

# **Loneliness and Health: Physiological and Cognitive Mechanisms in Adulthood and Childhood**

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A thesis submitted in partial fulfilment for the requirements of the degree of  
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## Student Declaration

I declare that while registered as a candidate for the research degree, I have not been a registered candidate or enrolled student for another award of the University or other academic or professional institution.

I declare that that no material contained in the thesis has been used in any other submission for an academic award and is solely my own work.

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## Abstract

This thesis outlines a series of six studies that examine the potential cognitive and physiological mechanisms that underpin the association between loneliness and health. The current theoretical model (Cacioppo & Hawkley, 2009) proposes that loneliness is linked to poor health through hypervigilance to social threat (HSTH), resulting in increased activation of the hypothalamic-pituitary-adrenal (HPA) axis. The first two studies address gaps in the adult literature for loneliness and health and examine HSTH and the HPA axis stress response in real life social contexts: public speaking and meeting strangers.

In adulthood, long term loneliness has been linked to poor health (Shioitz-Ezra & Ayalon, 2010); within childhood literature loneliness and health has only been examined in cross-sectional studies (Mahon & Yarcheski, 2003; Mahon et al., 1993). Thus, the fourth and fifth studies use a longitudinal design to examine loneliness and health in childhood. Cacioppo and Hawkley (2009) also propose that the HSTH in lonely people results in cognitive biases in processing of social information, which affect behavioural responses in social situations. Although cognitive biases have been examined in adulthood, this is yet to be examined in children, so the sixth study addresses this gap in the literature. The final study examines relationships between loneliness and perception of social threat in a real life social context for children: the transition from primary to secondary school.

Findings demonstrate, similar to adult literature, that long-term loneliness in childhood is linked to poor health. Further, evidence for HSTH in lonely adults and children in real life social contexts was demonstrated, offering ecological validity for the current theoretical model (Cacioppo & Hawkley, 2009). The results also implicate chronic stress and a lack of cortisol flexibility as functional mechanisms linking loneliness to poor health. Unlike research with adults, memory biases for social information were not found in lonely children, indicating that lonely children may process social information different to lonely adults. Lonely children also found it harder to ignore irrelevant distractors in cognitive tasks than non-lonely children, when the distracting information involved speech, but not when it was a visual

distraction, indicating that speech information is processed differently than other distractors in lonely children.

It is argued that Cacioppo and Hawkley's (2009) model should be re-examined in light of the findings. Key areas for examination of the current theoretical model (Cacioppo & Hawkley, 2009) are highlighted and discussed: the adoption of chronic stress as a functional mechanism linking loneliness to poor health, investigation of mechanisms that result in a reduction of loneliness levels, and an introduction of a developmental perspective to understanding processes involved in the maintenance of loneliness.

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## Abbreviations

ANS	autonomic nervous system
ACTH	adrenocorticotrophic hormone
BMI	body mass index
CAR	cortisol awakening response
CDI	Child Depression Inventory (Kovas, 2005)
CRH	corticotrophin releasing hormone
EIA	enzyme immunoassay
HPA	hypothalamic-pituitary-adrenal
HSTH	hypervigilance to social threat hypothesis
LACA	Loneliness and Aloneness Scale for Children and Adolescents (Marcoen & Brumage, 1985)
LLSSED	Lancashire Longitudinal Study of Social and Emotional Development
NWCTS	North West Child Transition Study
SNS	sympathetic nervous system
PedsQL	Pediatric Health Quality of Life Measure (Varni, Seid, & Rode, 1999)
PFC	Prefrontal cortex
PNS	parasympathetic nervous system
PSQI	Pittsburgh Sleep Quality Index (Buysee, Reynolds, Monk, Berman, & Kupfer, 1989)
RIA	radioactive immunoassay
TMB	tertramethylbenxidine

## Chapter 1: Introduction & Overview of the thesis

Traditionally, research into loneliness has been clearly demarcated into separate strands for children and adults. Associations between loneliness and poor health have been demonstrated in adulthood, but evidence of links between health and loneliness are limited in childhood. The current theoretical model for loneliness and health (Cacioppo & Hawkley, 2009) has only been examined in some adult studies and does not offer an explanation of the development of loneliness. This thesis aims to address gaps in literature supporting the current model for loneliness and health by examining both adulthood and childhood literature. This thesis combines the adult and child literature in order to offer a developmental life span approach to loneliness research and re-examine the current model in light of results from child studies. The thesis will explore commonalities and differences between loneliness in children, adolescents, and adults, specifically in relation to health and cognitive functioning. To ensure clarity of explanation the thesis has been separated into two sub-sections: first, an adult section (Chapters 2-7) and second, a child section (Chapter 8-12). The research evidence for both sections is combined in a general discussion at the end of the thesis (Chapter 13).

### *Current position of Literature on Loneliness and Health in Adulthood*

Loneliness is an aversive state experienced when people perceive a discrepancy between the interpersonal relationships they have and those they wish to have (Peplau & Perlman, 1982). Loneliness is distinguished from social isolation: lonely and non-lonely people have been found not to differ in the amount of time spent with other people (Hawkley, Burleson, Bernston & Cacioppo, 2003); instead, loneliness is associated with the quality of these relationships (Hughes, Waite, Hawkley & Cacioppo, 2004).

Loneliness in adulthood has been linked to poor health (Hawkley & Cacioppo, 2003) and increased mortality (Pennix et al., 1997; House, Robbins, & Metzner, 1982). A number of potential mechanisms have been implicated, such as increased health-risk behaviours, lack of social buffering of environmental stressors, prolonged activation of physiological systems, impaired repair and restoration processes, and impairments of the immune system (Cacioppo & Hawkley, 2003;

Cacioppo et al., 2002). More recently, research has established that it is the long term experience of loneliness that results in poor physical and mental health, rather than temporary periods of loneliness (Cacioppo, Hawkley, & Thisted, 2010; Shioitz-Ezra & Ayalon, 2010; Qualter et al., 2013b).

*Model of loneliness and health (Cacioppo & Hawkley, 2009)*

Characteristics of lonely people indicate that they interpret social situations differently to non-lonely people (Cacioppo et al., 2000; Duck, Pond & Leatham, 1994; Jones & Freeman, 1981; Jones, Sansone & Heim, 1983). This negativity and passivity towards social relationships has been suggested to increase their perceptions of threat and stress in daily social encounters. In turn, this increased stress in everyday life places cumulative wear and tear on physiological systems resulting in poor health (McEwen & Stellar, 1993). Cacioppo and Hawkley (2009) have proposed a theoretical model to explain the impact of loneliness on health; it considers how increased daily stress experienced by lonely people is directly linked to poor health. They argue that loneliness results in hyper-vigilance for social threats (HSTH) which leads to attention, memory, and confirmatory biases altering the likelihood of social interaction; these dispositions then impact on behaviour, resulting in confirmation of a necessity for heightened vigilance for social threat. These dispositions also activate neurobiological mechanisms increasing activation of the hypothalamic-pituitary-adrenal (HPA) axis and diminish sleep quality. According to Cacioppo and Hawkley (2009), repeated and chronic activation of these threat surveillance systems and diminished anabolic processes heighten cognitive load, diminish executive functioning, dysregulate brain and physiological systems, which in turn lead to broad based morbidity and increased mortality.

*Evidence for the proposed model for loneliness and health*

There is some evidence to support Cacioppo and Hawkley's (2009) model, which falls into four broad categories: 1) naturalistic cortisol daily rhythm studies, 2) laboratory stress challenge studies, 3) studies examining the HSTH, and 4) studies examining cognitive biases. Research in some of these areas is limited and further studies are necessary.

### *1) Naturalistic cortisol daily rhythm studies*

Cacioppo and Hawkley's (2009) model indicates that lonely people differ to non-lonely people as they have increased HPA axis activation, demonstrated by increased levels of cortisol. There is evidence in adulthood that lonely people experience different cortisol diurnal rhythms over the day in comparison to non-lonely people. Studies have shown that lonely people have a higher cortisol awakening response (Doane & Adam, 2010; Steptoe et al., 2004), increased mean levels of cortisol (Cacioppo, et al., 2000), and flattening of the diurnal cortisol slope (Doane & Adam, 2010) when compared to non-lonely people. This evidence supports the proposition of Cacioppo and Hawkley's (2009) model that lonely people have increased activation of the HPA axis.

### *2) Laboratory stress studies*

The naturalistic daily rhythm studies do not tell us why lonely people are experiencing these increased levels of cortisol. Cacioppo and Hawkley's (2009) model indicates that this increased activation of the HPA axis is due to increased perception of social threat for social stressors in everyday life. To evidence this increased activation of threat surveillance mechanisms, researchers have used laboratory stress tasks, which examine physiological responses to stress induced in a laboratory. Laboratory stress studies have shown an increased autonomic nervous system (ANS; measuring heart rate and blood pressure) response in lonely adults, but do not consistently demonstrate raised cortisol levels, (Cacioppo et al., 2000; Steptoe, Owen, Kunz-Ebrecht, & Brydon, 2004). One reason for the lack of heightened cortisol in lonely adults is that the laboratory based studies that measure cortisol stress reactivity have not used a social stressor with a social evaluation aspect (Steptoe et al., 2004). Evidence from a meta-analysis into cortisol responses to stressors (Dickerson & Kemeny, 2004) indicates that a social evaluation context is essential to activate the HPA axis. Hence, in order for laboratory studies to examine the stress response in lonely people they should include social evaluation, such as public speaking. Also, laboratory based stress studies have limited ecological validity as they do not examine stress in a real-world social situation. To further research knowledge in this area it would be important to examine cortisol response to

real-life socially stressful challenges. This thesis aims to address this gap in the literature by examining cortisol response in real life situations involving social evaluation, such as public speaking.

### *3) Evidence for hypervigilance to social threat hypothesis (HSTH)*

HSTH has been evidenced in lonely adults in laboratory studies using three different methodologies: 1) self-reporting, 2) cognitive tasks, and 3) eye tracker studies. First, where researchers have placed participants in unacquainted dyads and friendship pairs in a laboratory and asked them to rate their interaction following conversations, lonely adults rate their own performance more negatively, expect others to rate them more negatively, and make negative global conclusions about their own relationships (Duck, Pond, & Leatham, 1994; Jones, Sansone, & Helm, 1983). Although, these studies do not directly measure a perception of social threat, they do demonstrate that lonely adults are more focused on the negative information in social interaction which indicates HSTH.

Second, cognitive tasks have also been used to examine HSTH in lonely people. These measure speed to respond to a threat stimuli or neutral stimuli. One task that has been used to examine HSTH in lonely adults: the emotional Stroop task. This task measures speed to name the colour a word is written in when words are either neutral or threatening. Lonely adults are slower to respond to negative social words (i.e. social threats) than non-lonely adults (Shintel, Nusbaum, & Cacioppo, 2006). The slower reaction time in lonely adults indicates anxiety in relation to the threat word.

Third, eye tracker studies have been used to measure HSTH using videotaped footage of real social scenes and photographs depicting social rejection. These are particularly useful studies to measure HSTH as they measure actual visual viewing and show HSTH as fixation on a given stimuli. These studies have shown that lonely adults are more likely to fixate first on socially threatening stimuli than non-lonely for the first two seconds; following this, lonely adults display the same avoidant viewing of social threatening stimulus as non-lonely adults (Bangee, Harris, Bridges, Rotenberg, & Qualter, under review; Bangee, under preparation). Lonely people are displaying an initial hypervigilance to socially threatening stimuli followed by

avoidance, the typical pattern displayed in anxiety research known as the hypervigilance-avoidance hypothesis (Mogg, Philippot, & Bradley, 2004).

What is yet to be examined is whether lonely adults display HSTH in real life context as only laboratory studies have been carried out. This thesis aims to address this gap in the literature by examining HSTH in real life situations involving social evaluation, such as public speaking.

#### *4) Studies examining cognitive biases*

Cacioppo and Hawley (2009)'s model suggests that HSTH in lonely people would result in lonely adults attending to negative social information and remembering more negative social events than non-lonely people, and behave in a way that would limit social contact, for example, by withdrawing from social contexts. Lonely adults have a bias for recall of social events (Gardner, Pickett, Jeffries, & Knowles, 2005) and those with fewer close friends are more accurate at identifying emotional expressions and more attuned to positive and negative vocal cues (Gardner, Pickett & Brewer, 2000). Lonely adults also show less activation in brain areas associated with reward to pictures of people than non-lonely adults (Cacioppo, Norris, Decety, Monteleone, & Nusbaum, 2008), indicating that lonely adults experience less reward from social interaction. In diary studies lonely adults report social interactions as more negative and less satisfying than non-lonely (Cacioppo et al., 2000).

General attention deficits and cognitive decline in lonely people has also been found in lonely people. In a dichotic listening task lonely people in comparison to non-lonely showed an attention deficit when voluntary attentional control conflicted with automatic attention processes (Cacioppo et al., 2000). In older adults, loneliness has been linked to increased cognitive decline (Tilvis et al., 2004; Wilson et al., 2007). The cognitive decline/deficit displayed in lonely people is not fully explained by Cacioppo and Hawley's (2009) model. These cognitive impairments could be the result of prolonged activation of the HPA axis (as proposed in Cacioppo & Hawley's 2009 model) which has been associated with memory impairments (Lupien et al., 2005; Wolf, 2003). An alternative explanation could be that the state of loneliness increases a person's cognitive functioning load leading to general impairments on task performance and difficulties with executive functioning, such as

inhibition of undesired/inappropriate task responses. Current research has yet to examine the specific mechanisms involved in reduced cognitive functioning.

#### *Current position of Literature on Loneliness and Health in Childhood*

There is limited research on loneliness and physical health in childhood. A few studies have examined specific health risk behaviour in childhood, but only in adolescence. These studies found that lonely adolescents participate in less physical activity (Page & Tucker, 1994), report more symptom patterns of psychological, physical, and psychosomatic manifestations of psychological distress (such as headaches, loss of appetite), and report low general perceived health status (Mahon & Yarcheski, 2003; Mahon, Yarcheski, & Yarcheski, 1993). Lonely early and middle adolescents also report greater sleep disturbance, such as midsleep awakenings, movements during sleep, and soundness of sleep than non-lonely, but no difference in sleep patterns is found between lonely and non-lonely late adolescents (Mahon, 1994). These cross-sectional studies are limited because they do not explore the impact of long term loneliness on children's health and focus only on adolescent loneliness.

Recently, a few studies have examined health in younger children experiencing long term loneliness. Qualter, Brown, Munn, and Rotenberg (2010) demonstrated that, like adults, long term loneliness in childhood can lead to difficulties with mental health during adolescence. This is an important study as it also demonstrates the impact of the chronicity of loneliness on mental health in childhood, highlighting the limitation of existing studies on childhood loneliness and physical health, which are all cross-sectional studies and restricted to adolescence. This thesis aims to address this gap in the childhood literature by examining longitudinal loneliness and physical health, to examine whether, similar to adults (Cacioppo et al., 2010; Shioitz-Ezra & Ayalon, 2010), it is the long-term experience of loneliness that is the risk factor for poor health in childhood.

## *Evidence for Cacioppo and Hawkley's 2009 model in childhood literature*

### *1) Studies examining HPA axis*

Although the impact of loneliness on HPA axis and the cortisol diurnal rhythm has been examined in adulthood (Cacioppo et al., 2000; Doane & Adam, 2010; Steptoe et al., 2004), there are currently no studies examining HPA axis functioning in lonely children. This thesis aims to address this gap in the literature, comparing cortisol diurnal rhythm in lonely and non-lonely children.

### *2) Studies examining hypervigilance to social threat (HSTH)*

Similar to adults, lonely children display negativity (Qualter & Munn, 2002; Renshaw & Brown, 1993) and passivity (Coplan, Closson, & Arbeau, 2007) in social encounters. Some lonely children also display hostility and aggression (Coplan et al., 2007; Qualter & Munn, 2002) in their social interactions. Qualter et al.'s (2013a) eye tracker study indicates that lonely children (as young as 8 years old) have difficulty disengaging from socially threatening stimuli in comparison to non-lonely children. This demonstrates that children are displaying HSTH (Cacioppo & Hawkley, 2009) as they are initially focused on the social threat information (hypervigilance) and continue to have a difficulty to disengage from this threat information. This differs to eye tracker results with adults where it was found that lonely adults displayed an initial vigilance (evidenced by attention fixation) followed by avoidance of the stimuli (Bangee et al., under review). These results indicate that there may be some differences between the cognitive processing of social information between lonely children and lonely adults. These differences warrant further investigation. The studies in this thesis explore differences in the cognition of lonely children and compare the results to those with adult populations.

### *3) Studies examining cognitive biases*

Cacioppo and Hawkley (2009) indicate that HSTH in lonely people leads to cognitive biases. Although eye tracker studies have been carried out with children and display evidence of the HSTH in childhood (Qualter et al., 2013a), no studies

have examined whether lonely children display cognitive biases, such as increased memory for social information. What is also yet to be examined is whether children display the cognitive impairments/deficits that lonely adults experience. This thesis details a series of cognitive studies that examine cognitive biases and deficits in childhood in relation to loneliness.

Similar to adult literature, there are no studies to date that examine HSTH within a real life context in childhood. The thesis addresses this by examining a real life social challenge for children: transition to secondary school. In relation to Cacioppo and Hawkley's (2009) model it would be expected that lonely children experience increased stress during a transition period, display more HSTH, and make less adjustment to the transition. The adult and child literature and studies within this thesis are compared in the discussion following the child section (Chapter 11) and Cacioppo and Hawkley's (2009) model is re-examined in the general discussion (Chapter 12).

### *Overview of the Thesis*

#### *a) Adult studies* (outlined in Chapter 3)

Two initial studies were carried out on an adult population (details of adult population used in each of the studies are outlined at the end of Chapter 2) to address the gaps in the existing adult loneliness and health literature. Studies 1 (Chapter 3) and 2 (Chapter 4) measured physiological responding (HPA axis activation measured by levels of salivary cortisol) and HSTH in relation to two naturally occurring social stressors 1) public speaking (Study 1), and 2) meeting strangers (Study 2). These adult studies extend the field by examining the proposed theoretical model for loneliness and health in a real life context. It is particularly important to offer ecological validity for Cacioppo and Hawkley's (2009) model; to date, no examination of the impact of loneliness on physiological responding or HSTH in a real life context have been carried out.

#### *b) Child Studies* (outlined in Chapter 6)

The remaining PhD studies focus on exploring health and cognitive functioning in lonely children. The existing research evidence is very limited: there is no examination of long term loneliness in childhood and its impact on physical

health or HPA axis functioning. The first two studies address this limitation by using a child population for which data were collected over a 4.5 year period (details of the research population for studies 3 and 4 are outlined at the end of Chapter 6): Study 3 (Chapter 7) examines physical health (self-reported health and sleep dysfunction), and Study 4 (Chapter 8) examines daily cortisol rhythm in children who experience loneliness chronically over this period and those who do not.

