SUBJECTIVE WELLBEING


CIRCADIAN RHYTHMICITY AND SUBJECTIVE WELLBEING


Appendix A – PSS-10

PSS – 10

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, please indicate with a tick how often you felt or thought a certain way.

1. In the last month, how often have you been upset because of something that happened unexpectedly?

<table>
<thead>
<tr>
<th>Never</th>
<th>Almost never</th>
<th>Some times</th>
<th>Fairly often</th>
<th>Very often</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

2. In the last month, how often have you felt that you were unable to control the important things in your life?

<table>
<thead>
<tr>
<th>Never</th>
<th>Almost never</th>
<th>Some times</th>
<th>Fairly often</th>
<th>Very often</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

3. In the last month, how often have you felt nervous and "stressed"?

<table>
<thead>
<tr>
<th>Never</th>
<th>Almost never</th>
<th>Some times</th>
<th>Fairly often</th>
<th>Very often</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

4. In the last month, how often have you felt confident about your ability to handle your personal problems?

<table>
<thead>
<tr>
<th>Never</th>
<th>Almost never</th>
<th>Some times</th>
<th>Fairly often</th>
<th>Very often</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

5. In the last month, how often have you felt that things were going your way?

<table>
<thead>
<tr>
<th>Never</th>
<th>Almost never</th>
<th>Some times</th>
<th>Fairly often</th>
<th>Very often</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Continued over
6. In the last month, how often have you found that you could not cope with all the things that you had to do?

7. In the last month, how often have you been able to control irritations in your life?

8. In the last month, how often have you felt that you were on top of things?

9. In the last month, how often have you been angered because of things that were outside of your control?

10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

(Cohen & Williamson, 1988)
Appendix B – DASS-21

**DASS-21**

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you over the past week. There are no right or wrong answers. Do not spend too much time on any statement.

*The rating scale is as follows:*

- 0: Did not apply to me at all
- 1: Applied to me to some degree, or some of the time
- 2: Applied to me to a considerable degree, or a good part of time
- 3: Applied to me very much, or most of the time

<table>
<thead>
<tr>
<th>Number</th>
<th>Statement</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I found it hard to wind down</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>2</td>
<td>I was aware of dryness of my mouth</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>3</td>
<td>I couldn't seem to experience any positive feeling at all</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>4</td>
<td>I experienced breathing difficulty (eg, excessively rapid breathing, breathlessness in the absence of physical exertion)</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>5</td>
<td>I found it difficult to work up the initiative to do things</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>6</td>
<td>I tended to over-react to situations</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>7</td>
<td>I experienced trembling (eg, in the hands)</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>8</td>
<td>I felt that I was using a lot of nervous energy</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>9</td>
<td>I was worried about situations in which I might panic and make a fool of myself</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>10</td>
<td>I felt that I had nothing to look forward to</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>11</td>
<td>I found myself getting agitated</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>12</td>
<td>I found it difficult to relax</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>13</td>
<td>I felt down-hearted and blue</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>14</td>
<td>I was intolerant of anything that kept me from getting on with what I was doing</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>15</td>
<td>I felt I was close to panic</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>16</td>
<td>I was unable to become enthusiastic about anything</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>17</td>
<td>I felt I wasn't worth much as a person</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>18</td>
<td>I felt that I was rather touchy</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>19</td>
<td>I was aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat)</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>20</td>
<td>I felt scared without any good reason</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>21</td>
<td>I felt that life was meaningless</td>
<td>0 1 2 3</td>
</tr>
</tbody>
</table>
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Appendix C – PWI-Adult

PWI-A

The following questions ask how satisfied you feel, on a scale from zero to 10. **Zero** means you feel completely dissatisfied. **10** means you feel completely satisfied. And the **middle of the scale is 5**, which means you feel neutral, neither satisfied nor dissatisfied.”

Please indicate your response to each item with a mark in the corresponding square.

Part 1

1. “Thinking about your own life and personal circumstances, how satisfied are you with your life as a whole?”

<table>
<thead>
<tr>
<th>Completely Dissatisfied</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Completely Satisfied</th>
</tr>
</thead>
</table>

Part 2

1. “How satisfied are you with your standard of living?”

<table>
<thead>
<tr>
<th>Completely Dissatisfied</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Completely Satisfied</th>
</tr>
</thead>
</table>

2. “How satisfied are you with your health?”

<table>
<thead>
<tr>
<th>Completely Dissatisfied</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Completely Satisfied</th>
</tr>
</thead>
</table>

3. “How satisfied are you with what you are achieving in life?”

<table>
<thead>
<tr>
<th>Completely Dissatisfied</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Completely Satisfied</th>
</tr>
</thead>
</table>
4. “How satisfied are you with your personal relationships?”

5. “How satisfied are you with how safe you feel?”

6. “How satisfied are you with feeling part of your community?”

7. “How satisfied are you with your future security?”
Appendix D – WSAS (modified)

**WSAS**

Please rate your level of agreement with each of the following statements on a scale from 0 to 10; with 0 indicating no agreement (i.e. you have no impairment in that area) and 10 indicating complete agreement (i.e. you have very severe impairment in that area). Please indicate your response to each item with a mark in the corresponding square.

1. Because of my life circumstances, my ability to work is impaired.

<table>
<thead>
<tr>
<th>Completely Disagree</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Neutral</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>Completely Agree</th>
<th>10</th>
</tr>
</thead>
</table>

2. Because of my life circumstances, my home management (cleaning, tidying, shopping, cooking, looking after home or children, paying bills) is impaired.

<table>
<thead>
<tr>
<th>Completely Disagree</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Neutral</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>Completely Agree</th>
<th>10</th>
</tr>
</thead>
</table>

3. Because of my life circumstances, my social leisure activities with other people (such as parties, bars, clubs, outings, visits, dating, home entertainment) are impaired.

<table>
<thead>
<tr>
<th>Completely Disagree</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Neutral</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>Completely Agree</th>
<th>10</th>
</tr>
</thead>
</table>

4. Because of my life circumstances, my private leisure activities done alone (such as reading, gardening, sewing, walking alone) are impaired.

<table>
<thead>
<tr>
<th>Completely Disagree</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Neutral</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>Completely Agree</th>
<th>10</th>
</tr>
</thead>
</table>

5. Because of my life circumstances, my ability to form and maintain close relationships with others, including those I live with, is impaired.

<table>
<thead>
<tr>
<th>Completely Disagree</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Neutral</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>Completely Agree</th>
<th>10</th>
</tr>
</thead>
</table>

*Used with kind permission Dr Marks, SSHC, London (Mundt, Marks, Shear, & Greist, 2002)*
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Positive Event (Uplift) Scale

This scale asks you to think about the positive events (uplifts) that you experienced in the last month. Positive daily events are the small day to day happenings that lead people to feel uplifted. From such events people can feel inspired, alert, attentive or active. Positive events can also lead to feeling emotions such as interest, excitement, strength, pride, determination and enthusiasm.

For each item, circle in the left column how often that event occurred (for example, circle 1-3 if the event happened 1 to 3 times). It is important that you try to remember the number of times the event occurred during the last month. Then in the right column, indicate how much of an uplift each of those events were (on average) during the same period (for example circle 1 if it was a little of an uplift or 4 if it was an extreme uplift). If the event did not occur, circle 0 in the left column and then move on to the next item without scoring a number in the right column. Please consider each item only with the last 4 weeks (previous month) in mind.