The next study focuses on the gap in the childhood literature for an examination of loneliness and cognitive functioning and uses a separate child population to studies 3 and 4 (details of the research population for Study 5 and 6 are outlined at the end of Chapter 6). Study 5 (Chapter 9) details a series of tasks that examine cognitive biases and impairment in children. Finally, Study 6 (Chapter 10) uses the same group of participants as Study 5 and examines HSTH within a naturally occurring, real-life social context for children: the transition from primary school to high school.

#### *Research Aims of the thesis*

- To address the gaps in the research literature on loneliness and health in adults by examining physiological responses (HPA axis activation) and HSTH to social stress in a real life context to offer ecological validity for Cacioppo and Hawkley's (2009) model within an adult population.
- Extend existing childhood literature to examine loneliness longitudinally and its impact on physical health.
- To advance theoretical understanding of models of loneliness and health by examining differences in 1) health, 2) physiological, and 3) cognitive functioning in lonely and non-lonely children, offering a developmental, life span approach to current literature.
- To further advance loneliness and health literature by exploring differences in health and HSTH between lonely and non-lonely children to a real life social challenge: transition to high school, offering ecological validity for Cacioppo and Hawkley's (2009) model within a child population.

- To re-examine Cacioppo and Hawkley's (2009) model of loneliness and health in light of the findings of this thesis in both adult and child studies, to offer a developmental approach to loneliness research.

*Findings, propositions or new discoveries in the thesis*

*Adult studies*

Studies 1 and 2 are the first to examine HSTH and HPA stress response to a real life, naturally occurring social stressors: public speaking in Study 1 and meeting strangers in Study 2. Results provided evidence for HSTH, but not HPA axis stress reactivity, offering ecological validity for Caccioppo and Hawkley's (2009) proposition of HSTH in lonely people, but not increased HPA stress response to social challenges. The evidence implicates chronic stress as a functional mechanism of the association between loneliness and health, as findings showed that lonely people report higher levels of stress than non-lonely people typically in everyday life rather than perceived stress levels in lonely people being dependent on the stressful situation and/or HPA axis activation.

*Child studies*

Study 3 is the first to examine longitudinal loneliness and its impact on physical health in children. Results demonstrate that children who experience high loneliness at 8-10 years, despite a reduction in loneliness at pre-/early adolescence, report poorer perceived physical health and greater sleep disturbance in pre-/early adolescence, than children who follow a low, stable trajectory of loneliness across middle childhood to pre-/early adolescence. These findings are similar to those found in adults, indicating that in childhood, as in adulthood, experiencing long term loneliness leads to poor perceived health and greater sleep disturbance.

Study 4 is the first to examine HPA axis functioning in lonely children. Results showed no differences in cortisol diurnal patterns in relation to loneliness. However, when cortisol levels were compared on a school and non-school day children with a current high loneliness state did not display cortisol flexibility (i.e. did not have increased levels to meet the increased demands on the school day). In

comparison, children with a low current state of loneliness had higher levels of cortisol on a school day, indicating cortisol flexibility. This lack of cortisol flexibility (Mikolajczak, et al., 2010) evident in lonely children may be a potential functional mechanism explaining the association between loneliness and health in childhood.

Study 5 examined cognitive biases and attention control in lonely children. Results showed that lonely children did not have better memory recall for social information than non-lonely children. Findings from Study 6 indicated that, similar to adults, lonely children have difficulties with attentional control, but only when the attention task involved speech. As it has been demonstrated that lonely people have a HSTH (Cacioppo & Hawkley, 2009; Qualter et al., 2013a), it is likely that the sensitivity to distraction by speech is the result of an increased necessity to screen speech information for social threat.

Study 6 is the first to examine the impact of loneliness across the transition from primary to secondary school (occurring in the UK when children are 10-11 years old). Results show that loneliness decreased across the transition period. However, loneliness did not decrease for a group of children who had high stable loneliness across the transition. These children who retained high levels of loneliness across transition reported lower levels of adjustment, higher levels of stress, poorer health, and greater sleep dysfunction. The children experiencing high stable loneliness also reported higher levels of perceived social threat, which remained high throughout the transition period. Importantly, in Study 7 there was a group of children who had high loneliness prior to transition which reduced in loneliness following transition: for at least some lonely children it seems, transition may provide opportunities for re-connection with others.

### *Impact and Further Research*

The work in this thesis demonstrates that there are some key similarities between loneliness in adulthood and childhood and also some key differences. Similar to adulthood, in childhood it is the long term experience of loneliness that leads to poor health. The findings in this thesis indicate that both children and adults experience chronic stress as a result of being lonely and report higher levels of HSTH in everyday life than their non-lonely peers. However, there are some key

differences between loneliness in childhood and loneliness among adults. Findings in this thesis indicate that lonely children do not have the same cognitive biases for social information as lonely adults. Although, future research will be necessary in this area, it appears that lonely children may not have been lonely for long enough to have developed the same biases that lonely adults have or that there are differences in cognitive processing of social information that is the result of developmental change (Anderson, 2002). In addition, the findings in this thesis indicate that loneliness may reduce at key time points across a person's life, such as during a social transition. Given this evidence it is important that future research work and theoretical models attempt to develop a developmental perspective to understanding loneliness and health.

An important finding is that for some lonely children trajectories of growth of loneliness may change: some factors may influence reductions in loneliness. It may be that transition times offer opportunities to form new friendships and address difficulties with social interaction for some children who experience high loneliness, resulting in a reduction in their levels of loneliness at this time. As there is no current research about intervention strategies for lonely children, this has important implications for theoretical understanding within loneliness literature. It may be that the transition itself supports re-connection and reduces loneliness simply by there being more potential others to connect with (Güroglu, Cillessen, Haselager, & van Lieshout, 2012) or it may be that involvement from others (Bohert, Aikens, Wargo, & Arola, 2013), such as teachers or parents, increases positivity about forming new friendships and changes the way that lonely children interact with others.

The findings of this thesis indicate that there are a number of key areas that need to be re-examined in Cacioppo and Hawkley's (2009) model for loneliness and health: 1) chronic stress as a functional mechanism linking loneliness to poor health, 2) mechanisms that result in a reduction of loneliness levels, and 3) a developmental perspective to understanding processes involved in the maintenance of loneliness. Each of these key areas is discussed in detail in Chapter 12.

## Chapter 2: Literature Review 1

### *Loneliness and Health in Adulthood*

Human beings are social animals and experience pain and distress when separated from others. Baumeister and Leary (1995, p499) have argued that a need to belong, “*to form and maintain at least a minimum quality of interpersonal relationships,*” is an innate drive. This belongingness need involves the need for human contact, but also the need for close relationships with others. Where belongingness needs are not met individuals experience mental health difficulties and physical health problems (Baumeister & Leary, 1995). Positive social relationships are associated with lowered physiological responding to stress (Heinrichs, Baumgartner, Kirschbaum & Ehlert, 2003) and beneficial effects on cardiovascular, endocrine and immune systems (Uchino, Cacioppo & Kiecolt-Glaser, 1996). In comparison, a lack of social connections has been associated with morbidity (Seeman, 1996) and early mortality (Penninx, Tilberug, Kriegsamn, Deeg, Boeke & Eijk, 1997; House, Robbins & Metzner, 1982), even when health related risk factors such as smoking and drinking are controlled.

#### *Loneliness*

Loneliness is a particularly distressing experience activating the same brain regions as physical pain (Eisenberger, Lieberman, & Williams, 2003). It is an aversive state experienced when one perceives a discrepancy between the interpersonal relationships they have and those they wish to have (Peplau & Perlan, 1982). Loneliness is distinguished from social isolation: lonely and non-lonely people have been found not to differ in the amount of time spent with other people (Hawkley, Burleson, Bernston & Cacioppo, 2003), instead, loneliness is associated with the quality of these relationships (Hughes, Waite, Hawkley & Cacioppo, 2004). Weiss (1973) highlights the impact of the quality of social relationships and distinguishes between emotional loneliness, a lack of meaningful and intimate relationships and social loneliness, an insufficient amount of contact with others. Throughout this thesis it is emotional loneliness that is examined.

Loneliness is considered to have a functional purpose (Cacioppo & Patrick, 2008). The adverse state experienced by lonely people promotes alleviation of pain and discomfort by seeking social interactions and connections. Evolutionary psychologists suggest that the negative feelings associated with loneliness supported survival in hunter-gather societies where people lived in small social groupings; it promoted sharing of resources to offspring, hence, ensuring continuation of genes (Cacioppo et al, 2006). It is in contemporary society that loneliness becomes maladaptive when people are unable to meet their social connection needs; as loneliness is prolonged, it becomes associated with adverse health consequences. Loneliness in adulthood is associated with poor health (Hawkley & Cacioppo, 2003), poor mental well-being (Cacioppo, Hughes, Waite, Hawkley & Thisted, 2006), higher risks of cardiovascular disease (Hawkley, Thisted, Masi, & Cacioppo, 2010; Caspi, Harrington, Moffitt, Milne, & Poulton, 2006), decreased survival following surgery (Herlitz, Wiklund, Caidahl, Hartford, Haglid, Karlsoon, Sjöland & Karlsson, 1998) and mortality (Pennix, Tilburg, Kriegsman, Deeg, Boeke & van Eijk, 1997; House, Robbins & Metzner, 1982).

#### *Prevalence of loneliness in adulthood*

The prevalence of loneliness appears to be increasing: in a recent survey of 2,256 people carried out by Mental Health Foundation in the UK (Griffin, 2010) one in ten people (11%) felt lonely often and only 22% reported that they never felt lonely. One in three (30%) responded that they would be embarrassed to admit to feeling lonely and four in ten (42%) reported being depressed because they felt alone. Almost half (48%) suggested that people are getting lonelier in general. Loneliness among those aged 65 years and above is marked, with around a third of respondents suggesting they are sometimes lonely (Victor, Scambler, Bowling, & Bond, 2005).

#### *Chronic and transient loneliness*

Many people suffer from loneliness at certain times in their lives, such as moving to a new area or following the loss of a family member, but for some loneliness is permanent and long-lasting. Recent theorists are beginning to

distinguish between chronic and transient loneliness (Shioitz-Ezra & Ayalon, 2010). Transient loneliness is temporary and often situation dependent, whereas chronic loneliness persists regardless of the situation or context the person is in (Luanaigh & Lawlor, 2008). It is the frequency and severity of loneliness that make it a risk factor for health and disease (Page, Wrye, & Cole, 1986). Although both chronically and situationally lonely older adults are at a greater risk of early mortality and poor health, those who are chronically lonely (relative to situationally lonely) are at a higher risk (Shioitz-Ezra & Ayalon, 2010).

Early theorists discussed the concepts of trait and state loneliness, arguing that loneliness could be dependent on the situation (state-loneliness), but also that some people who report feeling lonely may have a disposition towards loneliness: (trait-loneliness, Jones & Carver, 1991; Jones, Rose, & Russell, 1990). These early concepts of state- and trait-loneliness may be linked to chronic and transient loneliness: the long-lasting chronic loneliness is more likely to be dispositional and relate to trait loneliness, whereas transient loneliness as it is dependent on the context may relate better to state loneliness. Luanaigh and Lawlor (2008) suggest a bio-psycho-social model of loneliness where some people are pre-disposed genetically to loneliness, and other people experience loneliness as the result of their situation or alongside other conditions such as depression and grief.

There is a growing body of evidence suggesting there is a genetic component to loneliness, which may explain why some people remain lonely over time (i.e. chronically lonely). Heritability estimates demonstrate the genetic contribution of loneliness to be between 48%-55% in adoption (McGuire & Clifford, 2000) and twin studies (Boomsma, Willemsen, Dolan, Hawkey & Cacioppo, 2005; McGuire & Clifford, 2000). Recent theorists have implicated polymorphisms of serotonin and oxytocin receptors in the genetic propensity to loneliness. Van Roekel, Scholte, Verhagen, Goosens, and Engels (2010) implicated a polymorphism of the serotonin transporter gene (5-HTTLPR) as a susceptibility factor for loneliness. That gene encodes for a long and short allele, and van Roekel et al. (2010) found loneliness levels remains high and stable in those with the short allele indicating these people may be genetically predisposed to chronic loneliness. Van Roekel et al. (2010) also found the propensity for loneliness could be protected by high levels of parental relational support, as short allele carriers who received high social support from mothers had lower levels of loneliness at 12-14 years. This polymorphism of 5-

HTTLPR has also been implicated in biological reactivity to stressful life events (Gotlib, Joorman, Minor, & Hallmayer, 2008). Therefore, it may be that individuals who report loneliness have a genotype (short allele) that also increases stress reactivity.

Oxytocin, a hormone that is a central regulator of social connection and bond, has also been implicated in the genetic propensity to loneliness (Insel & Young, 2001; Carter, 1998). Nasal administration of oxytocin has been shown to suppress cortisol levels and subjective responses to psychosocial stress in the laboratory (Henrichs et al., 2003) indicating that it plays a role in buffering the impact of social stress. Polymorphisms of oxytocin receptors have been associated with loneliness (Lucht et al., 2009) indicating that lonely people may have a lowered sensitivity to oxytocin which increases their levels of stress in response to a social stressor. The research knowledge in this area is in its infancy, but it indicates that lonely people may have less responsiveness to oxytocin, which may in turn increase their stress-reactivity in social situations.

What is important is that these biochemical studies indicate that there may be a genetic propensity to loneliness: the result of a polymorphism of serotonin and/or oxytocin receptors which increases the likelihood of loneliness, but may also increase stress reactivity. However, it appears that a genetic propensity for loneliness only results in loneliness when other factors that may buffer loneliness are not present, such as parental relational support. Hence, the genetic propensity to loneliness may explain why some individuals experience long term loneliness, but, the social context and the quality of a person's relationships will be the critical factor in whether they do, indeed, experience long term loneliness.

#### *Characteristics of lonely individuals*

It is not just the experience of loneliness that distinguishes lonely people from their non-lonely peers; lonely people have different characteristics to non-lonely. Lonely people find social stimuli less rewarding and are less likely to experience 'uplifts' from social encounters (Cacioppo & Hawkley, 2005). Cacioppo, Norris, Decety, Monteleone, and Nusbaum (2008) demonstrated that lonely people have different activation of reward centres in the brain to non-lonely in response to visual images of people and objects. Lonely people demonstrate a weaker activation in

reward areas to people rather than objects, whereas non-lonely demonstrate the opposite effect. Lonely individuals also differ from their non-lonely peers in the way they interpret social encounters and how they deal with difficulties with relationships. Lonely people are more likely to attribute problems with social relationships to others and view themselves as victims (Cacioppo et al., 2000). Lonely people are also less likely to actively cope, seek instrumental support from others (Cacioppo et al., 2000; Steptoe, Owen, Kunz-Ebrecht, & Brydon, 2004).

To explain these characteristics, loneliness has been associated with a lack of affiliative tendency which is a generalised positivity of social relationships; lonely people do not expect social relationships to be generally positive, pleasant and rewarding. Those low in affiliative tendency also demonstrate sensitivity to rejection and have fear and apprehension that interactions with others will result in rejection, discomfort, and suffering (Mehrabian, 1994). This indicates that lonely people will act in social interactions in a self-protective way that further confirms their feelings of fearfulness of social situations. Lonely individuals tend to interpret their own and their social partners behaviour negatively in social encounters; they also expect others to rate them negatively (Duck, Pond, & Leatham, 1994; Jones, Freemon, & Goswick, 1981; Jones, Sansone, & Heim, 1983).

### *Assessment of Loneliness*

Loneliness in adults is generally assessed using self-report measures. This presents a weakness as it is only the publically declared experience of loneliness that is assessed, which may differ from the private experience of loneliness (Luanaigh & Lawlor, 2008). This is important as it may be difficult for people to express the feeling of loneliness publicly on a self-report measure because it is perceived as a social deficit. Loneliness has been assessed in some academic research by asking a single question, for example, “Do you feel lonely?” or by using detailed self-reported measures. Some of the more detailed measures distinguish between social and emotional loneliness, following Wiess’s distinction (i.e., De Jong-Gierveld Scale [1987], DiTommaso & Spinner [1993, 1997], and Wittenberg’s Emotional vs Social Loneliness scale [Wittenberg, 1986, in Shaver & Brennan, 1991]). Others separate loneliness into further sub-categories, for example, the Loneliness Rating Scale (Scalise, Ginter, & Gerstein, 1984) defines agitation, dejection, depletion and

isolation; the Differential Loneliness Scale (Schmidt & Sermat, 1983) defines romantic, friendship, family and large group loneliness.

The most widely used loneliness scale for adults is the Revised UCLA Loneliness Scale (Russell, 1996; Russell, Peplau, & Cutrona, 1980). Russell's scale differs to other measures as it is a uni-dimensional scale for loneliness. This scale is considered to be a reliable measure (Hartshorne, 1993; Knight, Chisholm, Marsh, & Godfrey, 1988; Russell, 1996). The scale measures satisfaction with social relationships and does not refer to loneliness in any of its statements. The work in this thesis centres on emotional loneliness and because the UCLA scale is an efficient measure of emotional loneliness it is used in all the adult studies discussed in this thesis. Russell's scale is particularly useful because it encourages honesty in self-reporting of loneliness by not referring to loneliness specifically. To summarise similarities and differences between the scales the UCLA loneliness measure is compared to other scales for adults in Table 2.1.

#### *Loneliness and Health: Potential mechanisms*

A number of potential mechanisms have been suggested for the link between loneliness and poor health (Hawkley & Cacioppo, 2003): increased health-risk behaviours, lack of social buffering of stress, prolonged activation of physiological systems, impaired repair and restoration processes, and impairments of the immune system. Each of these potential mechanisms is discussed in the following section.

##### *Health Behaviours*

Lonely people have been suggested to take part in more activities that are detrimental to health, such as smoking and drinking. As negative health behaviours are generally considered socially undesirable the presence of others may act to prevent participation in unhealthy practices. There is evidence to suggest that lonely people are more likely to participate in smoking (Lauder, Mummery, Jones, & Caperchione, 2006), have higher body mass index (BMI), and are more likely to be obese (Lauder et al, 2006).