<table>
<thead>
<tr>
<th>How Often?</th>
<th>How much of an Uplift (average)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = did not happen</td>
<td>0 = no uplift</td>
</tr>
<tr>
<td>1-3 = happened 1 to 3 times</td>
<td>1 = a little of an uplift</td>
</tr>
<tr>
<td>4-6 = happened 4 to 6 times</td>
<td>2 = somewhat of an uplift</td>
</tr>
<tr>
<td>7-9 = happened 7 to 9 times</td>
<td>3 = a lot of an uplift</td>
</tr>
<tr>
<td>10+ = happened 10 times or more</td>
<td>4 = extreme uplift</td>
</tr>
</tbody>
</table>

**Type of Positive Event**

**Your Friends**

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1-3</td>
<td>4-6</td>
<td>7-9</td>
<td>10+</td>
</tr>
<tr>
<td>1</td>
<td>Support received from friend/s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Support given to friend/s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Positive feedback from friend/s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Positive communication with friend/s</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Social Events**

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1-3</td>
<td>4-6</td>
<td>7-9</td>
<td>10+</td>
</tr>
<tr>
<td>1</td>
<td>Going to a party</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Going out for drinks or dinner (e.g. friends place)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Going to the pub</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Recent social events</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Work (if in paid employment)**

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1-3</td>
<td>4-6</td>
<td>7-9</td>
<td>10+</td>
</tr>
<tr>
<td>1</td>
<td>The nature of your job/work</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Your job security</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Use of your skills in your work</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>The ideas you have at work</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Your Supervisor/employer**

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1-3</td>
<td>4-6</td>
<td>7-9</td>
<td>10+</td>
</tr>
<tr>
<td>1</td>
<td>Support received from supervisor/employer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Support given to supervisor/employer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Positive communication with supervisor/employer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Positive feedback from supervisor/employer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Doing enjoyable things with supervisor/employer</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Interactions with other workers**

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1-3</td>
<td>4-6</td>
<td>7-9</td>
<td>10+</td>
</tr>
<tr>
<td>1</td>
<td>Support received from other workers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Support given to other workers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Positive feedback from other workers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Doing enjoyable things with other workers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How Often?</td>
<td>How much of an Uplift (average)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 = did not happen</td>
<td>0 = no uplift</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-3 = happened 1 to 3 times</td>
<td>1 = a little of an uplift</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-6 = happened 4 to 6 times</td>
<td>2 = somewhat of an uplift</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-9 = happened 7 to 9 times</td>
<td>3 = a lot of an uplift</td>
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<tr>
<td>10+ = happened 10 times or more</td>
<td>4 = extreme uplift</td>
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</table>

<table>
<thead>
<tr>
<th>Type of Positive Event</th>
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</thead>
<tbody>
<tr>
<td><strong>Relationship with your Spouse/partner (include boy/girlfriend)</strong></td>
</tr>
<tr>
<td>0 1-3 4-6 7-9 10+</td>
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<tr>
<td>0 1-3 4-6 7-9 10+</td>
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<td>0 1-3 4-6 7-9 10+</td>
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<td>0 1-3 4-6 7-9 10+</td>
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<tr>
<td><strong>Problems with Parents (or Parents-in-law)</strong></td>
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<td>0 1-3 4-6 7-9 10+</td>
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<td>0 1-3 4-6 7-9 10+</td>
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<tr>
<td><strong>Your Children</strong></td>
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<td>0 1-3 4-6 7-9 10+</td>
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<td>0 1-3 4-6 7-9 10+</td>
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<td><strong>Household</strong></td>
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<td>0 1-3 4-6 7-9 10+</td>
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<td>0 1-3 4-6 7-9 10+</td>
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</table>
## Negative Event (Hassle) Scale

This scale asks you to think about the negative events (hassles) that you experienced in the last month. Negative daily events are the small day to day happenings that lead people to feel hassled. From such events people can feel distressed, upset, guilty or scared. Negative events can also lead to people feeling hostile, irritable, nervous, afraid, ashamed or frustrated. Below are some events that can be a hassle.

For each item, circle in the left column how often that event occurred (for example, circle 1-3 if the event happened 1 to 3 times). It is important that you try to remember the number of times the event occurred during the last month. Then in the right column, indicate how much of a hassle each of those events were (on average) during the same period (for example circle 1 if it was a little of a hassle or 4 if it was an extreme hassle). If the event did not occur, circle 0 in the left column and then move on to the next item without scoring a number in the right column. Please consider each item only with the last 4 weeks (previous month) in mind.

<table>
<thead>
<tr>
<th>How Often?</th>
<th>How much of a Hassle (average)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - did not happen</td>
<td>0 = no hassle</td>
</tr>
<tr>
<td>1-3 = happened 1 to 3 times</td>
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</tr>
<tr>
<td>10+ = happened 10 times or more</td>
<td>4 = extreme hassle</td>
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</table>

### Type of Negative Event

#### Problems with Friends

<table>
<thead>
<tr>
<th>0</th>
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</tbody>
</table>

1. Negative feedback from your friend/s
2. Negative communication with friend/s
3. Conflict with a friend/s
4. Disagreement (including argument/s) with a friend/s

#### Problems with your Spouse/partner (include boy/girlfriend)

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
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</table>

5. Negative communication with your spouse or partner
6. Conflict with your spouse or partner
7. Disagreement (including argument/s) with spouse or partner
8. Rejection by your spouse or partner
9. Your spouse or partner let you down

#### Work (if in paid employment)

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</tbody>
</table>

10. The nature of your job/work
11. Your work load
12. Meeting deadlines or goals on the job
13. Use of your skills at work

#### Problems with your Work supervisor/employer

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<td>1</td>
</tr>
</tbody>
</table>

14. Negative feedback from your supervisor/employer
15. Negative communication with your supervisor/employer
16. Conflict with your supervisor/employer
17. Disagreement (including argument/s) with your supervisor/employer

#### Money

<table>
<thead>
<tr>
<th>0</th>
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<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
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<td>1</td>
<td>1</td>
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<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

18. Not enough money for food, clothing, housing etc.
19. Not enough money for education
20. Not enough money for emergencies
21. Not enough money for extras such as entertainment/holiday
<table>
<thead>
<tr>
<th>How Often?</th>
<th>How much of a Hassle (average)?</th>
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</thead>
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</tr>
<tr>
<td>10+ = happened 10 times or more</td>
<td>4 = extreme hassle</td>
</tr>
</tbody>
</table>

### Type of Negative Event

**Problems with Children**
- 22. Negative communication with your child(ren)  
  0 1 2 3 4
- 23. Conflict with your child(ren)  
  0 1 2 3 4
- 24. Disagreement (including arguments) with your child(ren)  
  0 1 2 3 4

**Problems with Parents (or Parents-in-law)**
- 25. Negative communication with your parents/in-law  
  0 1 2 3 4
- 26. Conflict with your parents/in-law  
  0 1 2 3 4
- 27. Disagreement (including arguments) with parents/in-law  
  0 1 2 3 4
- 28. Negative feedback from your parents/in-law  
  0 1 2 3 4

**Problems with other Workers**
- 29. Negative communication with other worker/s  
  0 1 2 3 4
- 30. Conflict with other worker/s  
  0 1 2 3 4
- 31. Disagreement (including arguments) with other worker/s  
  0 1 2 3 4
- 32. Doing things with other worker/s  
  0 1 2 3 4

**Problems with other relative/s**
- 33. Conflict with other relative  
  0 1 2 3 4
- 34. Disagreement (including arguments) with other relative  
  0 1 2 3 4
- 35. Negative feedback from other relative  
  0 1 2 3 4
- 36. Doing things with other relative  
  0 1 2 3 4

**Health Problems**
- 37. Your health  
  0 1 2 3 4
- 38. Your physical abilities  
  0 1 2 3 4
- 39. Your medical care  
  0 1 2 3 4
- 40. Getting sick (e.g. flu, colds)  
  0 1 2 3 4

**Household**
- 41. Cooking and food preparation  
  0 1 2 3 4
- 42. Doing cleaning and other housework  
  0 1 2 3 4
- 43. Eating at home  
  0 1 2 3 4
- 44. Being organized  
  0 1 2 3 4
- 45. Doing gardening (such as mowing, weeding)  
  0 1 2 3 4
- 46. Doing home maintenance or repairs  
  0 1 2 3 4
### BRIEF COPE