Table 2.1. Assessment of loneliness measures

Loneliness assessment measure	Reference	Description	Psychometric properties
UCLA loneliness Scale	Russell (1980, 1996)	20 item Likert scale – loneliness as a uni-dimensional measure	High internal consistency $\alpha = 0.89-0.94$ , good test-retest reliability ( $r = 0.73$ after 12 months)
de Jong-Gierveld Scale	De Jong-Gierveld (1987)	11 item scale, 6 items assess for emotional loneliness while other 5 assess social loneliness	Moderate internal consistency $\alpha = 0.7-0.76$ , high correlation between 6 item and 11 item scale = $0.93-0.95$
Social and Emotional Loneliness Scale for Adults	DiTommaso & Spinner (1997, 1993)	37 item 7-point Likert scale, subscales measuring romantic, family, and social loneliness	High internal consistency $\alpha = 0.89-0.93$
Wittenberg Emotional vs. Social Loneliness Scale	Wittenberg (1986, in Shaver & Brennan, 1991)	Two x 5 item Likert scales to assess social and emotional loneliness	Moderate internal consistency $\alpha = 0.78$ and $0.76$ respectively, low correlation between the two subscales
Loneliness Ratings Scale	Scalise, Ginter, & Gerstein (1984)	40 item Likert scales assesses 4 ten-item dimensions: agitation, dejection, depletion and isolation	High internal consistencies for the four subscales ( $0.82-0.89$ )
Differential Loneliness Scale	Schmidt & Sermat (1983)	60 item true-false scale, subscales measuring romantic, friendship, family, large group loneliness	High internal consistency $\alpha = 0.89$ , with subscale internal consistencies above $0.70$

Adapted from Luanaigh & Lawlor (2008)

However, these studies that demonstrate associations between loneliness and health risk behaviours have used retrospective surveys to collect data, rely on self-reporting measures, and are not always replicated (Steptoe et al., 2004). In addition, they do not always demonstrate an impact of loneliness independently of other psychosocial factors, such as depression (Bonin, McCreary & Sadava, 2000). Also, there is not consistency in results using different methodology; where daily reporting has been used in diary studies no difference in the health behaviours between lonely and non-lonely is evident (Hawkley, Burleston, Bernston, & Cacioppo, 2003; Cacioppo et al., 2000).

However, there is sufficient evidence to suggest involvement of a specific health risk behaviour that may put lonely people at risk of health problems: lonely people are less likely to participate in physical activity than non-lonely (Hawkley, Thisted, & Cacioppo, 2009; Page & Hammermeister, 1995). Loneliness has been associated with poor emotional self-regulation that is, in turn, associated with lower physical activity (Hawkley et al., 2009), indicating that lonely people may have difficulties in resisting other distractions in favour for healthy practices such as physical activity.

### *Stress Buffering*

It has been suggested that having others available for support and assistance acts as a buffer against stress (Cohen & Wills, 1985). Cohen and Wills (1985) argue that following a stressful event an interaction with another person may result in the individual re-assessing their situation, which leads to an attenuation of stress appraisal or alternative methods of coping. The benefits of social support have been illustrated in laboratory studies. When participants had the social support of a friend prior to a stress inducing laboratory task (Trier Social Stress test) they report less stress and have lower levels of cortisol than participants without the support of a friend (Heinrichs et al., 2003). More recently, Taylor et al. (2010) demonstrated that those who interacted with more supportive individuals on a daily basis (for a ten day period) had reduced cortisol reactivity to a social stressor. These findings indicate that social support can reduce reactivity to stress even without a supportive friend present.

There are a number of problems with using stress buffering as a potential mechanism of the links between loneliness and health. First, studies have not found direct links between social support and loneliness (Larose, Guay, & Boivin, 2002; Newcomb & Bentler, 1986) and social network impacts on mood and health distinct from loneliness (Golden et al., 2009). Second, the amount of social support is not sufficient to impact on health; it is the quality of relationships that is paramount: negative social interaction increases stress rather than buffers it (Seeman & McEwen, 1996; Uchino et al., 1996). Seeman (1996) suggests that social integration has a varied effect on health and argues that social relationships are complex, dynamic and multi-faceted and it is both the structure and quality that influence health. This may relate to the discrepancy element of loneliness regarding the perception of social relationships not meeting an individual's need (Peplau & Perlman, 1982).

#### *Prolonged activation of physiological systems*

Lonely people have prolonged activation of physiological responses that may result in poor health. Loneliness is related to differences in cardiovascular response patterns: lonely people have higher total peripheral resistance (i.e. resistance to blood flow) and lower cardiac output (i.e. the amount of blood pumped by the lower chambers of the heart in one minute, Hawkley et al., 2003; Cacioppo et al., 2002), higher mean cortisol levels across the course of a day (Cacioppo et al., 2000) and higher systolic blood pressure (Hawkley et al., 2010; Cacioppo et al., 2002) in comparison to non-lonely people. In fact, blood pressure has a cumulative effect in that it rises significantly over time in lonely people suggesting they are at a higher risk of hypertension. Lonely people do not experience more stressful events in daily life than non-lonely, but rate these incidents as more stressful (Hawkley et al., 2003), indicating that they may have a heightened reactivity to stress, which has been suggested by genetic studies (Gotlib et al., 2008; van Roekel et al., 2010). Aanes, Mittelmark, and Hetland (2010) found that, when a person is faced with interpersonal stress, they are most likely to experience psychological distress and somatic symptoms if they are lonely. Hence, it may be the interpretation of stressful events that leads to the heightened physiological response in everyday life rather than lonely people experiencing increased incidences of stressful situations.

### *Diminished Repair and Restore mechanisms*

Although lonely people spend similar amounts of time in bed to non-lonely, they spend more of this time in bed awake (Cacioppo et al., 2002; Steptoe et al., 2004), indicating lonely people have poorer sleep quality and may lack the restorative processes that sleep provides. Siegel, Leproult, and Cauter (1999) demonstrate that, with less than one week of reduced sleep (restricted to 4 hours sleep time), people experience alterations in metabolic and endocrine function. Glucose tolerance and thyrotropin concentrations are lower, evening cortisol levels are raised, and activity of the sympathetic nervous system is increased. The effects of sleep deprivation on physiological processes are similar to those experienced in normal aging, suggesting sleep debt may increase aging processes and severity of age-related chronic disorders. Sleep has also been demonstrated to impact on cognitive processing (Lim & Dinges, 2010), suggesting lonely people may also have cognitive impairments as a result of this lack of sleep efficiency.

### *Impairment of the Immune System*

Studies have demonstrated that the immune system is also influenced by loneliness. Lonely college freshman were shown to have a reduced immune response to influenza vaccination (Pressman et al., 2005) and lonely psychiatric inpatients had lower levels of natural killer cell activity and poor lymphocyte response (Kiecolt-Glaser et al., 1984). Complex alterations in the pattern of gene expression relating to immune system response have been found in lonely people (Cole et al., 2007), which increases their risk of inflammation related diseases and ability to fight off disease and infection. However, when undergraduate students were given an oral wound there was no significant association between wound healing and loneliness (Bosch, Engeland, Cacioppo, & Marucha, 2007). This evidence suggests that there may be an influence of loneliness on the immune system, but that it is a specific relationship affecting certain aspects of the immune system.

### *Loneliness and health: Theoretical models*

As discussed, there are a number of potential mechanisms that may explain the relationship between loneliness and health. These mechanisms may have specific individual effects on health, but may also interact to result in an overall impact of loneliness on health. To increase the understanding of loneliness and health a theoretical model that explains the interplay of these mechanisms is needed.

The theory of 'allostatic load' proposed by McEwen and Stellar (McEwen, 1998a) suggests that cumulative wear and tear across multiple physiological systems, such as hypothalamic-pituitary-adrenal (HPA) axis and cardiovascular system from repeated exposure to life challenges is a significant contributor to overall health risk. McEwen and Stellar (1993, p. 2093) define allostatic load *“as the cost of chronic exposure to fluctuating or heightened neural or neuroendocrine response resulting from repeated or chronic environmental challenge that an individual reacts to as being particularly stressful.”* As lonely people are characterised by negativity and passivity in social encounters they are likely to experience increased stress in everyday life due to repeated perception of social threat in daily encounters with others (Cacioppo et al., 2000; Jones & Freeman, 1981; Jones et al., 1983; Steptoe et al., 2004). This increased activation of physiological stress mechanisms in lonely people would increase their allostatic load and would contribute to poor health. There is limited research that has examined the link between loneliness and allostatic load. One study showed that greater social integration and emotional support is associated with lower allostatic load in older people (Seeman, Singer, Ryff, Love, & Levy-Storms, 2002). This indicates that lower social integration (i.e. loneliness) may be associated with a higher allostatic load.

The stress response system is considered to be an adaptive, life saving process designed to support survival in a threatening situation. In response to a perception of threat, individuals have a number of physiological responses; two important ones are the autonomic nervous system response (ANS) (Figure 2.1) and the endocrine response (Figure 2.2). The ANS functions to mobilise energy and deliver oxygenated blood to the body ready to respond to the threat through fight-flight reactions (Cannon, 1939, cited in Aldwin, 2007). The ANS comprises of the sympathetic (SNS) and parasympathetic system (PNS). The SNS prepares the body for action, whereas the PNS maintains and conserves the body's resources.

Following an appraisal of threat noradrenaline is released into the bloodstream, which results in activation of the SNS and suppression of the PNS. Activation of the SNS increases blood pressure, heart rate, and respiration rate allowing more oxygen to flow to the brain and muscles enabling greater physical and mental effort.

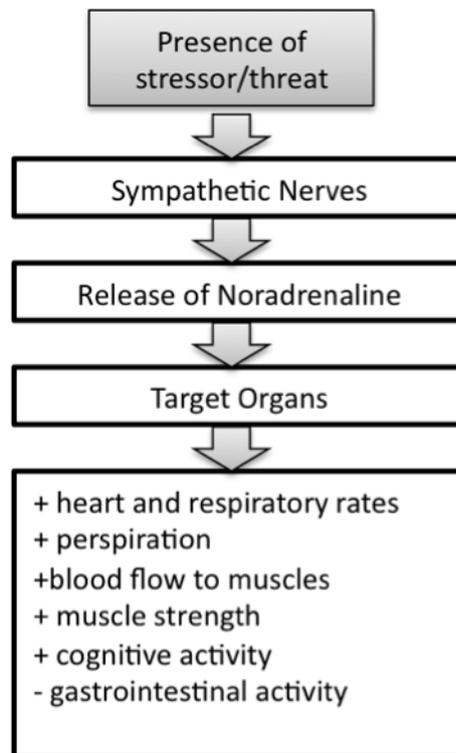


Figure 2.1 Autonomic nervous system response to stress (adapted from Aldwin, 2007)

The ANS response is fast acting and acts immediately upon appraisal of threat whereas the endocrine system activation takes around 30 minutes. The main endocrine system that is important in the stress response is the HPA axis. This axis also plays an important role in homeostasis (Miller & O'Callagan, 2002) regulating a number of bodily processes and displays a circadian rhythm (Buckley & Schatzberg, 2005; King & Hegardoren, 2002; see Figure 2.4). In relation to the stress response, a perception of a threat stimulates the hypothalamus to secrete corticotrophin releasing hormone (CRH). CRH stimulates the anterior lobe of the pituitary to release adrenocorticotrophic hormone (ACTH) into the blood stream. The adrenal cortex then releases glucocorticoids (e.g. cortisol). The end product of HPA axis activation; cortisol, releases energy stores and elevates blood glucose to provide fuel for the

body. It also regulates the immune system, for example, it acts as an anti-inflammatory agent to suppress certain aspects of immune functioning (Sapolsky, 2004). Cortisol also exerts permissive effects on the SNS (Miller & O'Callagan, 2002). Cortisol supports a negative feedback of the endocrine system, as elevated levels of cortisol suppress the release of CRH and ACTH at the hypothalamus and anterior pituitary.

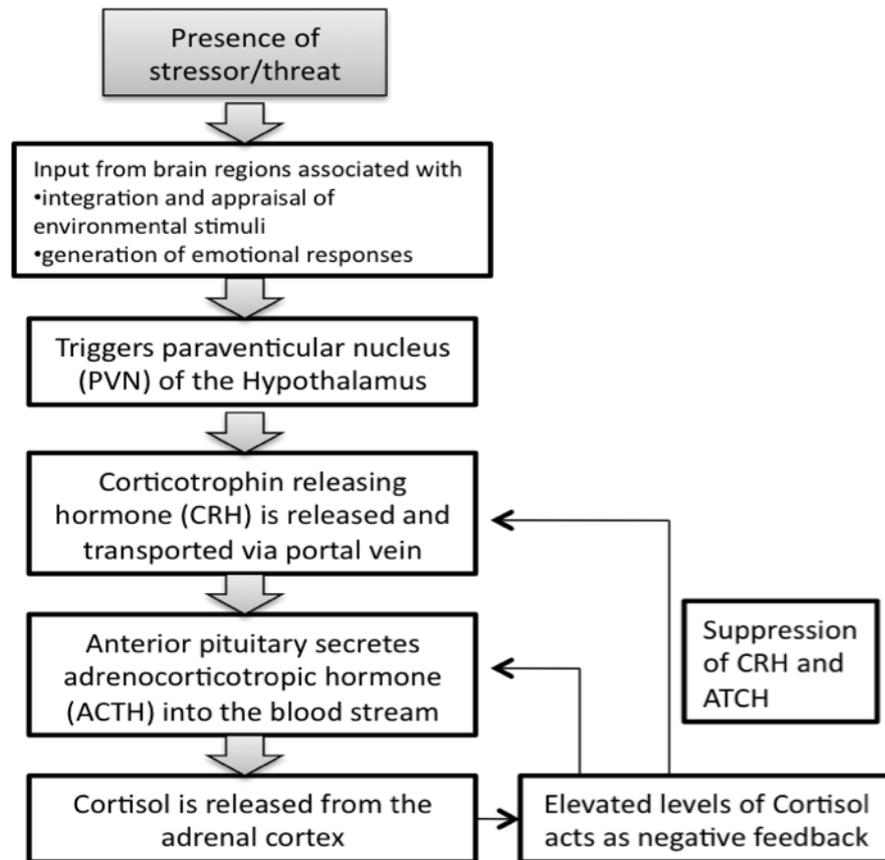


Figure 2.2. Hypothalamic-pituitary-adrenal (HPA) axis response to stress

These stress responses are thought to be adaptive as they release energy and regulate other physiological systems to deal with acute demands (Sapolsky, 2004). However, for both systems there are negative effects if they are activated for too long. Prolonged activation of the autonomic nervous system results in cardiovascular disease (Sapolsky, 2004); prolonged activation of the HPA axis results in a number of negative health consequences - it impacts on sleep efficiency reducing restore and repair processes (Buckley & Schatzberg, 2005) and has been linked to atherosclerosis of the carotid arteries, which increases the risk of

cardiovascular disease (Dekker, et al., 2008). Prolonged or repeated exposure to cortisol is also thought to damage receptors within the HPA axis resulting in poor regulation of cortisol (Sapolsky, 2004). This can lead to dysfunction of the HPA resulting in blunted cortisol responses to stress.

#### *Theoretical Model for Loneliness and Health (Cacioppo & Hawkley, 2009)*

Cacioppo and Hawkley (2009) have suggested a model of the potential mechanisms of loneliness on health. They argue the perception of loneliness itself results in a hyper-vigilance for social threats in everyday life, which leads to attention, memory and confirmatory biases altering the likelihood of social interaction. These dispositions impact on behaviour, resulting in confirmation of a necessity for heightened vigilance for social threat. In turn, they also activate neurobiological mechanisms increasing activation of the HPA axis and diminish sleep quality. The HPA axis has been shown to play an important role in maintaining alertness and modulating sleep (Buckley & Schatzberg, 2005; Clow, Hucklebridge, Stader, Evans, & Thorn, 2010). Cognitive load is increased, executive functioning is impaired, and chronic heightening physiological systems leads to broad based morbidity and increased mortality, when these neurobiological mechanisms (i.e. threat surveillance mechanisms) are repeatedly activated. Cacioppo and Hawkley's (2009) model of loneliness and health is presented in Figure 2.3.

#### *Evidence for Cacioppo and Hawkley's 2009 Model of Loneliness and Health*

##### *1) Naturalistic studies on cortisol daily rhythm*

Naturalistic studies have investigated the differences in the cortisol daily rhythm in lonely and non-lonely adults to examine the proposition by Cacioppo and Hawkley (2009) that lonely people have increased HPA activation. Cacioppo and Hawkley (2009) propose that lonely people are on a heightened state of alert for social threat in everyday life resulting in chronic activation of the HPA, so one would expect to find an atypical cortisol diurnal rhythm in lonely people in comparison to non-lonely.

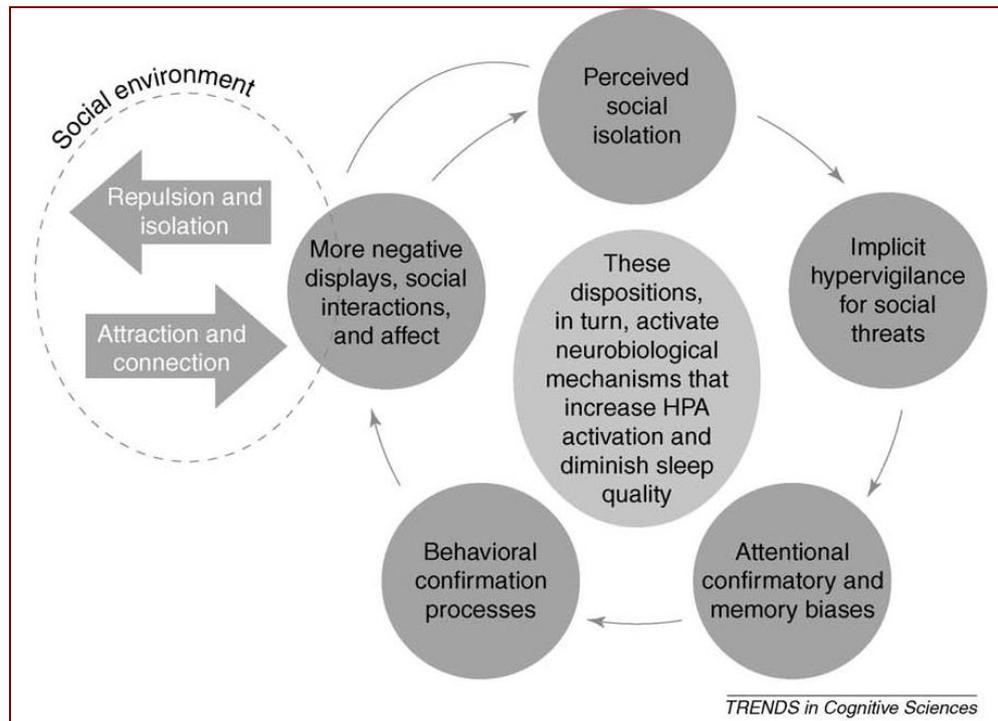


Figure 2.3. Loneliness and Health Model (from Cacioppo & Hawkley, 2009)

The normative diurnal rhythm (see Figure 2.4) demonstrates that cortisol is at its greatest levels in the morning and increases dramatically on awakening (this is known as the cortisol awakening response), and then shows a pronounced decrease throughout the late morning. Levels tend to stabilise and flatten throughout the afternoon and early evening, reaching the lowest nadir in the late evening and early morning hours (King & Hegadoren, 2002).