**INSTRUCTIONS:**
- We are interested in how people respond when they confront difficult or stressful events in their lives.
- There are lots of ways to try to deal with stress.
- This questionnaire asks you to indicate what you generally do and feel, when you experience stressful events. Obviously, different events bring out somewhat different responses, but think about what you usually do when you are under a lot of stress.
- Then respond to each of the following items by CIRCLING ONE NUMBER on your answer sheet for each, using the response choices listed just below.
- Please try to respond to each item separately in your mind from each other item. Choose your answers thoughtfully, and make your answers as true FOR YOU as you can. Please answer every item. There are no “right” or “wrong” answers, so choose the most accurate answer for YOU— not what you think “most people” would say or do. Indicate what YOU usually do when YOU experience a stressful event.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I’ve been concentrating my efforts on doing something about the situation I’m in.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>I’ve been trying to come up with a strategy about what to do.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>I’ve been trying to see it in a different light, to make it seem more positive.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>I’ve been accepting the reality of the fact that it has happened.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>I’ve been making jokes about it.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>I’ve been trying to find comfort in my religion or spiritual beliefs.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>I’ve been getting emotional support from others.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>I’ve been trying to get advice or help from other people about what to do.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>I’ve been turning to work or other activities to take my mind off things.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>I’ve been saying to myself “this isn’t real”.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>I’ve been saying things to let my unpleasant feelings escape.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>I’ve been using alcohol or other drugs to make myself feel better.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>I’ve been giving up trying to deal with it.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>I’ve been criticizing myself.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>I’ve been learning to live with it.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>I’ve been taking action to try to make the situation better.</td>
<td>1 2 3 4</td>
<td></td>
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<tr>
<td>17.</td>
<td>I’ve been thinking hard about what steps to take.</td>
<td>1 2 3 4</td>
<td></td>
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<tr>
<td>18.</td>
<td>I’ve been looking for something good in what is happening.</td>
<td>1 2 3 4</td>
<td></td>
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<tr>
<td></td>
<td>I usually don't do this at all</td>
<td>I usually do this a little bit</td>
<td>I usually do this a medium amount</td>
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<tr>
<td>19.</td>
<td>I've been making fun of the situation.</td>
<td>1</td>
<td>2</td>
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<tr>
<td>20.</td>
<td>I've been praying or mediating.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>21.</td>
<td>I've been getting comfort and understanding from someone.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>22.</td>
<td>I've been getting help and advice from other people.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>23.</td>
<td>I've been doing something to think about it less, such as going to movies, watching TV, reading, daydreaming, sleeping or shopping.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>24.</td>
<td>I've been refusing to believe that it has happened.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>25.</td>
<td>I've been expressing my negative feelings.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>26.</td>
<td>I've been using alcohol or other drugs to help me get through it.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>27.</td>
<td>I've been giving up the attempt to cope.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>28.</td>
<td>I've been blaming myself for things that have happened.</td>
<td>1</td>
<td>2</td>
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Appendix H – Composite Scale

Composite Scale

Please tick the response for each item that best describes you.

1. Considering only your own “feeling best” rhythm, at what time would you get up if you were entirely free to plan your day?
   - [ ] 5:00-6:30 a.m.
   - [ ] 6:30-7:45 a.m.
   - [ ] 7:45-9:45 a.m.
   - [ ] 9:45-11:00 a.m.
   - [ ] 11:00 a.m. – 12:00 (noon)

2. Considering only your own “feeling best” rhythm, at what time would you go to bed if you were entirely free to plan your evening?
   - [ ] 8:00-9:00 p.m.
   - [ ] 9:00-10:15 p.m.
   - [ ] 10:15 p.m. -12:30 a.m.
   - [ ] 12:30-1:45 a.m.
   - [ ] 1:45-3:00 a.m.

3. Assuming normal circumstance, how easy do you find getting up in the morning? (Tick one.)
   - [ ] Not at all easy
   - [ ] Slightly easy
   - [ ] Fairly easy
   - [ ] Very easy

4. How alert do you feel during the first half hour after having awakened in the morning? (Tick one.)
   - [ ] Not at all alert
   - [ ] Slightly alert
   - [ ] Fairly alert
   - [ ] Very alert

5. During the first half hour after having awakened in the morning, how tired do you feel? (Tick one.)
   - [ ] Very tired
   - [ ] Fairly tired
   - [ ] Fairly refreshed
   - [ ] Very refreshed

6. You have decided to engage in some physical exercise. A friend suggests that you do this one hour twice a week and the best time for him is 7:00-8:00 a.m. Bearing in mind nothing else but your own “feeling best” rhythm, how do you think you would perform?
   - [ ] Would be in good form
   - [ ] Would be in reasonable form
   - [ ] Would find it difficult
   - [ ] Would find it very difficult

Smith, Reilly & Midkiff (1989)
7. At what time in the evening do you feel tired and, as a result, in need of sleep?

- 8:00-9:00 p.m.
- 9:00-10:15 p.m.
- 10:15 p.m. - 12:30 a.m.
- 12:30-1:45 a.m.
- 1:45-3:00 a.m.

8. You wish to be at your peak performance for a test which you know is going to be mentally exhausting and lasting for two hours. You are entirely free to plan your day, and considering only your own “feeling best” rhythm, which ONE of the four testing times would you choose?

- 8:00-10:00 a.m.
- 11:00 a.m. - 1:00 p.m.
- 3:00-5:00 p.m.
- 7:00-9:00 p.m.

9. One hears about “morning” and “evening” types of people. Which ONE of these types do you consider yourself to be?

- Definitely a morning type
- More a morning than an evening type
- More an evening than a morning type
- Definitely an evening type

10. When would you prefer to rise (provided you have a full day’s work (8 hours) if you were totally free to arrange your time?)

- Before 6:30 a.m.
- 6:30-7:30 a.m.
- 7:30-8:30 a.m.
- 8:30 a.m. or later

11. If you always had to arise at 6:00 a.m., what do you think it would be like?

- Very difficult and unpleasant
- Rather difficult and unpleasant
- A little unpleasant but no great problem
- Easy and not unpleasant

12. How long a time does it usually take before you “recover your senses” in the morning after rising from a night’s sleep?

- 0-10 minutes
- 11-20 minutes
- 21-40 minutes
- More than 40 minutes

13. Please indicate to what extent you are a morning or evening active individual.

- Pronounced morning active (morning alert and evening tired)
- To some extent, morning active
- To some extent, evening active
- Pronounced evening active (morning tired and evening alert)
Appendix I – Sleep Diary Sample Page

DAY: ___________________ DATE: ___________________

1. What time did you go to bed last night? _____am/pm

2. How long did it take you to fall asleep? _____hrs _____mins
   If long, why?

3. What time did you wake up today? ______am/pm

4. How many times did you wake (or were you woken) during the night? ______
   How long were you awake each time? ________________________________

5. What was your total sleep time? _____hrs

6. How rested did you feel after waking? (please place a mark on the line below)
   not at all rested __________________________________________
   extremely well rested

7. How would you rate the quality of your sleep last night? (please place a mark on
   the line below)
   ________________________________
   extremely low
   extremely high

8. Are you experiencing any symptoms of ill health at the moment?  Y / N
   If yes, please describe:
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

COMMENTS:
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

Please indicate how much of each of the following you consumed yesterday:

Caffeine: _______________________________ Alcohol: _______________________________

Cigarettes: _______________________________ Other: _______________________________
This page has intentionally been left blank.
Saliva Collection Instructions

On two consecutive days you will need to collect saliva in the morning and again in the evening. Please collect your specimens ½ hour after rising in the morning and ½ hour before your bedtime in the evening.

On each occasion you collect saliva please follow the instructions below:

1. Rinse your mouth thoroughly with water.
2. Rest for around 5 minutes, swallowing any saliva that may be present in your mouth.
3. At the end of this rest, get a collection tube out of its zip-lock bag. Note the date and time on the label on the bag (this is your start time).
4. Express saliva directly from your mouth into the sample tube by holding the tube against your lower lip.
5. Fill the tube to the 4ml mark.
6. Seal the sample tube tightly and place it into the labelled zip lock bag.
7. Place the sealed bag into your freezer.
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Appendix K – Interview Topics and Questions

Semi-Structured Interview
Question Stems / Topics

Please Note: This list is not exhaustive / mandatory - priority was given to participant’s own views of their health & well-being.

Caring Role (Carers only)

- what is the primary diagnosis of the person(s) you provide care for?
- how would you rate their health? (using a scale from 0 ‘very poor’ to 10 ‘excellent’)
- how would you rate their level of capacity to meet needs? From 0 (totally dependent) to 10 (totally independent)
- what care do you provide? what does it involve?
- how many hours a week (approx) do spend in your caregiving role?
- how long have you been in your caregiving role?
- how much assistance do you feel you have with this role? (from 0 ‘none’ to 10 ‘all I need’)
- do you receive any respite? is the amount enough for your needs?
- do you have other sources of support?
- overall how would you rate your ability to cope with your caring role? (on a scale from 0 ‘very poor’ to 10 ‘excellent’)
- what are the best aspects of your caregiving role?
- what are the worst aspects?
- is there anything else you would like to say about being a carer?

General Interview questions

Work
- how many hours a week are you in paid employment?
- How would you rate your financial security? (from 0 ‘extremely insecure’ to 10 ‘extremely secure’)

Circumstances
- how would you describe your life circumstances?
- how do you feel about your life in general?

Sleep/Activity Patterns
- briefly describe rising & retiring on a typical week-day?
- a typical weekend day?

Behaviour
- do you do regular exercise? if so, how often per week?
- do you have regular medical check-ups?
- do you try to eat a balanced diet?

Health & well-being
- how is your health currently? (could you rate it on a 0-10 scale from 0 ’very poor’ to 10 ’excellent’)
- how would you describe your health generally? (on a 0-10 scale from 0 ’very poor’ to 10 ’excellent’?)
- estimated number of doctor’s visits in last 12 months (for yourself)
- visits to other health providers?
what is your estimate of the number of illnesses you've had in the last 12 months?
how far is it to the nearest GP / other health provider / hospital?
is there anything else you would like to say about your physical health?

Carers only:
have you noticed any changes in your health over the time you've been a carer?
do you think these are related to being a carer or related to something else?

Rhythmicity
how much sleep do you get on average per night?
do you think you get enough sleep on average?
how would you rate the quality of your sleep (in general)? (from 0 'very poor' to 10 'best possible')
are you a light sleeper? A restless sleeper?
if you wake in the night, do you have a problem getting back to sleep?
if so, what stops you falling asleep?
how do you usually wake up in the morning? (e.g. alarm? set time?)
do you usually feel rested when you wake up?
what do you think affects your ability to sleep?
what do you think affects the quality of your sleep?
how alert do you usually feel over the course of the day?
what is your mood like over the course of the day? Does it vary much? Is there a pattern?
are you aware of any changes that have occurred with your time of day preferences? e.g. have you changed your bedtimes &/or waketimes over time?

Carers only
does this relate to your taking up the caring role?
is there anything else you would like to mention about your daily patterns?

Stress
how would you describe your usual level of stress?
what would you give yourself as a stress level rating from 0 (none) to 10 (the maximum you can imagine)?
what are the key sources of stress in your life?
which is the biggest source?
is there anything else you would like to say about your experience of stress?

Support
what are the key sources of support in your life? Family? Friends? Neighbours?
Formal sources?
what other sources of support do you use when you're stressed? Please describe (e.g. community organisations, meals on wheels, therapist, etc)
have you sought therapy or counselling?
Temperature Data Logger Instructions

1. Remove the temperature sensor lead (with one smooth end and one plug end) from its packaging.

2. Connect the plug of the sensor lead into the data logger. You should hear a click when it is correctly connected.

3. Slowly insert the other end of the lead into the rectum. It is suggested that 10-15cm be inserted to ensure the sensor does not work itself free. Do not use any lubricant, as the sensor may be more likely to work itself loose.

4. The sensor needs to be removed when showering and when performing bowel motions. Please re-insert the sensor as soon as possible after these events. When removing and re-inserting the sensor you can clean it with a dry tissue.

5. The logger can be kept in a pocket or in underwear. Try to ensure that the cord does not protrude loosely from the body as it may catch on objects.

6. When logging is complete you should remove the sensor lead and disconnect it from the data logger. The sensor lead should then be discarded and the data logger kept in a safe place for collection by the researcher.

*** Please make a note in your Sleep and Activity Diary ***
# Appendix M – Participant Information Sheet

**Carer Stress & Well-Being Study**  
**INFORMATION SHEET**  
*** PLEASE KEEP THIS SHEET FOR FUTURE REFERENCE ***

This study is being conducted by Jane Buschkens, a PhD student in the Department of Psychology, James Cook University (JCU), Cairns. Her supervisor is Dr Deborah Graham. The aim of the study is to investigate daily rhythms and their role in the health and well-being of people experiencing chronic stress. Participation in this study will involve an interview about your life circumstances and your views about your health and well-being. It will also require you to complete eight brief questionnaires and a sleep diary and also to collect your own saliva (in tubes provided) on up to 6 occasions. An additional optional component will involve the measurement of core body temperature over a 24-hour period of time using a self-administered rectal temperature sensor (according to an instruction sheet). The interview and questionnaires will take a maximum of two (2) hours and will be conducted in your home (or preferred location) at a time of your choice. You will be asked permission to audio tape the interview. The sleep diary is a booklet with simple questions about such things as the time that you go to bed and get up in the morning and will need to be filled out every morning for 7 days (this will take a few minutes each morning). On two mornings and evenings, and during the night if you wake, you will also need to collect saliva samples following instructions provided on the sheet with collection tubes. You will need to store these in your fridge (in the bag provided) until they are collected (as per instruction sheet). If you agree to measure your core body temperature for 24 hours, you will need to wear a self-administered rectal sensor (as per an instruction sheet).

The following list contains contact information for the investigator, her department and some support services. If you have any questions about the study please contact the investigator. If you have any concerns her supervisor, head of department, or the university ethics officer will be keen to hear from you. If you become distressed through participation or need further support please contact Lifeline or the Carer Resource Centre.

<table>
<thead>
<tr>
<th>Investigator</th>
<th>Jane Buschkens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ph: (07) 40421851</td>
<td><a href="mailto:jane.buschkens@jcu.edu.au">jane.buschkens@jcu.edu.au</a></td>
</tr>
<tr>
<td>Ethics Approval Number</td>
<td>H2704</td>
</tr>
<tr>
<td>Project Supervisor</td>
<td>Dr Deborah Graham</td>
</tr>
<tr>
<td>Senior Lecturer, JCU Dept of Psychology Cairns</td>
<td>Ph: (07) 40421620</td>
</tr>
<tr>
<td></td>
<td><a href="mailto:deborah.graham@jcu.edu.au">deborah.graham@jcu.edu.au</a></td>
</tr>
<tr>
<td>Head of Department of Psychology JCU (Townsville)</td>
<td>Dr Frances Quirk</td>
</tr>
<tr>
<td></td>
<td>Ph: (07) 47 814253</td>
</tr>
<tr>
<td></td>
<td><a href="mailto:frances.quirk@jcu.edu.au">frances.quirk@jcu.edu.au</a></td>
</tr>
<tr>
<td>JCU Ethics Officer (Townsville)</td>
<td>Tina Langford</td>
</tr>
<tr>
<td></td>
<td>Ph: (07) 47814342</td>
</tr>
<tr>
<td></td>
<td><a href="mailto:tina.langford@jcu.edu.au">tina.langford@jcu.edu.au</a></td>
</tr>
<tr>
<td>Lifeline</td>
<td>131114 freecall</td>
</tr>
<tr>
<td>24-hour Telephone counselling</td>
<td>131114 freecall</td>
</tr>
<tr>
<td>Commonwealth Carer Resource Centre</td>
<td>1800 242636 freecall</td>
</tr>
<tr>
<td>Carer counseling (telephone &amp; face-to-face)</td>
<td>1800 242636 freecall</td>
</tr>
<tr>
<td>Other Carer Resources</td>
<td>website</td>
</tr>
<tr>
<td>Carers Queensland, Cairns Office</td>
<td>Ph: (07) 40310163</td>
</tr>
</tbody>
</table>
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Appendix N – Participant Consent Form

Informed Consent Form

Principal Investigator: Jane Buschke

Project Title: Circadian Rhythm, Well-Being & Immunity; Psychobiological Interactions in Chronic Care Stress

School: JCU School of Arts and Social Sciences (Department of Psychology)

Contact Details: Phone: 40 42 1651
Email: jane.buschke@jcu.edu.au

In this study you will be asked to participate in an interview which will include questions about you and your experience of stress as well as about your health and wellbeing. You will be asked if your responses to these questions can be digitally recorded. The interview will also involve the completion of a number of brief questionnaires about your sleep preferences, mood, well-being, experience of stress, social interactions and daily events.

The whole interview will take approximately 2 hours.

At the end of the interview you will be given a diary booklet and asked to briefly document your health, sleep and activity patterns over the next 7 days. You will also be given collection tubes with written instructions asking you to collect your own saliva on up to 6 occasions.