Cortisol is typically measured in saliva samples for naturalistic studies as this is considered a non-invasive method, involves less stress than collection via blood samples, and offers ease of collection outside a laboratory (Kirschbaum & Hellhamer, 1994). Saliva sampling for cortisol assessment is considered a reliable method (Kirschbaum & Hellhamer, 1989) and there are good correlations between cortisol in saliva and an alternative method using blood serum in adults (Kahn, Rubinow, Davis, King, & Post, 1988; Kirschbaum & Hellhamer, 1989) and children (Woodside, Winter, & Fisman, 1991). Saliva samples are typically obtained from participants using a salivette (i.e. plastic tube containing a polyester swab) which

enables efficient collection of saliva in a container suitable for centrifuging the sample (to remove the saliva from the swab ready for assaying). Passive drool (where saliva is pooled into the mouth and then drooled down a straw) is also used to collect saliva but this is not as convenient for naturalistic studies (especially when participants are collecting their own samples) and is not as reliable as salivettes as a collection method for the measurement of cortisol (Gröschl & Rauh, 2006; Poll et al., 2007).

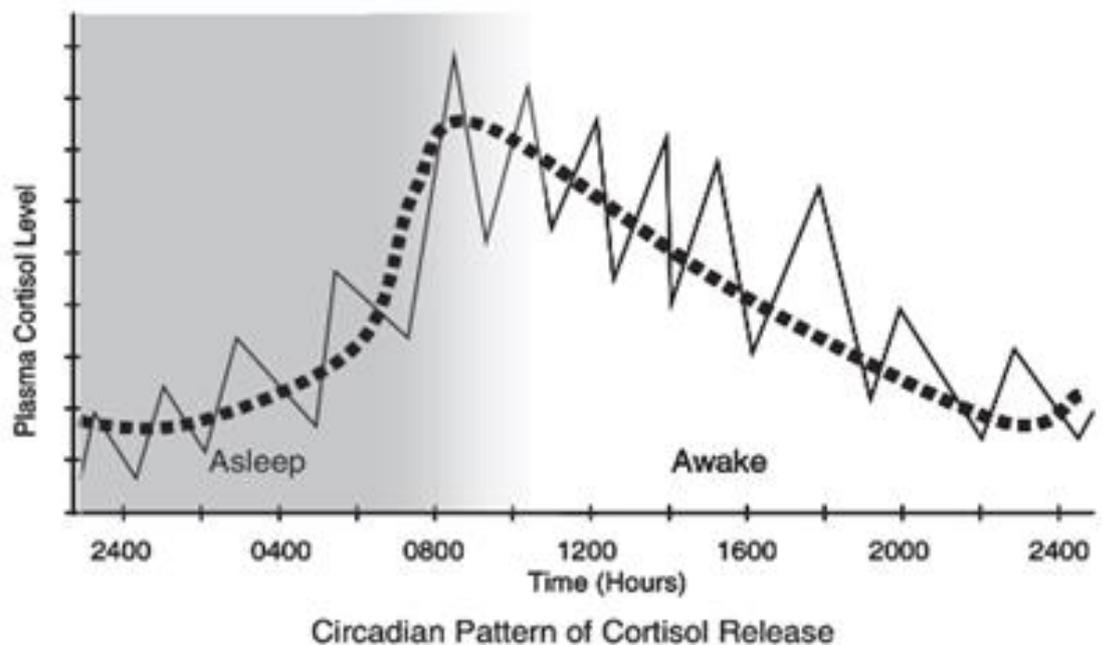


Figure 2. 4. Cortisol diurnal rhythm (from King & Hegadoren, 2002).

Once the saliva samples are collected cortisol is measured using a competitive enzyme immunoassay (EIA) which uses an enzyme as a marker for cortisol. An alternative method for assaying saliva samples is radioimmunoassay (RIA) which is considered a more reliable method (Schultheiss & Stanton, 2009). However, RIAs use a radioactive marker for cortisol, so EIAs are typically used in this type of research as they do not require the use of radioactive materials, so present researchers with greater ease of testing (Schultheiss & Stanton, 2009). EIAs use pre-prepared plates with anti-bodies attached. The method uses a competition between the cortisol within the sample and cortisol linked to horseradish peroxidase (this acts as a marker within the measurement) to bind with the anti-bodies binding sites on the plate. Where there is a high concentration of cortisol in the saliva sample

less cortisol linked to horseradish peroxidase will be able to bind with the antibodies. The bound cortisol and horseradish peroxidase reacts with the substrate tetramethylbenzidine (TMB) to produce a blue colour. This blue colour is turned to a yellow colour by stopping its reaction with TMB with sulphuric acid. The optical density of this colour is then measured (i.e. indicating the amount of cortisol bound with horseradish peroxidase) which is inversely proportional to the amount of cortisol present.

One important factor that influences the typical diurnal rhythm is sleep and it is important to control for this in cortisol research. The HPA axis plays an important role in the transition from sleeping to awakening and the cortisol awakening response (CAR) appears to be a physiological response to awakening (Clow et al., 2010). As sleep patterns and HPA axis are linked closely, insomnia can increase cortisol levels (Vygontzas et al., 2001), early wakening or shift work can result in atypical patterns of cortisol (Magid & Steptoe, 2005; Toitou et al., 1990) and sleep deprivation one day results in elevated cortisol levels the following day (Leproult, Copinschi, Buxton, & Van Cauter, 1997). To overcome this issue, cortisol researchers typically exclude participants who are very early risers, start work early or work shift patterns (Clow, Thorn, Evans, & Hucklebridge, 2004). Sleep quality and time of awakening on the day of testing are measured and used as co-variants in analysis of data where there are expected differences between participants (Balscovich, Vanman, Medes, & Dickerson, 2011).

The cortisol diurnal rhythm is investigated in five main ways: a) by examining differences in the cortisol awakening response (CAR), b) investigating the steepness of the slope of cortisol across the day, c) measuring the total cortisol output, d) measuring cortisol at specific time points, and e) measuring cortisol reactivity to momentary experience (Saxbe, 2008). Early studies tended to focus on the mean level of cortisol or total cortisol output, but as current researchers suggest it is deviations from the typical diurnal pattern that contribute to poor health outcomes (Stone et al., 2001), researchers now tend to use measurements that assess diurnal change, such as the CAR or the diurnal slope (Adam & Kumari, 2009).

- a) *Cortisol awakening response (CAR)* Within approximately 30 minutes of awakening, there is a substantial increase of cortisol levels of between 50-75%, before the typical cortisol diurnal decline. The CAR is measured by

taking saliva samples across this period (at awakening and post awakening), with samples typically taken on awakening, 20 minutes after awakening, and 45 minutes after awakening (some studies have taken more/less samples). The CAR<sub>i</sub> (change in awakening cortisol level) is often calculated by subtracting the peak level of cortisol (i.e. post awakening) from the level at awakening (Chidea & Steptoe, 2009). However, where there are more than two values an area under the curve can be calculated (CAR<sub>au</sub>, i.e. the overall level of cortisol release, Chidea & Steptoe, 2009; Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003).

Individual differences in demographic, health, early waking, and sleep factors have predicted the magnitude and trajectory of the CAR, so it is important that researchers control for such factors. In addition, the CAR is sensitive to sampling conditions and participant compliance and poor adherence to study protocol (i.e. not taking the first sample immediately on awakening) has been associated with a reduced CAR (Kudielka, Broderick, & Kirschbaum, 2003).

There is currently some inconsistency in data relating to CAR and health: chronic psychological stress and adverse health outcomes have been linked both negatively and positively with the size of the CAR (Saxbe, 2008). Depression has been associated with an increased CAR (Bhagwagar, Hafizi, & Cowen, 2003; Pruessner, Hellhammer, Pruessner, & Lupien, 2003) and also a reduced CAR (Ellenbogen, Hodgins, Walker, Couture, & Adam, 2006; Stetler & Miller, 2005). There has been some recent evidence to suggest that an increased CAR is adaptive and in response to increased demands of the day (Fries, Dettenborn, & Kirschbaum, 2009; Mikolajczak, et al., 2010), for example, both adults (Kunz-Ebrenct, Kirschbaum, Marmot, & Steptoe, 2004) and children (Watamura, Kryzer, & Robertson, 2009, Harris, Robinson, Bradley, & Qualter, under review) have increased CAR and/or levels of morning cortisol on work/school days in comparison to rest days. Thus, a lack of cortisol flexibility (i.e. not increasing in relation to increased demands of the day) has been theoretically linked to poor health because it is considered maladaptive.

- b) *Cortisol Slope* Cortisol declines across the day demonstrate a distinct cortisol slope, which is measured by simply subtracting the evening cortisol value from the morning value (e.g. Tuner-Cobb, Rixon, & Jessop, 2011); where there are a number of samples the cortisol level is regressed by time and the resulting variable is used as a dependent variable (e.g. Kurina, Schneider, & Waite, 2004). When there are large numbers of participants multi-level modelling is used with time at level 1 and between subject predictors at level 2 and day at level 2/3 (Adam, 2006; Doane & Adam, 2010). Flattened cortisol slopes have been associated with high chronic stress and poor psychosocial functioning (Saxbe, 2008). Flattened cortisol slopes can be due to low morning levels that remain low throughout the day (a flat “low” cycle) or high morning levels that fail to show a normal diurnal decrease (a flat “high” cycle). This area is under-researched and as such many studies fail to define between “high” and “low” cycles.
- c) *Total cortisol output* Total cortisol output is examined in two different ways. First, some studies average the cortisol levels over time points taken across a day to give a mean level of cortisol and higher mean levels of cortisol have been linked to chronic stress (van Eck & Nicolson, 1994). Second, other studies attempt to calculate the area underneath the curve (AUC). However, studies using AUC have reported inconsistent results, there is no consensus about how to calculate the AUC, and it does not relate to the CAR or diurnal slope measures, indicating that it may tap into different HPA axis physiology (Saxbe, 2008).
- d) *Specific time points* Some researchers have taken saliva samples at specific time points and studies have shown high cortisol late in the day and a smaller-than-average drop in cortisol at the end of the day are associated with higher stress (Essex, Klein, Cho, & Kain, 2002) and fewer psychosocial resources (Powell et al., 2002). Clow, Hucklebridge, Stadler, Evans and Thorn (2010) have noted the significance of the awakening cortisol sample (S1), if taken at the appropriate time, they argue that this is linked to an attenuated CAR and consequently poor

health. They stress the importance of reporting this measure specifically, but alongside other measures, such as the CAR. This approach enables a fuller understanding of the cortisol functioning in the morning.

Only measuring cortisol at one specific time point is not likely to be informative as the typical diurnal pattern is not examined. In some studies the time points are carefully selected to ensure some measurement of the diurnal pattern across the day and measures are taken at awakening, peak cortisol, and evening. There is some indication that these can offer a reliable measure when only minimal sampling is viable. For example, one study demonstrated a correlation of .69 when AUC for 15 samples was compared to AUC for the three samples (Harville et al., 2007) and in another study the diurnal slope associated with 2 time points (wake up and bedtime) was correlated (.94) with a diurnal slope using 6-7 samples per day (Adam & Kumari, 2009). These results indicate that normative diurnal patterns can be reliably examined using a few saliva collection time points, especially when only a few saliva collection points would be viable, e.g. if participants are unable to collect saliva samples in their place of work or school, samples could be collected in the morning, late afternoon, and evening, enabling a measurement of each time point and cortisol slope to be calculated.

- e) *Response to momentary experiences* Momentary experiences and related cortisol response have only recently started to be examined. Researchers tend to use a daily diary approach for participants to record their mood or emotion changes using approaches such as the Experience Sampling Methodology (Larson & Csikszentmihalyi, 1983). Multiple observations are collected from participants and within person associations between mood/emotion and cortisol are examined. Associations between momentary experiences and cortisol levels tend to be examined using multi-level modelling. Several studies have found associations between higher than expected cortisol levels and stressful experiences and negative mood states when time of day effects on cortisol level are controlled for (Adam, 2006; Hanson Maas, Meijman, & Godaert, 2000; Van Eck, Berkhof, Nicolson, & Sulon, 1996).

The impact of loneliness on the cortisol diurnal rhythm has been examined using some of these measures. Cacioppo and Hawkley's (2009) model for loneliness and health suggests that there is increased activation of the HPA axis in lonely people. Differences between the cortisol diurnal rhythm between lonely and non-lonely people which have been observed offer some evidence for this model. Studies have shown that lonely people have a higher cortisol awakening response (Doane & Adam, 2010; Steptoe et al., 2004), increased levels of total cortisol output (measured using an average of cortisol levels across the day, Cacioppo, et al., 2000) and flattening of the diurnal cortisol slope (Doane & Adams, 2010) in comparison to non-lonely people. In addition, prior day feelings of loneliness are also associated with a higher cortisol awakening response the next day in the general population (Doane & Adam, 2010; Adam, Hawkley, Kudielka & Cacioppo, 2006), demonstrating that the state of loneliness increases cortisol. In contrast, Cacioppo et al.'s (2002) one-day cortisol study showed no differences between mean cortisol levels of lonely and non-lonely people. However, Cacioppo et al.'s (2002) study has some methodological limitations: it was a one-day study that may not be long enough to demonstrate differences, and it used total cortisol output that does not measure deviations from the typical diurnal pattern which are thought to contribute to poor health outcomes (Stone et al., 2001).

These naturalistic cortisol daily rhythm studies indicate that lonely people experience heightened stress in their everyday life and the mood state of loneliness activates the HPA axis as Cacioppo and Hawkley's (2009) model of loneliness and health proposes. A higher cortisol awakening response and flattening of the cortisol slope have been demonstrated to be indicative of poor health (Clow et al., 2004). Therefore, in support of Cacioppo and Hawkley's (2009) model, the increased HPA axis activation and subsequent deviations from normative cortisol rhythms in lonely people may be a functional mechanism by which the association between loneliness and poor health can be explained (Stone et al., 2001).

## 2) *Stress challenge laboratory tasks*

Another way that the current model for loneliness and health (Cacioppo & Hawkley, 2009) has been evidenced is using stress challenge tasks in a laboratory. This methodology examines physiological responding when a participant

experiences a stressor induced within a laboratory, for example, the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993) is a public speaking/cognitive combination task that elicits a strong HPA axis response. This methodology requires participants to give a five minute speech to a panel of judges in relation to a pretend job application, which is then followed by a backwards subtraction number task. It appears that this is a particularly effective method for eliciting a cortisol response to stress as it involves participants not feeling in control and includes social evaluation (Dickerson & Kemeny, 2004); these factors have been suggested to be essential to elicit a cortisol stress response. In order to capture the peak in cortisol reactivity in response to an environmental stressor cortisol levels should be taken at baseline (i.e. before on-set of the stressor), 20-40 minutes following the on-set of the stressor (stress recovery), immediately post stressor, and during the recovery from the stressor.

There are a number of factors that are known to influence cortisol reactivity in stress challenge tasks and should be controlled for. These include menstruation (Kirschbaum, Kudielka, Gaab, Schommer, & Hellhammer, 1999; Kirschbaum, Pirke, & Hellhammer, 1995) and oral contraceptive use (Kirschbaum, Pirke, & Hellhammer, 1995). It has been suggested that women using the oral contraceptive are excluded from stress reactivity studies and laboratory stress tasks are timed so women are not in the luteal phase, however, this is not likely to be time or cost prohibitive in the context of most research studies so self-report measures should include questions about oral contraceptive use and menstruation cycle at time of testing (Blascovich, Vanman, Medes, & Dickerson, 2011). It is important to note that asking questions about contraceptive use and menstruation may present some ethical issues in relation to age and sexual practices and some universities may not be ethically prohibitive of such self-reporting in young populations.

Gender should be examined in stress reactivity studies because some studies have demonstrated gender differences in cortisol responses to stress. Studies either show there are no sex differences in cortisol reactivity to stress or that young men have higher cortisol responses to stress than young women (Kajantie & Phillips, 2006; Kudielka & Kirschbaum, 2005), particularly in response to psychosocial stress in a laboratory, i.e. the TSST test. Thus, the results in sex differences studies are conflicting. However, in Dickerson and Kemeny's (2004) meta-analysis ratio of male to female was not a significant predictor of effect sizes in cortisol stress studies,

indicating that gender did not influence the size of the HPA axis response to stress. It has been suggested that the differences in results of sex difference studies is likely to be due to methodological issues (Kudielka & Kirschbaum, 2005). Despite this it does seem that sex differences in cortisol reactivity studies may also be due to the specific nature of the stressor. For example, men show greater cortisol reactivity to achievement-based tasks (i.e. mental arithmetic) and women show greater reactivity to interpersonal tasks (i.e. social rejection, Stroud, Salovey, & Epel, 2002) and women display a higher cortisol response to martial conflict (Kiecolt-Glaser et al., 1997). These studies indicate that women have a greater cortisol reactivity to interpersonal stress than men. As some studies in a laboratory have found sex differences, it is important to examine gender differences in data sets and to try to ensure equal ratios of male and female groupings of participants for comparison studies (i.e. comparing lonely and non-lonely).

Other factors that impact on cortisol stress reactivity in stress challenge tasks are drinking caffeine or alcohol, eating, and smoking. Glucose increases cortisol reactivity to stress (Gonzalez-Bono, Rohler, Hellhammer, Salvador, & Kirschbaum, 2002) so eating and drinking prior to a stressor will elevate the cortisol stress response. Also, caffeinated drinks and alcoholic beverages are known to increase cortisol reactivity (al'Absi, Lovallo, McKey, & Pincomb, 1998; Cobb & van Thiel, 1982), so these should be avoided prior to the cortisol testing and during the testing period. In addition, nicotine affects the hypothalamus increasing CRH release and indirectly impacts on cortisol production (Weidenfeld, Bodoff, Saphier, & Benner, 1989) and smoking has been demonstrated to elevate salivary cortisol levels (Kirschbaum, Wüst, & Strasburger, 1992). As food, drink, and smoking may elevate cortisol levels reducing the accuracy of measurements participants are typically asked to refrain from smoking, drinking (with the exception of water), and eating for at least 2 hours prior to and during the testing session.

Another important factor is the time of the day that the testing occurs; due to the diurnal rhythm, cortisol is relatively stable in the afternoon in comparison to the decreasing levels found in the morning. A meta-analytic review of stress challenge studies found that those conducted in the afternoon were associated with an effect size of  $d = 0.46$ , in comparison to those carried out in the morning which had an effect size of  $d = 0.14$  (Dickerson & Kemeny, 2004). It would be sensible then, where possible, to carry out stress challenge tasks with participants in the afternoon.