At the interview you will also be asked if you would be willing to wear a self-administered rectal sensor to measure core body temperature over 24 hours. If you agree to this extra part of the study, you will be provided with additional instructions and materials at your interview.

The results from this study will be included in a PhD thesis and may be published in a journal article, newsletter or other publication. However, your particular responses and results will not be identified in any such work and will remain confidential.

The aims of this study have been clearly explained to me and I understand what is wanted of me. I know that taking part in this study is voluntary and I am aware that I can stop taking part in it at any time and may refuse to answer any questions.

I understand that any information I give will be kept strictly confidential and that no names will be used to identify me with this study without my approval.

Please tick as appropriate:
- I agree to take part in the interview, diary and saliva collection components of this study
- I agree to allow a digital audio-recording of my interview
- I agree to the 24-hour core body temperature measurement component of this study

Name: [provided]

Signature: ___________________________ Date: ___________________________

JCU Campuses at: TOWNEVILLE (07) 4781 4111 CAIRNS (07) 4042 1111 MACKAY (07) 4957 6048
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CIRCADIAN RHYTHMICITY AND SUBJECTIVE WELLBEING

Appendix O – Article Published in Stress & Health

RESEARCH ARTICLE

Well-Being Under Chronic Stress: Is Morningness an Advantage?
Jane Buschkens*,1, Deborah Graham & David Cottrell
Department of Psychology, James Cook University, Cairns Qld 4870 Australia

Abstract
This study investigated whether morningness was associated with better quality of life in individuals experiencing chronic stress. Thirty-one informal primary carers and 35 non-carers completed self-report measures of time-of-day preference, stress and well-being. The data were collected as part of a broader study of circadian rhythmicity under conditions of prolonged stress. There was a significant interaction between diurnal preference and caregiving, with morningness associated with better well-being outcomes in those providing long-term home care. It appears that chronic arousal, but not perceived stress, plays a role in this morningness-career interaction, with lower arousal levels also evident in carers with a greater preference for morningness. These results point to a possible role for circadian influences in the relationship between stress and subjective well-being. Copyright © 2010 John Wiley & Sons, Ltd.

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Keywords
morningness; subjective well-being; informal caregivers; chronic stress

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Introduction
Morningness has been found to be associated with enhanced well-being (Howell, Dugdall, Brot, & Shep-tycki, 2006; Randler, 2008). Yet subjective well-being (SWB) is considered to be relatively stable because of maintenance by behavioral and cognitive mechanisms that keep it within an adaptive range. Nevertheless, if conditions become extremely stressful such well-being maintenance may be overwhelmed (Cammins, 2005a). This study sought to examine whether stress would influence the relationship between morningness and well-being. To this end, the link between quality of life and morningness was examined among informal carers, a group acknowledged to be chronically stressed (Vitaliano & Young, 2004).

Individual differences in time-of-day preferences for rest and activity within the circadian (24 h) cycle are recognized as stable individual traits (Rice et al., 2005; Smith, Reddy, & Midkiff, 1989) under the control of endogenous factors such as genetics and ageing (Paine, Gander, & Travier, 2006; Roenneberg et al., 2007). Indeed, circadian preferences are mirrored by corresponding differences in physiological, psychological and behavioural variables such as core body temperature, subjective alertness and task performance (Cavallera & Giudici, 2008; Schmidt, Collette, Cajochen, & Peigneux, 2007; Smith et al., 1989). Many studies recognize extreme morning and evening chronotypes (Horne & Ostberg, 1976; Smith et al., 1989), however, morningness–eveningness may be better viewed as a continuous characteristic (Gaci et al.,

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Well-Being, Stress and Morningness

J. Buschkens, D. Graham and D. Cottrell


Unsurprisingly, circadian preferences are found to be related to sleep patterns (Carrié, Monn, Baysse, & Kupfer, 1997), with an evening preference associated with sleep inertia, problems falling asleep and sleepiness on waking (Saillard, Phillip, Chastang, Dieffenbach, & Boulic, 2001: Saillard, Phillip, Coste, Sagaspe, & Boulic, 2003). Morniness, on the other hand, is linked to increased reporting of sleep problems, including nocturnal waking, extreme early waking and daytime sleepiness (Taillard et al., 2001). Evening types appear to accumulate a sleep debt when working regular hours and to compensate for this by sleeping late on free days (Roenneberg, Wirz-Justice, & Merrow, 2003). They also seem to adapt better to shift work than Morning types (Griefahn, 2002: Khaledeg, 1998), who appear to have poorer sleep flexibility (Carravella & Gradle, 2008). Phase differences in the endogenous rhythms of key physiological variables, such as core body temperature, and subsequent differences in synchronization with environmental demands have been proposed as an explanation for the sleep effects associated with time of day preferences (Kerkhof & van Dongen, 1996: Selvi, Gülec, Agarun, & Besiroğlu, 2007).

Evening types have also been found to be up to 2.5 times more likely to report they were not in good health (Paine et al., 2006). Furthermore, evenness has also been found to be associated with greater levels of depression (Hrata et al., 2007) and anxiety (Diaz-Morales & Sanchez-Lopez, 2008: Vardar, Vardar, Molla, Kaynak, & Erood, 2008) among university students. Indeed, Evening types have been found to score higher on neuroticism (Tonetti, Fabbi, & Natale, 2009) and stress-prone behaviours (Mecacci & Rocchetti, 1998) whereas morningness has been found to be positively correlated with agreeableness, conscientiousness and emotional stability (DeYoung, Hercher, Dijik, Criger, & Peterson, 2007; Hogben, Ellis, Archer, & von Schantz, 2007). Moreover, as previously noted, recent indications are that morningness has a positive association with measures of life satisfaction (Randler, 2008) and global well-being (Howell et al., 2008).

One possible explanation for these differences is 'social jetlag', or the misalignment of biological and social clocks (Wittman, Dünch, Merrow, & Roenneberg, 2006). It has been suggested that, under many work and study schedules, eveningness may be associated with problems synchronizing internal and external timing, whereas morningness may confer an advantage (Wittman et al., 2006). Another possible explanation involves psychophysiological differences in arousal levels and stress reactivity. From this perspective, morningness may be associated with greater central nervous system adaptability that allows the individual to cope better with both intense, prolonged environmental demand as well as rapidly changing environmental conditions (Mecacci, Zani, Rocchetti, & R, 1986).

SWB is described as 'a stable sense of feeling positive about one's self and one's life' (Cummins, Lau, & Stokes, 2004: p. 415). Such measures of quality of life are increasingly recognized as essential components of any broad conceptualization of health (Diener, Sapyta, & Sib, 1998: Lazarus, 1999). SWB is generally considered to be robust because of protective cognitive and behavioural mechanisms that maintain it within a narrow healthy range (Cummins, 2009b). Nevertheless, according to the well-being homoeostasis model, once an individual experiences stress beyond a personal threshold, their personal resources can be overwhelmed and, subsequently, well-being will fail (Cummins, 2008a). It may be that individual differences along the morniness-eveningness dimension play a role in the relationship between stress and well-being. Furthermore, as chronic stress appears to be a particularly debilitating form of stress (Lepore, 1997: O'Connor, 2005), the relationship between quality of life and diurnal preferences in a chronically stressed group appears likely to provide unique insights.

A group that stands out as experiencing both chronic stress and exceptionally poor SWB is informal carers (Cummins et al., 2007; Schwarz & Dunphy, 2003; Stowell, Kecoll-Glasser, & Glasser, 2001; Vellara et al., 1999). An informal carer is defined as someone who provides long-term in-home care for a parent, partner, child, other relative or friend who has a disability, is frail aged or who has a chronic mental or physical illness (Gill et al., 2007). Informal caregiving has been described as a prototypic chronic stressor (Vitaliano & Young, 2004) involving continuous, prolonged demand (Pearlin, Mullan, Semple, & Skaff, 1990; Schütz & Quinones, 1998). It is this chronic stress that is proposed to overwhelm many carers' ability to maintain SWB levels within the normal range (Cummins et al., 2007). Cummins (2001) notes that mean SWB for Australian carers falls far below the narrow normative range found.
in the general population. There is much other evidence to support findings of reduced quality of life among carers with high levels of depression, anxiety (Palestinian, Stebbins, Cannon, & Samios, 2005; Schulz & Quittner, 1998), fatigue, physical health problems (Briggs & Fisher, 2000; Shevchuk, Richards, & Elliott, 1998; Vitaliano & Young, 2004) and poor sleep quality (Carter, 2002; Sato, Kanda, Anan, & Watanuki, 2002; Teel & Press, 1999) commonly reported.