Although, studies have shown that it is possible to elicit measurable stress reactivity in the morning and the TSST (Kirschbaum, et al., 1993) in particular has not shown differences in reactivity between participants who were tested in the morning and those tested in the afternoon (Kudielka, Schommer, Hellhammer, & Kirschbaum, 2004). Another factor in relation to timing that is important is the time of testing after the stressor; the meta-analytic review (Dickerson & Kemeny, 2004) also examined peak cortisol response to a stressor. It was found that effect sizes for increases in cortisol obtained 20-40 minutes after the onset of a stressor ranged from  $d = 0.38-0.41$ , in comparison to effect sizes of  $d = 0.13-0.29$  for 21-40 minutes after the stressor on-set. Effect sizes for samples taken 41-60 minutes from the stressor on-set were not significant, indicating that cortisol levels have returned to baseline (i.e. prior to on-set of the stressor). This indicates that samples should be taken prior to the stressor, and at least 20 minutes after the on-set of stressor, and at least 20 minutes post stressor to show recovery.

As Cacioppo and Hawkley (2009) have suggested that loneliness results in HSTH it would be expected that lonely people have an increased stress response to social challenges, for example, when public speaking. Within the loneliness literature, the HPA axis response to stress has been under-researched. There are currently only two studies relating to stress responses in lonely people to specific stressors; one of these studies only measures the ANS (Cacioppo et al., 2000) and the other examines both ANS and HPA axis activation (Stephoe et al., 2004). In Cacioppo et al.'s (2000) study participants displayed a lower heart rate reactivity when they were required to complete two social speeches (asking someone out for a date and describing why you're a likeable person) and two non-social speeches (describing objects in the room and describing the route from campus residence to first class of the week), and a mental arithmetic task. This pattern of stress reactivity demonstrated in lonely people is associated with helplessness and reliance on others or external factors to cope with stress, typically known as "passive coping" (Sherwood, Dolan & Light, 1990). In comparison, Steptoe et al. (2004) induced mental stress in the laboratory using a colour word interference task and a mirror tracing task and found no overall differences in heart rate reactivity between lonely and non-lonely people. However, a gender difference was noted: lonely women had higher increases in diastolic blood pressure than non-lonely women during the stress tasks. Cortisol responses to the stressor tasks were not examined in Cacioppo et al.'s

(2000) study and did not relate to loneliness in Steptoe et al. (2004) study. However, Steptoe et al.'s (2004) study did not use a social stressor and the HPA axis has been shown to have a specific role in social stress (Blascovich, Vanman, Mendes, & Dickerson, 2011; Dickerson & Kemeny, 2004).

Another important point to consider when assessing the impact of loneliness on stress reactivity is whether the stressor involves social evaluation. In a meta-analysis of physiological response to stress-inducing tasks within the laboratory Dickerson & Kemeny (2004) identified that a social evaluation context is essential to activate the HPA axis. Thus, it is important in loneliness studies that examine HPA stress reactivity that the stress-inducing task is perceived to involve social evaluation. They define a social evaluation context as one in which an important aspect of the self could be negatively judged by others. They found larger increases in cortisol when tasks had social evaluation components, such as 1) the presence of an evaluative audience, 2) the presence of a negative social comparison, or 3) video recording or audio-recording of the performance; although real-time evaluation created the greatest increases in cortisol. Dickerson and Kemeny (2004) suggest that HPA is activated by the social self-preservation system when a person perceives threats to their social self-esteem or status.

The characteristics of lonely individuals make them more likely to perceive increased threats to their social self in social contexts and they may interpret increased social evaluation in stress challenge tasks that involve a perception of social evaluation. It is important to explore cortisol response to stressors that involve social evaluation, such as public speaking and compare the cortisol response between lonely and non-lonely people. What is also missing from the existing literature is an examination of cortisol stress response in a real life context. Such an examination would offer ecological validity for Cacioppo and Hawkley's (2009) theoretical model of loneliness and health.

### *3) Studies to examine hypervigilance to social threat hypothesis(HSTH)*

HSTH has been evidenced in lonely adults in laboratory studies using three different methodologies: 1) self-reporting, 2) cognitive tasks, and 3) eye tracker studies. First, a number of laboratory studies have been conducted where researchers place participants in pairs to hold a conversation and are asked to rate themselves and

their conversational partners' behaviour. When placed in both unacquainted dyads and friendship pairs, lonely adults rate their own performance more negatively, expect others to rate them more negatively, and make negative global conclusions about their own relationships than their non-lonely peers (Duck, Pond, & Leatham, 1994; Jones, Sansone, & Helm, 1983). Although, these studies do not directly measure a perception of social threat, they do demonstrate that lonely adults are more focused on the negative information in social interaction which indicates HSTH.

Second, cognitive tasks have also been used to examine HSTH in lonely people. These measure speed to respond to a threat stimuli or neutral stimuli. To date, only the Emotional Stroop Task has been used to investigate HSTH in lonely people; no other tasks have been used. Using the emotional Stroop task, Shintel, Nusbaum, and Cacioppo (2006) found that lonely people had a slower reaction time to respond to negative social words (i.e. social threats) than non-lonely people, indicating that lonely people were experiencing anxiety in relation to the threat word. However, emotional Stroop tasks have been criticised as invalid methodology to measure HSTH as the participant is required to make a response involving the social threat stimuli. A slowed reaction time to a social threat could be due to inhibition of response rather than selective attention (Algom, Chajut, & Lev, 2004; Fox, 2004; MacLeod et al., 1986). It may be that the initial allocation of attention is equivalent to threat and non-threat information, but that in the later stage of processing, when the participant has to state the colour-name, greater cognitive resources are required in the case of threat-related words to suppress the response of reading the word. This criticism highlights the importance of not relying on one task to assess attentional deployment.

Recently, eye tracker studies using videotaped footage of real social scenes and photographs depicting social rejection have demonstrated that lonely adults are more likely to fixate first on socially threatening stimuli than non-lonely for the first two seconds, following this, lonely adults display the same avoidant viewing of social threatening stimuli as non-lonely adults (Bangee, Harris, Bridges, Rotenberg, & Qualter, under review; Bangee, under preparation). In comparison, eye tracker studies using pictures of people displaying different emotions have found no differences in eye fixations between lonely and non-lonely people (Bangee et al., under review). The results of these eye tracker studies indicate that even when social anxiety is statistically controlled for lonely people display initial vigilance to socially

threatening stimuli followed by avoidance; a typical pattern displayed in anxiety research known as the hypervigilance-avoidance hypothesis (Mogg, Philippot, & Bradley, 2004). However, this pattern of attention is only found for socially threatening stimuli situated in a social context (or that which displays social rejection) rather than faces depicting threatening expressions. This indicates that may not be a generalised hypervigilance to social threat as Cacioppo and Hawley's (2009) model proposes but that HSTH in lonely people may be context-specific. It is important that studies that examine HSTH explore socially threatening stimuli that is in a social context is not present.

An important criticism that can be made with the HSTH and loneliness research to date is that it is all studies have been situated within a laboratory context (Bangee et al., under review; Bangee, under preparation; Shintel et al., 2006). It would also be important to examine HSTH within a real life context to offer ecological validity to Cacioppo and Hawley's (2009) model.

#### *4) Studies examining cognitive biases*

Cacioppo and Hawley (2009) argue that HSTH would lead lonely adults to attend to negative social information more and remember more negative social events than non-lonely, and behave in a way that would limit social contact, for example, by withdrawing from social contexts. There are a number of studies that have examined cognitive biases in lonely adults but the evidence for behavioural biases in social interaction is very limited. Currently, only two studies have examined real-world social interactions in lonely people, and found that lonely people were less attentive to their conversation partner when placed in unfamiliar dyad groupings (Jones, Freeman, & Goswick, 1981; Jones, Hobes, & Hockenbury, 1982).

Studies examining cognitive biases indicate that lonely adults process information differently to non-lonely adults. It has been demonstrated that lonely adults have a bias for recall of social events (Gardner, Pickett, Jeffries, & Knowles, 2005) and those with fewer close friends are more accurate at identifying emotional expressions and more attuned to positive and negative vocal cues (Gardner, Pickett, & Brewer, 2000). Lonely adults experience less reward from social interaction: lonely adults also show weaker activation to pleasant pictures of people than to

equally pleasant pictures of objects, whereas, non-lonely adults show a stronger activation in reward and learning brain areas to pleasant pictures of people than to objects (Hawkley et al., 2007). Diary studies show lonely adults gain less from social interaction, reporting social interactions as more negative and less satisfying than non-lonely adults (Cacioppo et al., 2000).

In addition, to these specific cognitive biases for social information, there is some evidence to suggest that there are general attention deficits and cognitive decline in lonely people. Cacioppo et al. (2000) demonstrated in a dichotic listening task that lonely people in comparison to non-lonely showed an attention deficit when voluntary attentional control conflicted with automatic attention processes. Poor emotional self-regulation has also been associated with lonely people (Hawkley et al., 2009). Those asked to imagine a lonely future (i.e. this study did not use a self-report measure for loneliness) demonstrated impairment of attention regulation on a dichotic listening task, were less able to drink a healthy but bad tasting beverage and quit sooner on a frustrating task (Baumeister, DeWall, Ciarocco & Twenge, 2005). In older adults loneliness has been linked to increased cognitive decline, such as increased dementia and Alzheimer's disease (Tilvis et al., 2004; Wilson et al., 2007) and decrease cognitive function (such as impairments on verbal fluency and memory recall tasks; Shankar, Hamer, McMunn, & Steptoe, 2013), indicating that aging processes affecting cognition are more pronounced in lonely older adults than non-lonely.

Cacioppo and Hawkley (2009) argue that HSTH directly results in cognitive biases. However, the cognitive decline/deficit displayed in lonely people is not fully explained in their model. It could be that the cognitive impairments are the result of prolonged activation of the HPA axis (proposed in Cacioppo & Hawkley's 2009 model) which has been associated with memory impairments (Lupien et al., 2005; Wolf, 2003). An alternative explanation could also be that the state of loneliness loads a person's cognitive functioning leading to general impairments on task performance and difficulties with executive functioning, such as inhibition of undesired/inappropriate task responses. Current research has yet to examine the specific mechanisms involved in reduced cognitive functioning.

### *Gaps in research literature: Loneliness and Health in adults*

The studies in this thesis examine physiological responding (HPA axis activation) and social threat evaluation in real life social challenges that involves perception of social evaluation rather than laboratory stress challenges. This is important as there is no existing literature that has examined physiological responding or HSTH in a real life context. Thus, the studies in this thesis set in a real-world context offer ecological validity for Cacioppo and Hawkley's (2009) model. Further, there is currently only one study that has examined the cortisol response to stress challenge and this used a mental stressor rather than a psychosocial stressor (Steptoe et al., 2004). It is important that a social stressor is used that involves social evaluation as this is considered essential to activate the HPA axis (Dickerson & Kemeny, 2004).

### *Research Aims of adult studies*

To address gaps in the research literature on loneliness and physical health in adults by examining physiological responses and social cognition to social stress and everyday social encounters.

### *Outline of adult studies and research populations*

Two studies were conducted to explore physiological stress responses to real life social challenges. Two real-life social situations were examined in unique populations: 1) giving a presentation to an audience for course requirements (see Study 1; outlined in Chapter 3), and 2) meeting strangers during preparation activities prior to starting an undergraduate course (see Study 2; outlined in Chapter 5). In both situations physiological response (HPA activation measured by levels of salivary cortisol), self-reported stress and arousal, and evaluation of social threat were examined in lonely and non-lonely students. These studies aimed to address the gap in the literature for evidence that examines Cacioppo and Hawkley's (2009) model in a real life context offering unique evidence for the theoretical model.

Studies 1 and 2 used unique student populations to examine the impact of loneliness on physiological and HSTH in existing real-life social challenges. Study 1

recruited undergraduate psychology students from a partner college (a Further Education College that has a partnership with the university to deliver the first year of undergraduate psychology). Participants were recruited from a pool of students who were taking part in an oral presentation as part of their typical classroom activities. Students were recruited over a two year period and from two academic years.

Study 2 recruited from a pool of new undergraduates across the university taking part in a 3-day orientation to university scheme - “Flying Start” which took place during August. To ensure consistency of experience for all participants (as programme delivery changes each year based on student feedback and internal/external university time and economic constraints) recruitment only took place during one year period. The “Flying Start” scheme aims to prepare students for university life and students stay in university accommodation for 3 days and take part in a range of group ice breaker sessions, lecture sessions and social activities. Students on the programme were from all departments across the university, so the sample was recruited from all university subject divisions.

## Chapter 3: Study 1 – Physiological Stress Response to Presenting to an Audience in Lonely Adults

### Introduction

This chapter outlines one of two studies in this thesis that examine differences between lonely and non-lonely adults' hypothalamic-pituitary-adrenal (HPA) axis response to a stressor in a real life context. There is only one study to date that has examined HPA axis response to a stress challenge amongst lonely people and this used a mental (not a social) stressor in a laboratory context (Steptoe, Owen, Kunz-Ebrecht, & Bryon, 2004). The study in this chapter addresses the limitation of that earlier study and uses a social stressor that involves social evaluation, which has been suggested to be essential to activate the HPA axis (Dickerson & Kemeny, 2004). The current study is the first to offer ecological validity for Cacioppo and Hawkley's (2009) model by using a real life social stressor in a natural context rather than in a laboratory. This chapter outlines the first study within this thesis that uses a real life social context where raised HPA axis response would be expected: presenting to an audience. The next chapter (Chapter 4, Study 2) will outline another real life context: meeting strangers.

### *Cacioppo and Hawkley's (2009) model of loneliness and health*

The current theoretical model proposed by Cacioppo and Hawkley (2009) for loneliness and health (outlined in Chapter 2) suggests that loneliness leads to a hypervigilance for social threat (HSTH) which in turn results in increased activation of threat surveillance mechanisms (such as the HPA axis). They propose that chronic activation of physiological mechanisms results in poor health. The evidence for Cacioppo and Hawkley's (2009) model was outlined in Chapter 2. Although there is evidence to support an atypical cortisol diurnal rhythm in lonely adults, indicating HPA axis dysfunction, there is limited evidence of the heightened HPA axis activation in lonely people in response to a stressor. Based on Cacioppo and Hawkley's (2009) model, it would be expected that lonely adults would have an increased HPA axis response to social stress, as lonely people have an increased perception of social threat due to their HSTH. Therefore, it would be expected that in a

real life, naturally occurring social context lonely people would have a heightened HPA axis stress response, but also at the same time evidence HSTH. Currently to date, no studies have examined HSTH and HPA axis activation simultaneously. This chapter focuses on the first of two studies in this thesis (see Chapter 5 for the second study: Study 3) that have examined both the HPA axis response to stress and HSTH in lonely adults in comparison to non-lonely in a real life context involving a social stressor.

### *Evidence for HPA axis stress reactivity in lonely adults*

As Cacioppo and Hawkley (2009) have suggested that loneliness results in HSTH it would be expected that lonely people would find a social context more stressful and have an increased stress response to social challenges (only the HPA axis is mentioned in Cacioppo & Hawkley's, 2009 model). Within the loneliness literature there are currently only two studies that examine the physiological response to stressors. One of these studies only measures the autonomic nervous system (ANS), measuring heart rate (Cacioppo et al., 2000) and the other examines both ANS and HPA axis activation (Steptoe et al., 2004). Cacioppo et al. (2000) found that in response to social, non-social, and mental stressors lonely people had lower heart rate reactivity than non-lonely people, indicating a passivity of coping. The HPA axis is implicated as the only functional mechanism in Cacioppo and Hawkley's (2009) model, so evidence for this model should examine the HPA axis stress response. Steptoe et al. (2004) induced mental stress in the laboratory using a colour word interference task and a mirror tracing task and found cortisol responses to the stressor tasks were small and not related to loneliness, but importantly a social stressor was not used. Hence, Steptoe et al.'s (2004) results are limited as they did not use a social task which is important because the HPA axis stress response has a specific role in social stress (Blascovich, Vanman, Mendes, & Dickerson, 2011; Dickerson & Kemeny, 2010).

In a meta-analysis of physiological response to stress-inducing tasks within the laboratory Dickerson and Kemeny (2004) identify that a social evaluation context is essential to activate the HPA axis. Dickerson and Kemeny (2004) suggest that HPA axis is activated by the social self-preservation system when a person perceives threats to their social self-esteem or status. It is important then when examining

differences between lonely and non-lonely adults' response to stressors that a stressor is used that involves social evaluation as this is considered necessary to active the HPA axis (Dickerson & Kemeny, 2004). Further, it would be important to examine HPA axis stress response, as this is implicated in Cacioppo and Hawkley's (2009) model as a functional mechanism linking HSTH in lonely people to the poor health reported in this group. What is also missing from the existing literature is an examination of cortisol stress response in a real life social context because all studies to date have been carried out in a laboratory. Such an examination would offer ecological validity for Cacioppo and Hawkley's (2009) theoretical model of loneliness and health.

#### *Evidence for hypervigilance to social threat in lonely adults*

Cacioppo and Hawley (2009) propose that loneliness leads to a HSTH. If lonely people have generalised HSTH evidence would be found not only in a laboratory context, but also in real life contexts. There are limited studies to support the evidence of the HSTH (see Chapter 2). Where researchers have placed participants in unacquainted dyads and friendship pairs in a laboratory and asked them to rate their interaction following conversations, lonely adults rate their own performance more negatively, expect others to rate them more negatively, and make negative global conclusions about their own relationships (Duck, Pond, & Leatham, 1994; Jones, Sansone, & Helm, 1983). In addition, lonely adults are slower to respond to negative social words (i.e. social threats) than non-lonely adults (Shintel, Nusbaum, & Cacioppo, 2006). The slower reaction time in lonely adults indicates anxiety in relation to the threat word.

Finally, eye tracker studies have demonstrated that lonely adults display a hypervigilance-avoidance pattern (Mogg, Philippot, & Bradley, 2004) when viewing actual video footage of social rejection stimuli, which involves an initial fixation on socially rejecting information and then an avoidance of the stimuli (Bangee, Harris, Bridges, Rotenberg, & Qualter, under review; Bangee, under preparation).

All the existing studies examining HSTH in lonely adults have been conducted in a laboratory; to further advance research knowledge in this field it is important to examine the HSTH in a real life social context.

### *HPA axis response to public speaking*

The presence of a stress response involving the HPA axis in relation to public speaking tasks is well-established (Al'absi et al., 1997). Even the use of a virtual audience in public speaking tasks elicits a HPA axis stress response (Kelly, Matheson, Martinez, Merali, & Anisman, 2007). In a laboratory public speaking tasks result in higher increases in cortisol levels than typical mental stressors, such as mental arithmetic tasks (Al'absi et al., 1997). Kirschbaum, Pirke, and Hellhammer (1993) have developed a protocol for eliciting psychobiological stress in the laboratory, which involves a public speaking task (mock job interview): the Trier Social Stress Test (TSST). The TSST reliably increases cortisol 20 minutes following the public speaking and mental arithmetic tasks involved, reducing to baseline levels (i.e. cortisol levels prior to the task) up to one hour later (Hellhammer & Schuber, 2012). In their meta-analysis of stress studies, Dickerson and Kemeny (2004) implicate public speaking tasks as sufficiently stressful to elicit a HPA axis stress response. They conclude that public speaking raises cortisol levels because it involves social evaluation which is important to activate the HPA axis.

There are few studies that have examined the HPA axis stress response using public speaking in real life situations. Researchers have found that oral examinations (Schoofs, Hartmann, & Wolf, 2008) and lecturing (Filaire et al., 2011) increase cortisol levels. Public speaking in everyday life appears to increase cortisol levels similar to responses in the laboratory.

### *The current study*

The current study is the first to address the gaps in existing literature on loneliness and HPA functioning by examining both HPA stress reactivity and HSTH to a social stressor in a real life context. Participants in the current study took part in classroom activities that required them to present to the rest of their class, including peers and teachers. This real life, naturally occurring, context was used as a psychosocial stressor in this study. Participants' HPA reactivity to stress was measured using levels of cortisol in saliva samples and their perceptions of social threat were measured using self-reports.

## Method

### *Participants and Procedure*

Participants (N = 40) were recruited over two academic years (2010-11 and 2012-13) from a pool of first year undergraduates completing the first year of a psychology degree at a partner college (further education college that partners with the university to deliver some of the undergraduate degree in-house). Participants were aged between 18-30 years (mean = 19.79 years) and 63% were female. Participants were already taking part in a classroom activity as part of their course requirements that involved giving a presentation about a specific topic in Developmental Psychology in groups of 3-4 to the rest of their peers and tutor. In both academic years the presentation took place in March/April and students would have been in their class groups (2 classes of approximately 12-14 students in each academic year) since the October of the previous year. The presentation was a classroom learning activity and students were not assessed or graded on their participation.

Participants were recruited for the current study during a classroom session a few weeks before the presentations were due to take place. Prior to the start of the study participants were asked to complete a confidential medical screening questionnaire and were excluded from the study if they (i) had active infections, jaundice within the last year, hepatitis, haemophilia or were HIV antibody positive, (ii) had any history of neurological or psychiatric illness, (iii) awoke earlier than 6:30 am or later than 8 am to reduce the impact of cortisol diurnal patterns (Edwards, Clow, Evans, & Hucklebridge, 2001), and (iv) were taking medication known to effect cortisol levels, such as anti-depressants (Kirschbaum Wolf, May, Wippich & Hellhammer, 1996). Participants also completed a questionnaire prior to the testing sessions which included measures of loneliness, depression, and questions about demographic information. Participants were screened for depression using CES-D (Radloff, 1977) and seven were removed from the data set as they had clinical levels of depression symptoms (using a score 27 as a clinical cut off: Boyd, Wiessman, Thompson, & Myers, 1982; Haringsma, Engels, Beekman, & Spinhoven, 2004; Zich, Attkisson, & Greenfield, 1990). All participants gave written consent and were tested in accordance with the national and local ethics guidelines according to the

Declaration of Helsinki. These data for the remaining 33 participants were used in all the analyses.

Cortisol levels, arousal, and stress were collected on the day that students did the presentations to their peers and tutors (day 1) and a day that the students did usual classroom activities (day 2). Measures were taken at each time point immediately before the presentation (time 1), immediately after the presentation (time 2), and 20 minutes after the presentation. On day 2, when participants were involved in usual classroom activities, data were collected at the same times on same day of week as day 1. Half of the participants (year group 2011-12) completed the classroom presentation a couple of weeks before the control day (usual classroom activities) and half the participants (year group 2012-13) completed the classroom presentation a couple of weeks after the control day (i.e. half did the control day first and the other half of participants did the presentation day first).

### *Measures*

*Loneliness.* This was measured using the R-UCLA loneliness scale (Russell et al., 1980). This scale is considered to be a reliable measure (Hartshorne, 1993; Knight, Chisholm, Marsh, & Godfrey, 1988; Russell, 1996). Participants were asked to respond to statements about how they usually feel. Examples of statements were “I feel in tune with the people around me” and “I lack companionship”. Each of the 20 statements are rated on a scale of 1 (never), 2 (rarely), 3 (sometimes), and 4 (often). After reverse scoring some of the statements, loneliness scores are calculated by summing all statements. Possible scores range from 20 to 80, with higher scores signifying greater loneliness. Cronbach’s alpha was .91 in this sample.

*Depression.* The Centre for Epidemiologic Studies Depression Scale (CES-D, Radloff, 1977) was used. The CES-D is a self-report measure used to check for the presence and persistence of depression symptoms. In this study the CES-D was used to screen participants for clinical levels of depression (Boyd et al., 1982; Haringsma et al., 2004; Zich et al., 1990). The questionnaire contains 20 statements (16 negative and 4 positive) which describe a state of mind. For example, ‘*I was bothered by things that usually don’t bother me*’ and ‘*I felt fearful*’. Participant read each statement and then considered how many days over the last week they could agree

with statement, circling their responses on a 4-point Likert scale from 1 = rarely (less than one day) through to 4 = most of the time (5-7 days). Positive statement responses are reverse scored. Overall, a higher score is indicative of a high presence of depressive symptoms, with a possible range of scores of between 0-60. Cronbach's alpha was .92 in the current sample.

*Self-reported stress.* The stress subscale of the Stress and Arousal checklist (SACL; Mackay, Cox, Burrows, et al., 1978) was used. The stress subscale uses 19 positive and negative adjective mood-related words, such as 'Worried' or 'Peaceful.' Participants are required to select the word which best describes their current state from the options: 'Definitely Feel', 'Slightly Feel', 'Cannot Decide' and 'Definitely Do Not Feel'. A score of 1 is given when a person selects 'Definitely Feel' or 'Slightly Feel' for positive adjectives and 'Cannot Decide' or 'Definitely Do Not Feel' for negative adjective options are selected. A zero score is given to all other selections. The maximum score on the stress scale is 19. A higher score represents higher subjective feelings of stress. Cronbach's alpha for the stress sub-scale was an average of .70 on day one (time 1 = .90, time 2 = .83, and time 3 = .38) and .90 on day two (time 1 = .91, time 2 = .88, and time 3 = .92).

*Perception of Social Threat.* The perception of social threat scale used was made up from number of sub-scales: participation anxiety (anxiety about taking part in the session and meeting people), evaluation anxiety (anxiety about being evaluated by others and likelihood of being evaluated negatively), and friendship formation anxiety (likelihood of making positive friendships within the group). This scale was designed by the author of this thesis. Only the evaluation anxiety and friendship formation sub-scales were used in the current study because participation anxiety was not relevant to the research aims as participants had been in their class group for a long period. *Evaluation anxiety:* This was measured by responses to two questions using rating scale from 1 to 7 "how anxious do you feel about how other people in the group may perceive your participation in the session?" rated on the scale of 1 (not anxious at all) to 7 (extremely anxious) and "how likely do you think other people in the group may perceive your performance positively" rated on the scale of 1 (not very likely) to 7 (very likely). This later question was reverse coded. *Friendship formation:* This comprised the question "how much do you think that your

participation in the session today will have a positive effect on your friendships in the group". This was rated on a scale of 1 (negative effect) to 7 (positive effect). The friendship formation sub-scale was reversed scored. Cronbach's alphas were not calculated as evaluation anxiety is a two item measure and friendship formation is a single item measure.

*Saliva assaying.* Saliva samples were obtained using a salivette (saliva sampling device, Sarstedt Ltd, Leicester, UK). Participants were instructed to give unstimulated saliva samples by placing a salivette under their tongue for at least 2 minutes. All samples were taken between 10am – 12pm. Ideally, testing would have taken place between 2-5pm to take advantage of cortisol's diurnal plateau (Smyth et al. 1997) this was not possible due to the timetabling constraints of the college. As cortisol levels were expected to rise in response to the stressor (public speaking) and statistical analysis involved stress reactivity (increases in cortisol levels based on the stressor, rather than measurements of the mean or volume of cortisol) morning sampling was considered viable (Kudielka, Schommer, Hellhammer, & Kirschbaum, 2004). To avoid fluctuations in cortisol due to consumption of food or drink (Gonzalez-Bono, Rohler, Hellhammer, Salvador, & Kirschbaum, 2002) and smoking (Kirschbaum, Wüst, & Strasburger, 1992) participants were asked to refrain from smoking, eating, or drinking during the testing session (with the exception of drinking water) until the final cortisol sample has been taken.

Samples were stored at -20°C and were recovered by thawing the salivette at room temperature for 15 minutes, then centrifuging (1500 rpm) for 15 minutes. Cortisol concentration (nmol/l) in the saliva was then determined by a high sensitivity salivary cortisol enzyme-linked immunosorbant assay kit (Salimetrics, USA) as the manufacturer's instructions using the Perkin Elmer JANUS automated liquid handling system. Intra-assay variation was acceptable with a coefficient of variation of less than 10%. Any cortisol samples that were 3 standard deviations from mean were removed from all analyses. This resulted in removal of one sample on day one time 3 (from the data set of 33 participants). All other samples from participants remain in the analyses.

### *Data analysis plan*

First, each of the measures (cortisol and stress) was examined using factorial ANOVAs for each time point (1 = before the activity, 2 = immediately following the activity, and 3 = 20 minutes following the activity). Second, perception of social threat and each of the sub-scales (evaluation anxiety and friendship formation anxiety) between each day were compared using factorial ANOVAs. Alpha was adjusted for all post hoc comparisons (based on number of comparisons) using the Bonferroni's correction.

### Results

Participants were grouped into high and low lonely groups based on their scores on the R-UCLA loneliness scale (Russell, Peplau, & Cutrona, 1980). A mean split was used to group participants, the low lonely group scored below 35 (N =16, F = 13) and the high lonely group scored 40 and above (N =17, F = 8). The age range for the low lonely group was 18-29 years old, with a mean age of 19.70 years (SD = 2.62). The age range for the high lonely group was 18-30 years old, with a mean age of 19.87 years (SD = 2.87).

### *Cortisol*

Gender differences have been identified in cortisol stress reactivity studies (Kajantie & Phillips, 2006; Kudielka & Kirschbaum, 2005), so a repeated measures ANOVA (time x day x gender) was used to examine gender difference and determine whether it was necessary to control for gender. As there was not a significant main effect of gender ( $F(1,16) = 0.07, p = .790, \eta^2 = < .01$ ) or a significant day x gender interaction ( $F(1,16) = 0.28, p = .61, \eta^2 = .02$ ) or time x gender interaction ( $F(2,32) = 2.53, p = .095, \eta^2 = .14$ ), gender was not controlled for in further analysis.

A 3 x (Time: Time 1, Time 2, and Time 3) x 2 (Day: Day 1 – presentation and Day 2 – control) x 2 (Lonely group: high and low lonely) mixed ANOVA was used to examine cortisol level. There was not a significant main effect of day ( $F(1,16) = 0.27, p = .611, \eta^2 = .02$ ) on cortisol levels. There was a significant main effect of time ( $F(2,32) = 4.34, p = .022, \eta^2 = .21$ ) on cortisol levels. To examine the

main effect of time cortisol was averaged over the two days for each time point. Paired t-tests revealed that cortisol levels at time 1 were significantly higher than time 2 ( $t(20) = 2.28, p = .017, \text{one-tailed}$ )<sup>1</sup> and time 3 ( $t(21) = 3.13, p < .001, \text{one-tailed}$ ), but there was no significant difference between cortisol levels at time 2 and time 3 ( $t(20) 0.37, p = .356, \text{one-tailed}$ ). There were no differences between the days, so these results do not depict the typical stress response of an increased cortisol level immediately after the stressor (i.e. cortisol peaking at time 2, Kudielka et al., 2004). Thus, the oral presentation has not elicited a HPA axis stress response. The results do, however, demonstrate cortisol levels reduced over the testing period (see Figure 3.1). Given that the cortisol samples were taken in the morning (between 10-12 noon), the results may reflect typical circadian decreases (King & Hegadoren, 2002).

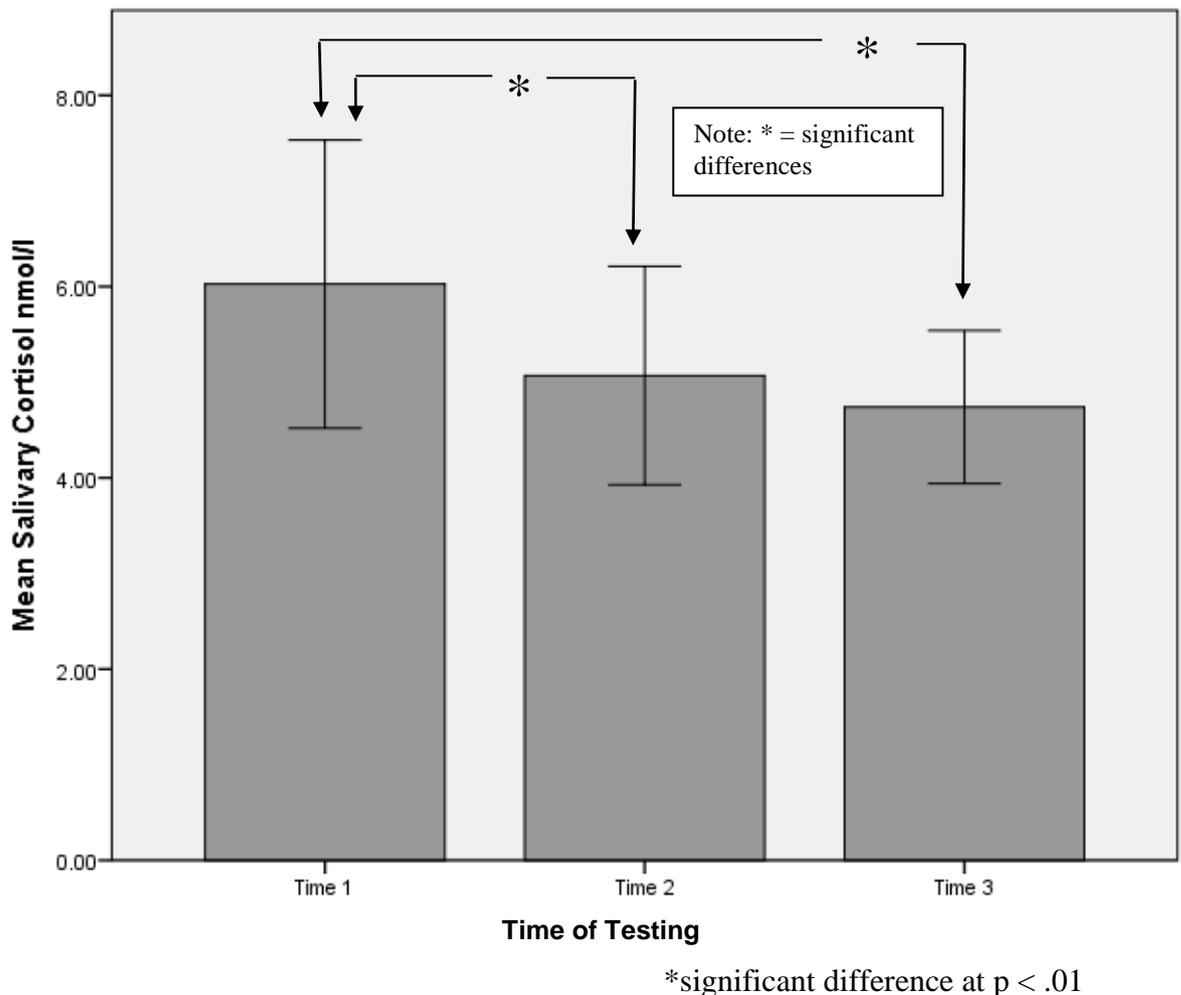


Figure 3.1 Cortisol levels averaged across the two days at each time point (with error bars at 95% CI)

<sup>1</sup> Bonferroni's correction was applied and alpha was adjusted to  $p < .01$  (i.e.  $\alpha/3 = 0.01$ )

There was not a significant main effect of loneliness group ( $F(1,32) = 2.83$ ,  $p = .112$ ,  $\eta p^2 = .15$ ), but there was a trend for a significant interaction between time and lonely group ( $F(2,32) = 2.48$ ,  $p = .099$ ,  $\eta p^2 = .13$ )<sup>2</sup>. There was a trend for a significant interaction between time and lonely group and predictions based on research literature on loneliness predict increased cortisol levels in the high lonely group, so priori tests were carried out to examine cortisol levels at each time point by lonely group. Although there were no significant differences between the lonely groups at each time point, there were different patterns of cortisol response between the lonely groups across the day. The high lonely group had a higher cortisol levels at time 1 than time 2 ( $t(10) = 2.04$ ,  $p = .034$ , one-tailed) and time 3 ( $t(9) = 2.98$ ,  $p < .001$ , one-tailed); cortisol levels were not significantly different at time 2 and time 3 ( $t(9) = 1.13$ ,  $p = .145$ ). In comparison, for the low lonely group there were no significant differences between the time points.

Figure 3.2 displays the cortisol levels by loneliness group at each time point (averaged across days). As the cortisol samples were taken in the morning (between 10-12 noon), the results may also be indicative of a higher morning cortisol level in the high lonely group which has been noted in previous research (Doane & Adam, 2010; Steptoe et al., 2004).

### *Self-reported Stress*

A 3 (Time: Time 1, Time 2, and Time 3) x 2 (Day: Day 1 – presentation and Day 2 – control) x 2 (Lonely group: high and low lonely) mixed ANOVA was used to examine self-reported stress levels. There was no significant main effect of day ( $F(1,20) = 0.70$ ,  $p = .414$ ,  $\eta p^2 = .03$ ) on perceived stress, indicating that the mean levels of self-reported stress were not significantly different between the two days. There was a significant main effect of time ( $F(2,40) = 14.85$ ,  $p < .001$ ,  $\eta p^2 = .43$ ) on perceived stress and a significant interaction between time and day ( $F(2,40) = 21.47$ ,  $p < .001$ ,  $\eta p^2 = .52$ ). The interaction effect between time and day is represented in Figure 3.3.