Although previous studies have indicated that time-of-day preferences may be associated with differences in personal well-being (DeYoung et al., 2007), the potential role of stress in this relationship has not been investigated. It may be that morningness provides a particular advantage with respect to well-being under stressful conditions. The current study was part of a broader study investigating the relationship between circadian rhythms, chronic stress and SWB. Examination of the relationship between quality of life and circadian preferences under conditions of chronic stress has the potential to provide insights into the more general role of circadian preferences in maintaining well-being. To our knowledge, these links have not yet been examined. The aim of the present study was to explore the relationship between SWB and morningness among individuals experiencing chronic stress. It was predicted that: (1) in line with recent reports, morningness would be associated with higher levels of SWB; and (2) morningness would be associated with an additional well-being advantage in those who were coping with chronic stress.

Method
Participants
Informal carers and age and gender-matched non-carers participated in the study. The carers were providing full-time, in-home care for a partner or a child with a disability or a chronic illness (Gill et al., 2007). The care receivers had high needs because of a range of disabilities, including autism spectrum disorder, cerebral palsy, Down’s Syndrome, schizophrenia and chronic medical illness. According to Cummins (2001), the nature of the care provided is not related to well-being once substantial care is required (Cummins, 2001). In accordance with this, the selection criteria for carers were: (1) being a current primary carer (i.e. having a primary role and providing the bulk of care to); and (2) having been in that role for a minimum of 12 months. Non-carers were defined as individuals who did not fulfill a caring role and were not experiencing any serious health or other challenges. The mean length of time of the carer role for this sample was 12.5 years (standard deviation (SD) = 10.6; range 2 to 40 yrs). Of 35 initial carer participants, four withdrew for personal reasons, including serious illness and death of the care recipient. Thus, the final sample consisted of 36 participants with a mean age of 54.9 years (SD = 14.6). See Table 1 for group demographics.

Materials
The 13-item Composite Scale of Morningness (CSM; Smith et al., 1989) was used to obtain self-reported time of day preferences, with higher scores indicating greater morningness (Smith et al., 1989). The CSM has good internal consistency, has been found to correlate very highly (r > 0.9) with the original Morningness–Eveningness Questionnaire (MEQ) developed by Horne and Ostberg (Caci, Deschaux, Adan, & Natale, 2008) and has the advantage of being short and easier to score. In the current study the Cronbach’s alpha for the CSM was 0.90.

The Personal Well-being Index (PWI) is a seven-item scale used to measure ‘the subjective dimension of quality of life’ (International Wellbeing Group, 2005; p. 5). The PWI taps satisfaction in seven life domains: standard of living, personal health, achieving in life, personal relationships, personal safety, community connectedness, and future security; on 11-point scales, with higher scores indicating higher well-being. The total is converted to a score out of 100 and provides an overall measure of SWB (Dover, Cummins & Stokes, 2007; International Wellbeing Group, 2005). Australian norms are regularly updated for the PWI, with the last reported population mean at 75.02, SEM = 0.81 (International Wellbeing Group, 2007). In the current study, Cronbach’s alpha for the PWI was 0.88.

The Perceived Stress Scale (PSS-10) is a 10-item scale used ‘to tap the degree to which respondents find their lives unpredictable, uncontrollable and overloaded’ (Cohen, 1986, p. 717). The PSS-10 is recommended for research purposes because of its tight factor structure and improved reliability compared with the original 14-item scale (Cohen & Williamson, 1988). A high PSS score indicates high levels of perceived stress. Cronbach’s alpha for the PSS-10 in this study was 0.90.
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Table I: Means and standard deviations for carer and non-carer groups on demographic and study variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Carer (n = 21)</th>
<th>Non-carer (n = 20)</th>
</tr>
</thead>
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<tr>
<td>Demographics</td>
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<tr>
<td>Gender, female</td>
<td>87.5</td>
<td>85.7</td>
</tr>
<tr>
<td>Marital status, single</td>
<td>74.2</td>
<td>65.7</td>
</tr>
<tr>
<td>Education, tertiary</td>
<td>42</td>
<td>83*</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>M</td>
</tr>
<tr>
<td>SD</td>
<td>15.25</td>
<td>14.05</td>
</tr>
<tr>
<td>Age (years)</td>
<td>54.56</td>
<td>55.46</td>
</tr>
<tr>
<td>Daily substance use†</td>
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</tr>
<tr>
<td>Nicotine</td>
<td>2.2</td>
<td>6.9</td>
</tr>
<tr>
<td>Caffeine</td>
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<td>1.2</td>
</tr>
<tr>
<td>Alcohol</td>
<td>1.4</td>
<td>1.0</td>
</tr>
<tr>
<td>Sleep and activity</td>
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<td></td>
</tr>
<tr>
<td>CSM morningness (max 55)</td>
<td>40.8</td>
<td>43.5</td>
</tr>
<tr>
<td>Wake time (dec hours)</td>
<td>6.5</td>
<td>6.3</td>
</tr>
<tr>
<td>Red time (dec hours)</td>
<td>22.6</td>
<td>22.5</td>
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<td>Sleep time (dec hours)</td>
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<tr>
<td>Sleep quality (max 10)</td>
<td>4.2</td>
<td>6.1*</td>
</tr>
<tr>
<td>Morning restlessness (max 10)</td>
<td>3.9</td>
<td>6.3*</td>
</tr>
<tr>
<td>Stress and distress</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSW well-being (max 100)</td>
<td>51.0</td>
<td>76.2*</td>
</tr>
<tr>
<td>PSS-10 perceived stress (max 10)</td>
<td>23.3</td>
<td>11.8*</td>
</tr>
<tr>
<td>DASS depression (max 42)</td>
<td>16.4</td>
<td>6.3*</td>
</tr>
<tr>
<td>DASS anxiety (max 42)</td>
<td>12.2</td>
<td>5.1*</td>
</tr>
<tr>
<td>DASS stress (max 42)</td>
<td>21.2</td>
<td>16.4*</td>
</tr>
</tbody>
</table>

*p < 0.001 (two-tailed t-test); † = Cohen’s d (effect size)
† One unit equals one cigarette; one cup of coffee (two of tea or one can Coca Cola); and one standard alcoholic drink.
Times are given in decimal hours; time awake during night has been subtracted for total sleep time.
PSW, Perceived Stress Scale; PSS-10, Perceived Stress Scale-10; DASS, Depression Anxiety Stress Scale; CSM, Composite Scale of Morningness; SD, standard deviation.

The Depression Anxiety Stress Scale (DASS, Lovibond & Lovibond, 1995). DASS-21, was used to measure these negative emotional states, with higher scores relating to higher levels of each. DASS depression and anxiety scales have been found to correlate well with the Beck scales for these constructs, indicating good construct validity (Lovibond & Lovibond, 1995). The DASS stress scale contains items such as ‘I found it difficult to relax’ and ‘I tended to over-react to situations’ and is considered to be a unique measure of stress characterized by chronic non-specific arousal (Lovibond & Lovibond, 1995, p. 9). In the current study, internal reliabilities for the seven-item depression, anxiety and stress subscales were 0.91, 0.78 and 0.89, respectively.

A 7-day sleep diary was developed for the study. Each day participants used this booklet to record their wake time, bedtime, night wakeings, estimated sleep length as well as sleep quality and morning restlessness (using 10-cm visual analog scales).

Procedure

Carers were recruited through Carers Queensland (CQ) meetings and CQ mailouts in the Far North Queensland region. Two articles in local newspapers also sought carer and non-carer participants. Flyers and email networks were also used for recruitment. Details of non-carer volunteers were placed on file and individuals were asked to participate if they matched a carer participant on age and gender. If an exact age match was not available the person of nearest age on the wait list was asked to participate.

A participation pack that included a folder containing the scales, demographic questions and a sleep diary was delivered to, and collected from, all participants.
All documents were individually coded for data collation. This research was conducted in accordance with NHMRC ethical guidelines and approved by the James Cook University ethics committee (approval #H2705).

**Statistical analyses**

Data analyses were conducted using SPSS 17 (SPSS Inc., Chicago, IL, USA). The scale scores and all other variables used in parametric analyses were investigated with respect to normality, linearity, homogeneity and the presence of outliers with no serious violations observed. All statistical tests were two-tailed and a significance level of $\alpha = 0.05$ was used throughout. Pearson correlation coefficients were used to examine the relationships among diurnal preference, sleep and psychological measures. A series of independent t-tests were conducted to examine group differences on the key study variables. Differences in categorical variables were examined using Chi-square. The differentiation of carers from non-carers was investigated using logistic regression. The interaction between morningness and the carer role was examined using moderated multiple regression (MMR) as recommended by Aguinis et al. (2005). The size of the moderating effect was calculated using Aguinis’ online program for estimation of the MMR statistic (see Aguinis et al., 2005). This program computes the variance accounted for by the moderator relative to the unexplained variance in the criterion variable and is suitable for the estimation of effect size for categorical variables in applied settings (see Aguinis & Pierce, 2006).

**Results**

**Sample characteristics**

Table 1 reports the results for carers and non-carers for demographic and psychological variables. With regard to well-being, the PWI score for non-carers in the sample at 70 ($C_{\alpha} = 65.9$ to 74.4), is significantly below the Australian norm but not yet below the suggested cut-off for a group experiencing homeostatic defeat (see Cummins, 2003). The mean PWI score of 51 for carers in the current study, $C_{\alpha} = 43.6$ to 58.4, was in line with the PWI means of 58.2 for all carers and 56.7 for carers who had spent 10 to 19 years in a caregiving role in Cummins et al's (2007) report. The somewhat higher values reported by Cummins may be related to the higher proportion of males in his sample (20% compared with 10% in this sample) and, more particularly, to his inclusion of non-primary carers.

Regarding perceived stress, the mean PSS-10 of the non-carer group at 14.8 ($C_{\alpha} = 12.4$ to 16.3), is similar to the comparison mean of 12.6 (SD = 6.1) reported by Cohen and Williamson (1988) in their original sample and the non-carer mean of 12.8 (SD = 7.4) recently reported by Brunner et al. (2006). The variability in sample non-carer scores would indicate that some individuals were experiencing considerable stress. Although several non-carers did report stressful life events during the data collection period, none reported ongoing life stress. The current carer mean PSS-10 score at 23.3 ($C_{\alpha} = 20.2$ to 25.0), is higher than the recently reported by either de Vogt et al. (2005), $M = 15.3$, or Brunner et al. (2006), $M = 17.6$ (SD = 7.4). However, these differences also appear consistent with the selection of long-term primary carers in the present study.

Mean DASS depression, anxiety and stress scores were within the moderate range for participating carers and within the normal range for sample non-carers (Lovibond & Lovibond, 1995). The DASS depression score for carers, at 16.4 ($C_{\alpha} = 12.4$ to 20.4), was very similar to the carer mean of 16.1 reported by Cummins (2007). Similarly, the carer DASS stress score in the current study, at 21.2 ($C_{\alpha} = 16.9$ to 25.2), was very similar to the mean of 20.8 also reported by Cummins. No carer DASS anxiety subscale or CSM morningness scores were available for comparison.

In sum, sample carers and non-carers appeared to be typical of their respective populations on the variables of interest. Furthermore, as reported in Table 1, there were no significant differences for gender, marital status, age or consumption of caffeine, nicotine, or alcohol. Nor were there significant differences in morningness, sleep duration or the timing of sleep between the two groups. There was, however, a significant difference with respect to education, with a greater percentage of non-carers having a tertiary education, $\chi^2 (1, N = 66) = 13.3, p < 0.001$.

**Differentiating carers from non-carers**

Series of two-tailed t-tests were conducted on the psychological, sleep and substance use measures using a bonferroni adjusted alpha of 0.01, 0.025 and 0.017 respectively, to control for Type I error. As can be seen from Table 1, the groups differed significantly on sleep...
quality and morning restlessness, with carers experiencing poorer sleep than non-carers. The two groups also differed significantly on all stress and well-being variables with carers reporting significantly poorer SWB. Correspondingly, carers had significantly higher scores for perceived stress, depression, anxiety and chronic arousal (as indicated by DASS stress), with very large effect sizes.

In order to check that stress was a key differentiating factor, stepwise logistic regression was performed to determine which of the psychological variables best predicted whether or not participants were in a carer role. All five psychological variables were used: SWB, perceived stress and the three DASS scales for depression, anxiety and stress. The final model was significant, $\chi^2(1, N = 66) = 27.1, p < 0.001$, indicating that it was able to distinguish between carers and non-carers. This model was able to explain between 35.4% (Cox and Snell $R^2$) and 47.2% (Nagelkerke $R^2$) of the variance in carer status. However, only perceived stress was retained in order to achieve this, with 82.3% of cases able to be correctly classified using this variable alone, $R = 0.234$, standard error (SE) = 0.057, Wald = 16.71, $df = 1$, $p < 0.001$, odds ratio $= 1.26$ (95% CI = 1.13 to 1.41). Clearly, perceived stress was the best discriminator of the two groups.

**Morningness and sleep**

The correlations between CSM morningness scores and sleep time variables are provided in Table II. Significant negative correlations between morningness and average bedtimes and average wake times indicate that earlier rising and retiring was, as expected, associated with increasing morningness. From Table III, however, it can be seen that there were no significant correlations between morningness and mean amount of sleep per night, sleep quality ratings or estimates of morning restlessness. Nevertheless, the positive correlation between morningness and restlessness did approach significance.

**Morningness and well-being**

Table III also gives the correlations between morningness, sleep ratings and the key psychological variables. There were significant negative correlations between morningness and perceived stress, depression and anxiety. Of particular interest was the significant moderate negative correlation between morningness and chronic arousal (DASS stress) and the significant moderate positive correlation between morningness and SWB.

**Morningness and the carer role**

Table IV reports the results of a hierarchical moderated regression used to investigate the moderating effect of the carer role on the relationship between morningness and SWB. In the first step, morningness accounted for 11.6% of well-being. The addition of carer role

### Table II. Correlations between morningness (CSM scores) and sleep variables (mean values from sleep diary)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pearson's $r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wake time</td>
<td>-0.469*</td>
</tr>
<tr>
<td>Bed time</td>
<td>-0.469*</td>
</tr>
<tr>
<td>Waking during night</td>
<td>0.013</td>
</tr>
<tr>
<td>Sleep time</td>
<td>0.031</td>
</tr>
</tbody>
</table>

$n = 66$, *p < .001.

CSM, Composite Scale of Morningness.

### Table III. Inter-correlations between the main study variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CSM morningness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. PSW wellbeing (perceived stress)</td>
<td>-0.579***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. DASS depression</td>
<td>-0.258</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. DASS anxiety</td>
<td></td>
<td>-0.256***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. DASS stress (chronic arousal)</td>
<td>-0.421**</td>
<td>-0.333***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Sleep quality</td>
<td>0.113</td>
<td>0.593***</td>
<td>-0.518***</td>
<td>-0.329***</td>
<td>-0.605***</td>
<td>-0.498***</td>
<td></td>
</tr>
<tr>
<td>7. Morningness</td>
<td>0.206</td>
<td>0.484***</td>
<td>-0.514***</td>
<td>-0.435**</td>
<td>-0.406**</td>
<td>-0.629***</td>
<td>0.862***</td>
</tr>
</tbody>
</table>

$n = 66$, *p < 0.05; **p < 0.01; ***p < 0.001; ****p = 0.072.