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<sup>2</sup> No other interactions were significant

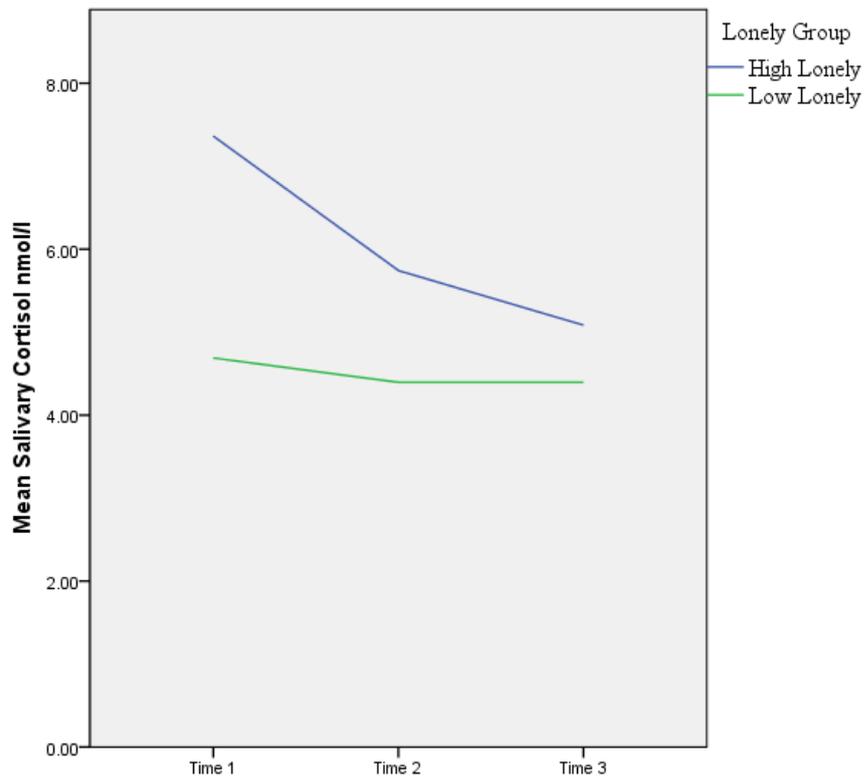


Figure 3.2 Cortisol levels averaged across days by lonely group

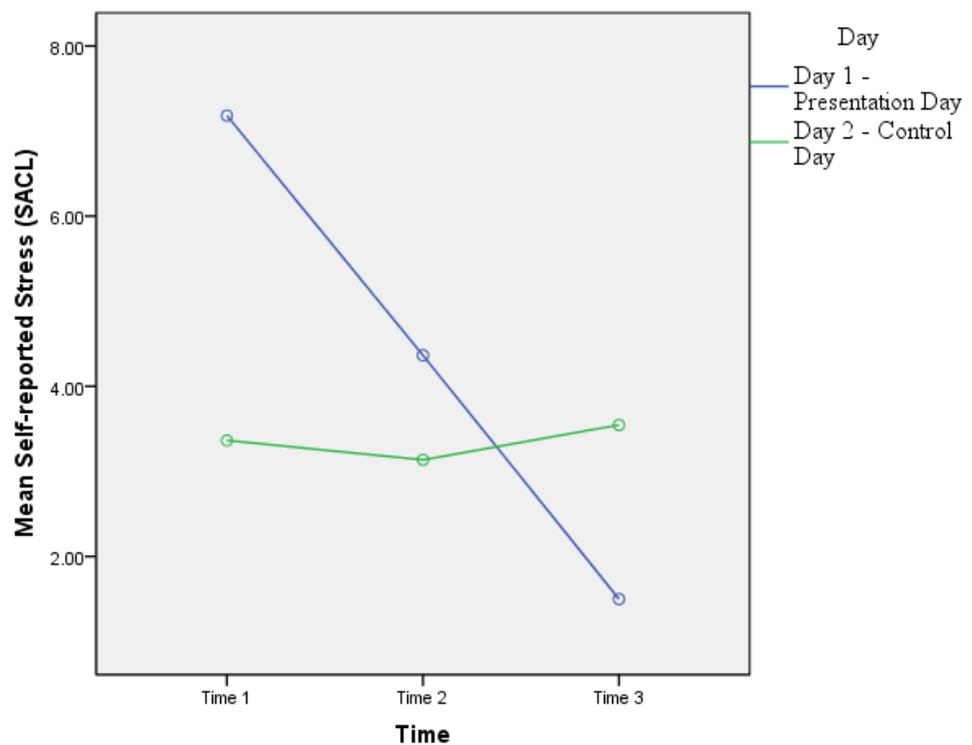


Figure 3.3 Mean stress-reported stress for all participants at each time point for day 1 and 2

Post hoc tests using paired samples t-tests revealed that on day 1 self-reported stress at time 1 was significantly higher than at time 3 ( $t(31) = 6.43, p = < .001$ , one-tailed)<sup>3</sup>, but no higher at time 1 than at time 2 ( $t(31) = 2.47, p = .019$ , one-tailed). Self-reported stress was significantly higher at time 2 than time 3 ( $t(30) = 3.91, p = < .001$ , one-tailed). In comparison, on day 2 there was no significant difference between self-reported stress at each of the time points, indicating that self-reported stress remains low and stable throughout the testing period.

When self-reported stress levels between day 1 and day 2 are compared at each time point, for time 1 there was a trend towards significance for higher perceived stress on day 1 ( $t(26) = 2.47, p = .009$ , one-tailed). At time 2 there was no significant difference between day 1 and day 2 ( $t(29) = 1.05, p = .150$ , one-tailed). At time 3 there was no significant difference between day 1 and day 2 ( $t(28) = 2.19, p = .019$ , one-tailed). These results indicate that there are different patterns of self-reported stress on day 1 and day 2. On the day of the oral presentation, before the presentation, participants stress levels are higher than on day two and their stress levels reduce after the presentation.

There was a significant main effect of lonely group ( $F(1,20) = 9.73, p = .005, \eta p^2 = .33$ ) and an examination of means revealed that the high lonely group report higher levels of stress (mean = 5.56, SD = 0.75) than the low lonely group (mean = 2.42, SD = 0.68). There was a significant interaction between lonely group and time ( $F(2,40) = 6.97, p = .003, \eta p^2 = .26$ ) and lonely group, time, and day ( $F(2,40) = 6.64, p = .003, \eta p^2 = .25$ ), but not lonely group and day. These interaction effects for the loneliness groups are displayed in Figure 3.4 (high lonely group) and 3.5 (low lonely group). To avoid making a type II error (due to reduction of alpha level for multiple comparisons, i.e. 24 would be needed), tests for this interaction were reduced (following guidelines by Wilkinson and the task force on statistical inference, 1999). As there was no day x lonely group interaction and the main effect of lonely group indicated that the high lonely group report higher level of stress on both days, day comparisons between the groups were not made. A priori comparisons were made to examine the patterns of perceived stress for each lonely group by each day.<sup>4</sup>

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<sup>3</sup> Alpha was adjusted to  $p < .004$ , i.e.  $\alpha/12 = .004$  using the Bonferroni correction

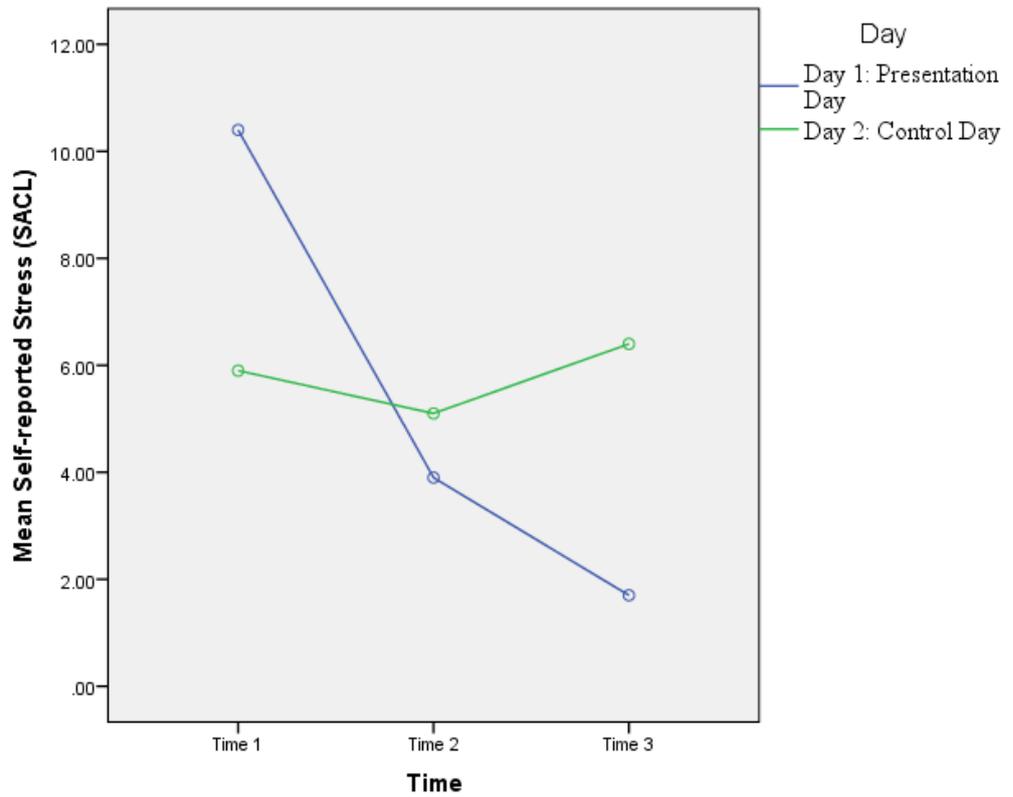


Figure 3.4 Mean stress-reported stress for the high lonely group by at each time point for day 1 and 2

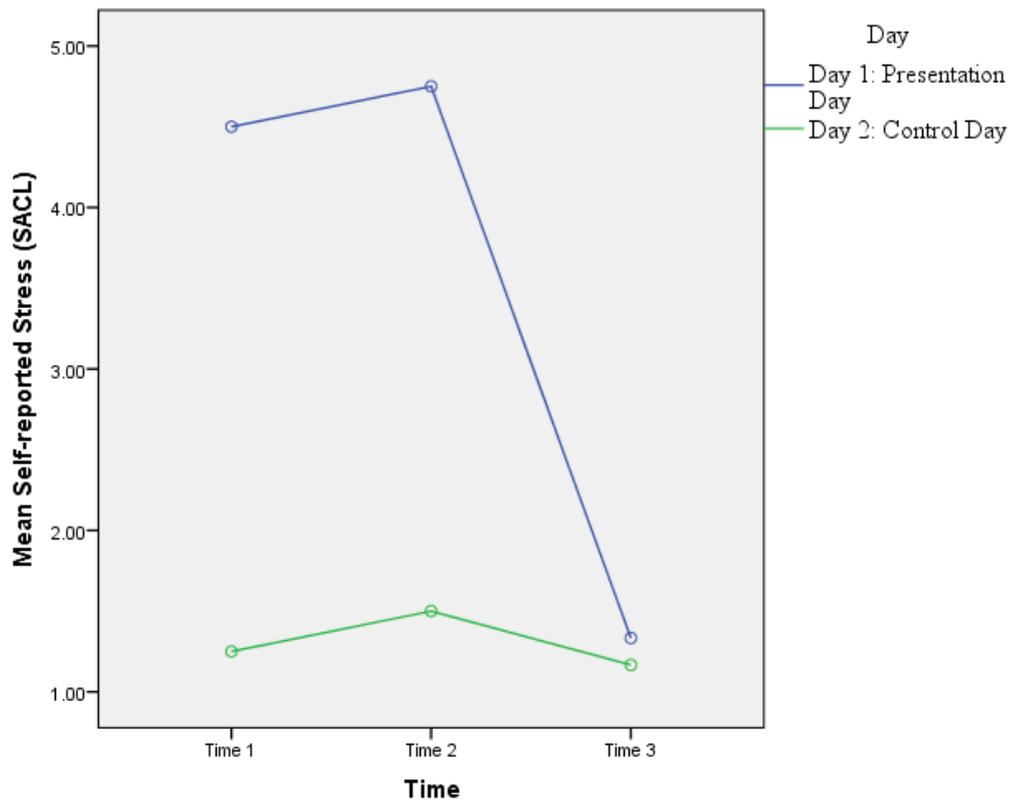


Figure 3.5 Mean stress-reported stress for the low lonely group by at each time point for day 1 and 2

First, for the high lonely group post hoc tests (using paired samples t-tests) revealed that on day 1 perceived stress levels at time 1 were not significantly higher than at time 2 ( $t(15) = 2.06, p = .028$ , one-tailed). Perceived stress was higher at time 1 than at time 3 ( $t(15) = 5.28, p < .001$ , one-tailed) and also higher at time 2 than at time 3 ( $t(14) 3.22, p = .003$ ). This pattern indicates that the high lonely group have increased levels of self-reported stress that reduce after the presentation.

Second, for the low lonely group post hoc tests (using paired samples t-tests) reveal that on day 1 this group do not report significantly different stress levels at time 1 than at time 2 ( $t(15) = 1.39, p = .092$ , one-tailed). They do not report higher perceived stress levels at time 2 than at time 3 ( $t(15) = 2.29, p = .019$ , one-tailed). But perceived stress is higher at time 1 than at time 3 ( $t(15) 3.72, p = .001$ ). This pattern indicates that for the low lonely group self-reported stress does not decrease until 20 minutes after the presentation.

In comparison, on day 2 (when participants were doing typical classroom activities), perceived stress was not significantly different between the lonely groups at each of the time points and remained similar throughout the testing period for both high and low lonely groups.

#### *Perception of social threat*

Anxiety about being evaluated by others (evaluation anxiety) and anxiety about forming friendships (friendship formation anxiety) were compared for each day and by lonely group.

#### *Evaluation Anxiety*

Mean evaluation anxiety for each day and by lonely group is displayed in Table 3.1.

Table 3.1 Mean evaluation anxiety by loneliness group for each day (and standard deviations)

	Day 1	Day 2	Total
High Lonely	10.00 (0.51)	9.50 (0.41)	9.75 (0.40)
Low Lonely	9.90 (0.53)	8.27 (0.42)	9.09 (0.42)
Total	9.95 (0.37)	8.89 (0.30)	

A 2 (Day: day 1 and day 2) x 2 (Lonely group: low and high lonely) mixed ANOVA revealed a main effect of day ( $F(1, 21) = 10.67, p = .004, \eta p^2 = .34$ ) on evaluation anxiety. An examination of the means for evaluation anxiety on each day (see Table 3.1) show that evaluation anxiety for all participants was higher on day 1 when participants were doing the classroom presentation. There was not a significant main effect of lonely group ( $F(1,21) = 1.27, p = .272, \eta p^2 = .06$ ) or a significant interaction between day and lonely group ( $F(1,21) = 3.02, p = .097, \eta p^2 = .12$ ).

#### *Friendship Formation Anxiety*

Mean evaluation anxiety for each day and by lonely group is displayed in Table 3.2.

Table 3.2 Mean friendship formation anxiety by loneliness group for each day (and standard deviations)

	Day 1	Day 2	Total
High Lonely	3.19 (0.26)	4.00 (0.27)	3.59 (0.20)
Low Lonely	2.64 (0.28)	2.93 (0.30)	2.79 (0.22)
Total	2.91 (0.19)	4.00 (0.28)	

A 2 (Day: day 1 and day 2) x 2 (Lonely group: low and high lonely ) mixed ANOVA revealed a significant main effect of day ( $F(1,28) = 4.52, p = .042, \eta p^2 = .14$ ) on friendship formation anxiety. An examination of means in Table 3.2 reveals that participants experienced higher levels of anxiety about forming friendships on the day that they were completing their typical classroom activities than the day they doing the oral presentation. There was also a significant main effect of loneliness group ( $F(1,28) = 7.39, p = .011, \eta p^2 = .21$ ) on friendship formation anxiety. An examination of means (see Table 3.2) reveals that the high lonely group had higher levels of anxiety about friendship formation than the low lonely group. There was not a significant interaction between day and loneliness group ( $F(1,28) = 1.05, p = .314, \eta p^2 = .04$ ).

## Discussion

The aim of the current study was to examine Cacioppo and Hawkley's (2009) model for loneliness and health. They propose that lonely people experience a HSTH in social situations that leads to an increased activation of the HPA axis. Currently, to date, this has not been examined in a real life social context, so the current study aimed to offer ecological validity for this theoretical model, by examining the HPA axis response to a socially stressful real life scenario (public speaking) and HSTH. It was expected that there would be higher levels of HSTH and an increased HPA stress response to public speaking in people experiencing high levels of loneliness in comparison to those experiencing low levels of loneliness.

### *Cortisol*

The results show that there is no difference in the cortisol response between the control day and the presentation day indicating that the presentation activity did not elicit a HPA axis stress response. The results demonstrate a reduction in cortisol levels over the testing period similar to typical cortisol diurnal rhythm (King & Hegadoren, 2002), indicating that the cortisol protocol was sufficiently rigorous to measure typical cortisol functioning. As public speaking has been shown to be a sufficient stressor to elicit a HPA axis stress response (Al'absi et al., 1997; Dickerson & Kemeny, 2004; Kelly et al., 2007; Kirschbaum, Pirke, & Hellhammer, 1993), it

was expected that the oral presentation in the current study would elicit a HPA axis stress response. However, the participants were not assessed on their presentations, were working in small groups rather than presenting alone, and were presenting to a small group (14-15) of other students who they had known for at least 6 months. Although, all participants reported a higher level of evaluation anxiety on the presentation day, it is possible, in the current study, that participants were not feeling evaluated by others sufficiently to have their HPA axis activated. Dickerson and Kemeny (2004) argue that in order to activate the HPA axis participants must feel social evaluation. It may also be that as participants were in small groups of 3-4 with people they knew well, they might have felt high levels of social support. Social support typically reduces cortisol elevations in stress tasks (Henrichs, Bumgartner, Kirschbaum, & Ehert, 2003; Kirschbaum, Klauer, Filipp, & Hellhammer, 1995; Unchino, Cacioppo, & Kiecolt-Glaser, 1996), and in the current study social support within the small groups could have attenuated typical cortisol raises to the stressor.