PSW, Personal Well-Being Index; DASS, Depression Anxiety Stress Scale; CSM, Composite Scale of Morningness.
CIRCADIAN RHYTHMICITY AND SUBJECTIVE WELLBEING

Table IV. Results of the hierarchical moderated multiple regression analyses of morningness, care status and their interaction, on subjective wellbeing, perceived stress and chronic arousal (DASS stress), respectively

<table>
<thead>
<tr>
<th>Variables</th>
<th>Well-being</th>
<th>Penetrated stress</th>
<th>Chronic annual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>ΔAdj R²</td>
<td>β</td>
</tr>
<tr>
<td>1 Morningness</td>
<td>0.36**</td>
<td>0.116**</td>
<td>−0.258*</td>
</tr>
<tr>
<td>2 Morningness</td>
<td>0.284***</td>
<td>0.180***</td>
<td>−0.161*</td>
</tr>
<tr>
<td>Care role</td>
<td>−0.417***</td>
<td></td>
<td>−0.060***</td>
</tr>
<tr>
<td>3 Morningness</td>
<td>−0.405</td>
<td>0.11**</td>
<td>−0.064</td>
</tr>
<tr>
<td>Care role × Morningness</td>
<td>−2.192***</td>
<td></td>
<td>1.246*</td>
</tr>
<tr>
<td>Morningness × care role</td>
<td>1.446**</td>
<td></td>
<td>−0.693</td>
</tr>
</tbody>
</table>

*p < 0.050  **p < 0.010  ***p < 0.001

PSS, Perceived Stress Scale; PWI, Personal Well-being Index; DASS, Depression Anxiety Stress Scale.

accounted for a further 18.6%. The final step, which included the interaction between morningness and care role, accounted for an additional 11%. The full model was significant, F(3, 63) = 15.93, p < 0.001, accounting for 41.2% of the variance in SWB. Although being a care worker was a significant predictor of well-being in the final model, the contribution of morningness was no longer significant. Nevertheless, the interaction term remained a significant predictor, with morningness associated with better well-being outcomes in the care group. In the current study caregiving had a relatively large moderating effect on the relationship between morningness and well-being, f² = 0.203 (see Aguinis et al., 2005).

Table IV also reports the results of two further hierarchical moderated regressions performed for both stress types, perceived stress and chronic arousal. These were conducted in an attempt to examine the effect of the care role on the relationship between morningness and the experience of stress. With regard to perceived stress, the full model was significant, F(3, 63) = 12.41, p < 0.001, and accounted for 34.8% of the variance in perceived stress. However, in this final model, only the care role remained a significant independent predictor of perceived stress with morningness and the interaction term no longer contributing significantly.

With respect to chronic arousal, the final model was significant, F(3, 63) = 15.44, p < 0.001, explaining 40.7% of the variance in chronic arousal. Nevertheless, the care–morningness interaction, in addition to the care role, remained a significant predictor of arousal stress in the full model. Both the care role and the care–morningness interaction remained significant predictors in the full model. Thus, the care role appeared to have a substantial moderating effect on the relationship between morningness and chronic arousal, f² = 0.104 (see Aguinis et al., 2005), with morningness associated with fewer symptoms of chronic arousal among carers.

Discussion

Firstly, the current study provides further support for previous findings that carers are more likely to be experiencing stress and distress than non-carers (Briggs & Fisher, 2000; Pakenham et al., 2005; Schulz & Quitter, 1998; Shewchuk et al., 1998). Indeed, there were significant differences on all psychological variables with perceived stress the best discriminator between the two groups. The results also support past findings that chronic stress (Vitaliano & Young, 2004) and extremely low SWB characterize informal caregivers (Brummett et al., 2005; Cummins, 2001; Cummins, Ockenstrom, Woerner, & Toyn, 2005) particularly those providing long-term care (Cummins et al., 2007). The results were also in line with previous findings of poor sleep quality among carers (Carter, 2002; Sato et al., 2002; Teel & Press, 1999).

Secondly, with regard to morningness, the current findings are in line with previous reports of positive correlations between morningness and SWB (Howell et al., 2008; Randler, 2008). The results also supported previous findings of an inverse relationship between morningness and anxiety (Diaz-Morales & Sanchez-Lopez, 2008; Vardar et al., 2008) and depression (Hirata et al., 2007). Further, the results indicate a negative relationship between morningness and perceived stress and chronic arousal stress. This appears to be congruent with previous evidence of links between eveningness and difficulties coping with environmental and social demands (Mecacci & Rocchetti, 1998).
Finally, the results support the prediction that the relationship between morningness and well-being would be enhanced under conditions of chronic stress. Indeed, it is clear from the regression analysis that the carer role had a moderating effect on the relationship between circadian preference and well-being, with a morning preference associated with greater well-being only in the carer group. It would appear that well-being homeostasis may be easier to maintain under stressful circumstances for individuals with a greater tendency to morningness. It is noteworthy that both previous findings of a relationship between well-being and morningness have been conducted using samples of university students. It could be argued that student samples are likely to be experiencing high stress levels and subsequent well-being challenge. It may be that the observed effects are related to the impact of stress on those students with lower morningness scores.

The role of stress appears complex however. Although lower levels of arousal were also associated with morningness in the carer group this interaction did not occur for perceived stress. This appears counter to the current finding that perceived stress was the key differentiating factor between the carer and non-carer groups. It would seem that morningness is associated with less physiological arousal because of the carer role, but not with fewer perceptions of being overwhelmed by that role. This appears to challenge previous studies' reliance on measures of perceived stress as the key measure of stress among carers (Brummell et al., 2006; de Vugt et al., 2005) and points to distinct characteristics of the DASS stress scale. Indeed, well-being homeostasis may reflect a physiological homeostasis that is associated with fewer symptoms of chronic arousal. Indeed, the moderation of chronic arousal is in line with previous reports that morningness may be associated with behaviours that reflect increased central nervous system adaptability in the face of environmental demand. This aligns with the proposal that morningness may be associated with a stronger capacity for central nervous system inhibition leading to effective coping through reduction of behaviours that are no longer adaptive (Meacci & Rocchetti, 1998). Clearly, more research is needed to clarify such stress effects.

The results of this study should be considered in light of several limitations. These include the use of a quasi-experimental design, a small sample size, the self-selection of carer participants and the heterogeneity of the carer group. The inevitable lack of control associated with the use of the naturally occurring carer role and the cross-sectional design necessarily preclude statements regarding causation. However, this approach is arguably the only ethical and ecologically valid method of exploring the impact of chronic stress, which is an experience unable to be replicated experimentally. From this viewpoint, the use of primary carers may be seen as a design strength as well as a potential limitation. Nevertheless, it may be of benefit to use activity as well as sleep diaries in future research to control for substantive behavioural variations. For example, exercise patterns and napping were not included in this study yet anecdotal reports from participants suggest such habits may be relevant to morningness effects. However, such additional demands do risk increasing participant burden. With regard to sample size, the current sample appeared to be adequate to detect the apparent large effect sizes. Nevertheless, the use of a larger sample in future studies would improve the robustness of the findings and provide an opportunity to further investigate the mediating and/or moderating effects of stress. A longitudinal approach would also be likely to provide insights into whether time-of-day preferences alter with time under stressful conditions.

Attention may also need to be paid to the self-selection of participants in future studies utilizing a caregiver sample. Although the current sample means were very similar to those reported by Cummins (2007), it is possible that self-selection led to the inclusion of a disproportionate number of relatively well-functioning carers, particularly given the potentially burdensome requirement of keeping a 7-day sleep diary. Indeed, anecdotal evidence from some carers who felt unable to participate indicated that they may be faring worse than participating carers. However, in that case, the observed differences appear likely to be an under-estimate rather than an overestimate, of any effects. The current study also used a heterogeneous group of carers. This was based on Cummins' (2001) finding that quality of life was unrelated to the type of care provided once high levels of care were required. Sample carer participants were indeed experiencing high levels of demand and associated well-being decrements. Even so, it may be that future studies using a more homogeneous carer group may provide further insights. For instance, the use of carers of individuals with a specific diagnosis may reduce differences in sleep, activity and stress experiences and subsequently provide clearer findings regarding the effect of morningness on well-being under
challenge. It may be that the interaction with circadian rhythms is related to specific stressors within the carer role that may be more salient for particular groups. However, it would be important to avoid ageing confounds as would be likely in partner carers of those with Alzheimer’s, which are a commonly used research population.

Despite these caveats, the current results would appear to indicate that the effect of morningness on well-being among caregivers is a strong one. Further research is needed to investigate the specific conditions for which this is so and to further explore the role of chronic arousal in well-being homeostasis. Such findings may provide insight into the regulation of personal well-being more generally and help to further elucidate the links between stress, health and chronobiological influences.

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