The results do not support Cacioppo and Hawkley's (2009) model that indicates that lonely people have an increased activation of the HPA axis in response to a social stressor. However, it is important to note that the social stressor in the current study (public speaking) did not elicit a stress response that activated the HPA axis, so it is more likely that the stressor itself was not sufficient to elicit a stress response. This is an unexpected result because public speaking is considered a socially relevant protocol to use in a laboratory setting to elicit a cortisol stress response (Al'absi et al., 1997). It is important to repeat this study using a public speaking exercise where participants felt they were being evaluated by others, which could be achieved by having an audience rate the performance of the speaker. The effect of social evaluation would be further enhanced by the presentation being delivered to a group of strangers. However, it would be important to use a real life situation to offer ecological validity for Cacioppo and Hawkley's (2009) model, perhaps using an assessed classroom presentation.<sup>4</sup>

There was a trend for higher levels of morning cortisol in the high lonely group on both days. This may reflect an increased cortisol awakening response in the high lonely group as testing was carried out in the morning. A higher CAR has been related to loneliness in previous studies (Doane & Adam, 2010; Steptoe et al.,

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<sup>4</sup> due to ethical restrictions within the university this was requested, but was not possible

2009). This lends support to Cacioppo and Hawkley's (2009) model for loneliness and health as it shows an atypical diurnal pattern among lonely people indicating increased HPA activation. Prolonged chronic activation of the HPA results in poor health (Buckley & Schatzberg, 2005; Dekker et al., 2008; Saplosky, 2004, also see Chapter 2), indicating that this may be a functional mechanism for the association between loneliness and poor health. It may be that the state of feeling lonely increases general activation of the HPA axis rather than increasing the stress response to social stressors in everyday life. One should be cautious about such an interpretation from the results of this study as the psychosocial stressor in the current study was not sufficient to elicit a HPA stress response. It is important to examine another social context that is sufficient to elicit a HPA stress response and compare lonely and non-lonely people's responses. The next chapter (Chapter 4) outlines Study 2 of the thesis which examined the HPA axis response when meeting strangers, which does elicit a HPA axis response (for further detail see Chapter 4).

#### *Self-reported stress*

Although there was not a physiological stress response (i.e. HPA axis response), the results indicate that there was a different pattern of self-reported stress on the day of the presentation. When perceived stress levels were averaged out across the days no differences were observed, but further analysis revealed marked differences in the pattern of stress reporting on each day. On the presentation day participants show a heightened perceived stress prior to the stressor followed by reducing levels post stressor, indicating that participants are experiencing high levels of stress in anticipation of the presentation. In comparison, on day two, when participants were doing their usual classroom activities, the self-reported stress levels remained low and stable throughout the testing period. This pattern of anticipatory stress prior to the stressor with reducing levels of perceived stress post stressor has been shown in other studies (Balodis, Wynne-Edwards, & Olmstead, 2010; Robinson, Bridges, Leach, McIntyre, & Kearsley, under review).

There was a difference in the levels of self-reported stress between the lonely groups: the high lonely group reported higher levels of stress on both days than the low lonely group. This is similar to results from other loneliness studies that have demonstrated that lonely adults report higher levels of stress in everyday life

(Hawkley, Thisted & Cacioppo, 2009; Pressman et al. 2005). This may relate to the tendency of lonely people to attribute difficulties in social relationships to others and view themselves as victims (Cacioppo et al., 2000) and to use passive coping, and behavioural disengagement in challenging social relationships (Cacioppo et al., 2000; Steptoe et al., 2004).

There were also different patterns of stress reporting between the high lonely and low lonely group dependent on the day. Both lonely groups reported higher levels of stress prior to the presentation on the day of presenting, but these reduced for the high lonely group immediately after the presentation, whereas, it is not until 20 minutes after the presentation that levels reduce for the low lonely group. This indicates that the focus of perceived stress may be different between the lonely groups. Although factors responsible for these differences cannot be fully explained with the current data, previous research indicates that lonely people are more likely to be focused on negative expectation of people's responding to their presentation (Cacioppo et al., 2000; Cacioppo & Hawkley, 2009; Steptoe et al., 2004) so stress levels may reduce immediately following the presentation when they receive some positive feedback from their teacher and/or peers. Future studies should examine self-reporting regarding the topic of stress to further outline these differences between the focus of stress for lonely and non-lonely adults.

#### *Perception of social threat*

The perception of social threat was included in the current study as a measure of HSTH. Cacioppo and Hawkley (2009) indicate that lonely people would be more sensitive to social threat and report higher levels of social threat in every day social interactions than non-lonely. In the current study participants reported on how anxious they felt about being evaluated by others (evaluation anxiety) and how confident they felt about forming friendships (friendship formation anxiety). Both evaluation anxiety and friendship formation anxiety, as key components of perceiving social threat in a social context, would be expected to be increased in a person with high levels of HSTH.

Evaluation anxiety was higher for all participants on the day that they were presenting than the day that they were doing their usual classroom activities. In comparison, friendship formation anxiety was greater for all participants on day 2

rather than day 1. As the presentation was carried out in small friendship groups it is likely that group membership was more salient on day 1 (Hogg & Terry, 2000) and buffered usual concerns about friendships in the group. Friendship formation anxiety was higher on both days in the high lonely group than the low lonely group. This indicates that lonely adults typically have higher anxiety about forming friendships than non-lonely adults and is likely to relate to their tendency to interpret social interactions negatively (Duck, Pond, & Leatham, 1994; Jones, Freemon, & Goswick, 1981; Jones, Sansone, & Heim, 1983) and blame others for difficulties in social relationships (Cacioppo et al., 2000).

As evaluation anxiety and friendship formation anxiety were increased in lonely people on typical days (i.e. when not public speaking), these results partially support Cacioppo and Hawkely's (2009) model. The findings show that lonely adults experience higher levels of HSTH (measured by perception of social threat) in everyday life, offering ecological validity for Cacioppo and Hawkley (2009)'s proposition in their model of HSTH in lonely people. However, HSTH was not increased in response to a social challenge in lonely people, it was higher in lonely adults than non-lonely adults on the day that participants were involved in their usual activities. This finding is important because it indicates that HSTH may not be specific to particular socially challenging situations, instead, lonely people may have increased levels of HSTH typically in everyday life, indicating that they are on a constant state of alert for social threat.

#### *Strengths and limitations of the current study*

An important strength of the current study is that it is the first study to offer ecological validity for Cacioppo and Hawkley's (2009) model. Although this study does not offer evidence that the HPA axis is increased in lonely people in response to a social challenge, public speaking in the current study was not sufficiently stressful to elicit a HPA axis stress response. The current study demonstrates that lonely people have an increased perception of social threat in an everyday social context supporting Cacioppo and Hawkley's (2009) proposition of a HSTH lonely people.

The levels of depression were high in the current cohort and seven participants were removed from the data set due to having clinical levels of depression. High levels of depression are typical in undergraduate populations

(Nightingale et al. under review). As loneliness has a co-morbid relationship with depression (Cacioppo, Hughes, Waite, Hawkley, & Thisted, 2006; Qualter, Brown, Munn, & Rotenberg, 2010) the removal of those with high depression also removed those with high loneliness. It would be important to replicate this study with a cohort with more normative levels of depression because depression has been associated with a blunted stress response (Burke, Davis, Otte, & Mohr, 2005); this may partly explain the lack of HPA stress response in a task that typically elicits a stress response (Al'absi, et al., 1997) in this particular cohort.

### *Conclusion and links to other chapters*

The current study did not demonstrate increased HPA stress reactivity to the social challenge of presenting to an audience in lonely adults. However, care must be taken in interpretation of these results because presenting to class peers in this study was not sufficiently stressful to elicit a HPA axis stress response that is typical when public speaking (so lonely group comparisons are not useful). Further studies using different social challenges that elicit a HPA stress response are essential to investigate the impact of loneliness on HPA stress reactivity in everyday life. The next chapter in this thesis outlines another social challenge, meeting strangers, which was sufficient to elicit the HPA stress response (see Chapter 4).

The findings of the current study show that all participants experienced anticipatory stress prior to public speaking, which reduced post stressor. Levels of perceived stress reduced quicker in those experiencing high levels of loneliness than those experiencing low levels of loneliness, indicating that the focus of anticipatory stress may be different for each of the lonely groups. Future research should examine factors that influence anticipatory stress in lonely and non-lonely adults.

The current study demonstrated increased HSTH in lonely people providing ecological validity for Cacioppo and Hawkley's (2009) theory. But, only partial support is provided: results show that HSTH is increased generally in everyday life, rather than being increased in relation to a particular social stressor. These results indicate that lonely people are on a constant state of alert for social threat in everyday life.

The next chapter in the thesis outlines the results of a similar study (Study 2) that examined HPA stress reactivity and HSTH in another real life, naturally

occurring social context; meeting strangers. The results (Study 1 and Study 2), that examined real life social contexts in relation to HPA axis stress reactivity and HSTH, are compared in Chapter 4. Finally, the two adult studies are examined in detail in relation to Cacioppo and Hawkley's (2009) model of loneliness and health in Chapter 5.

## Chapter 4 - Study 2: Physiological Stress Response to Meeting Strangers in Lonely Adults

### Introduction

This study is the second of two studies in this thesis that examine differences between lonely and non-lonely adults' hypothalamic-pituitary-adrenal (HPA) axis responding to a stressor in a real life context. Cacioppo and Hawley's (2009) model implicates a hyper-vigilance to social threat (HSTH) in lonely people that leads to increased HPA axis activation as a functional mechanism for the association between loneliness and poor health. The first study in this thesis to examine HPA axis responding and HSTH to a real life stressor (Study 1, outlined in Chapter 3) involved a group of undergraduates giving a classroom presentation to peers and tutor. Study 2 outlined in this chapter involves a group of new undergraduates meeting their peers for the first time on a university orientation programme in the summer holidays prior to starting university. The only study to date that has examined HPA axis response to a stress challenge used a mental stressor in a laboratory rather than a social stressor (Stephoe, Owen, Kunz-Ebrenct, & Bryon, 2004), so Study 1 (Chapter 3) and Study 2 (in this Chapter) of this thesis aim to address this limitation by using a social stressor. The studies also use a real life social stressor in a natural context rather than a laboratory offering ecological validity for Cacioppo and Hawley's (2009) model for loneliness and health. Based on this model (Cacioppo & Hawley, 2009) lonely people would be expected to display both an increased HPA axis stress response and higher levels of HSTH in an everyday social challenging context than non-lonely people (for a more detailed discussion of the background and rationale for these two studies see Chapter 3).

### *Summary of results from Study 1: Physiological stress response to presenting to an audience in lonely adults*

In Study 1 the classroom presentation did not elicit a HPA axis response (i.e. there was no difference between HPA axis responding on the day of the presentation in comparison to the control day where participants did typical classroom activities).

The high lonely group reported higher levels of stress on both days, indicating that the high lonely group were typically more stressed in everyday life than the low lonely group. This supports previous diary studies that have demonstrated that, although lonely people do not have more stressful events in their lives, they report these as more stressful than non-lonely (Cacioppo et al., 2000; Steptoe et al. 2004).

In addition, the high lonely group reported a different pattern of stress than the low lonely group on the day of the presentation. Although both lonely groups had higher levels of stress prior to the presentation, these levels reduced in the high lonely group immediately after the presentation, whereas, levels did not reduce in the low lonely group until 20 minutes after the presentation had finished. These results indicate that self-reported stress during the presentation activity may have a different focus for the low and high lonely groups.

The high lonely group had higher levels of anxiety about forming friendships than the low lonely group on both days. These results indicate that lonely adults experience a higher perception of social threat typically in everyday life and provide ecological validity for proposition of increased HSTH in lonely people in Cacioppo and Hawkley's (2009) model of loneliness and health.

#### *HPA stress response and meeting strangers*

Meeting new people and the associated ice breaker activities that are typical in an education environment are considered anxiety-provoking, but there are currently no studies that examine the stress response when meeting new people. As Cacioppo and Hawkley (2009) have suggested that lonely people have a HSTH, they are likely to be more sensitive to social threat when meeting new people, which is likely to bias their interaction with others and their perception of the social situation. It is also likely that, because lonely people feel a heightened sense of threat in social situations, they will find meeting new people more stressful than non-lonely people. Although it has not been empirically investigated, Cacioppo and Hawkley (2009) propose that this HSTH would lead to an increased activation of HPA axis in social interactions.

Lonely people tend to interpret their own and their social partners behaviour negatively in social encounters, they also expect others to rate them negatively (Duck, Pond, & Leatham, 1994; Jones, Freemon, & Goswick, 1981; Jones, Sansone,

& Heim, 1983). When people were paired with strangers to complete a “getting to know you exercise”, lonely people gave less self-disclosure and partner attention than non-lonely people, indicating that lonely people are more guarded when meeting new people (Jones, Hobbs, & Hockenbery, 1982; Solano, Batten, & Parish, 1982). Cacioppo and Hawkley (2009) argue that this type of negative and passive interaction from lonely people when meeting others is likely to result in repulsion and isolation from their conversational partners in social interactions and reinforce the lonely person’s negative beliefs. It is important to further research evidence in this area by measuring HSTH and HPA axis stress response when meeting people to examine, as Cacioppo and Hawkley (2009) propose that there is a heightened HPA axis stress response combined with an increased HSTH in lonely people in comparison to non-lonely when meeting new people. The current study is the first to examine the impact of loneliness on the stress response and associated HSTH when meeting new people.

#### *The current study*

The current study addresses the gaps in existing literature on loneliness and HPA functioning by examining both HPA stress reactivity and HSTH to another social stressor in a real life context. Participants in the current study were undergraduates who were meeting their peers for the first time during a university orientation programme in the summer holidays prior to their commencement of study. The HPA stress response and HSTH were assessed on the first day during an ice breaker session and on the third day (the final day of the university orientation programme) during a lecture session. Participants’ HPA reactivity to stress was measured using cortisol levels in saliva samples and their perceptions of social threat were also measured using self-reporting.

## Method

### *Participants & Procedure*

Participants (N = 45) were recruited from pool of students attending a 3-day orientation course as part of their preparation to join the university. Participants were from a range of academic disciplines across the university. The age range of participants was 17-46 years (66.70% were female).

All participants were taking part in a preparation for university programme which introduces students to the university and their peers over a three-day period during the summer prior to starting university in the October. Students stay in campus accommodation for the three days and are supported by university staff to take part in a series of activities, involving ice breakers, lectures, team-building activities, and social events with other new students.

Participants were recruited for the current study prior to the start of the 3-day programme and were asked to complete a questionnaire including loneliness, depression, and demographic information and a confidential medical questionnaire. Participants were excluded if they (i) had any active infections, jaundice within the last year, hepatitis, haemophilia or were HIV antibody positive, (ii) had any history of neurological or psychiatric illness, (iii) awoke earlier than 6:30 am or later than 8 am to reduce the impact of cortisol diurnal patterns (Edwards, Clow, Evans, & Hucklebridge, 2001), and (iv) were taking medication known to affect cortisol levels, such as anti-depressants (Kirschbaum Wolf, May, Wippich & Hellhammer, 1996). In addition, all participants were screened for depression using CES-D (Radloff, 1977) and three were removed because they had clinical levels of depression symptoms (using a score 27 as a clinical cut off, Boyd, Wiessman, Thompson, & Myers, 1982; Haringsma, Engels, Beekman, & Spinhoven, 2004; Zich, Attkisson, & Greenfield, 1990). The data for the remaining 42 participants were used in all the analyses. Table 4.1 displays demographic information for these participants. All participants gave written consent and were tested in accordance with the national and local ethics guidelines according to the Declaration of Helsinki.

Data were then collected on day 1 (first day) and day 3 (final day) of the programme. On day 1 participants were involved in an ice breaker session and were meeting people on the course for the first time, this took place approximately 12

noon, and lasted approximately one hour. Data were collected prior to the ice breaker session, immediately afterwards and 20 minutes later. On day 3 data was collected when participants had a lecture session, lasting approximately one hour. This took place at approximately 10am. Data were collected prior to the lecture session, immediately afterwards and 20 minutes later. Cortisol levels, arousal, and stress were collected at each of the three time points (time 1 = immediately before the session, time 2 = immediately after the session, and time 3 = 20 minutes after the session) and perception of social threat was collected at the beginning of the testing session (time 1), and were compared for lonely and non-lonely.

### *Measures*

*Loneliness.* This was measured using R-UCLA loneliness scale (Russell et al, 1980) as in Study 2 (Chapter 4). Cronbach's alpha was .92 in this sample.

*Depression.* The Centre for Epidemiologic Studies Depression Scale (CES-D, Radloff, 1977) was used as in Study 2 (Chapter 4). Cronbach's alpha was .87 in this sample.

*Self-reported Stress.* The SACL (Mackay, Cox, Burrows, et al., 1978) was used as Study 2 (Chapter 4). Cronbach's alpha for the stress sub-scale was an average of .85 on day one (time 1 = .87, time 2 = .84, and time 3 = .83) and .74 on day three (time 1 = .57, time 2 = .85, and time 3 = .80).

*Perception of Social Threat.* Participation anxiety (anxiety about taking part in the session and meeting people), evaluation anxiety (anxiety about being evaluated by others and likelihood of being evaluated negatively), and friendship formation anxiety (likelihood of making positive friendships within the group) subscales of the Perception of Social Threat scale from Study 2 (Chapter 4) were used. Each was measured by responses to questions using a rating scale from 1 to 7. *Participation anxiety* comprised of the questions, "How anxious do you feel about taking part in the session?" and "how anxious do you feel about meeting people in the session?" rated on the scale of 1 (not anxious at all) to 7 (extremely anxious). *Evaluation anxiety* and *friendship formation anxiety* were the same as Study 2 (Chapter 4). A measure of perception of social threat was calculated using an average of all the sub-scales (participation anxiety, evaluation anxiety, friendship formation anxiety).

Cronbach's alphas for perception of social threat were .76 on day one and .81 on day three.

*Saliva assaying.* Protocol for saliva sampling was the same as Study 2 (Chapter 4). Cortisol samples that were 3 standard deviations from mean were removed from all analyses. This resulted in removal of 5 samples (from the data set of 42 participants), one from the afternoon and evening from the evening on the first day and two from the afternoon and one from the evening on the second day. The other samples from these participants remain in the analyses.

#### *Data analysis plan*

First, each of the measures (cortisol and stress) was examined using factorial ANOVAs for each time point (1 = before the activity, 2 = immediately following the activity, and 3 = 20 minutes following the activity). Second, perception of social threat and each of the sub-scales (participation anxiety, evaluation anxiety, and friendship formation anxiety) between each day were compared using factorial ANOVAs. Alpha was adjusted for all post hoc comparisons (based on number of comparisons) using the Bonferroni's correction.

#### Results

Participants were grouped into high and low lonely groups based on their scores on the R-UCLA loneliness scale (Russell, Peplau, & Cutrona, 1980). A mean split was used to group participants, the low lonely group scored below 39 and the high lonely group scored 40 and above. Table 4.1 displays demographic information for each lonely group.

Table 4.1 Demographic information for all participants and by lonely groups

	All Participants (N = 42)	High Lonely (N = 21)	Low Lonely (N = 21)
% female	66.70	65	65
*Age range	17-46 years	17-33 years	18-46 years
Mean age	20.37	20.62	20.10
<i>% University Subject</i>			
Psychology, Neuroscience & Counselling	25	12.5	33.4
Other sciences	20	25	16.7
Computing	12.5	12.5	12.5
Media, Fashion & Design	17.5	18.75	16.7
Health/Exercise/Tourism	10	6.25	12.5
Law	5	12.5	0
Humanities	5	6.25	4.1
Languages	5	6.25	4.1

Notes: \*One participant did not give their age

### *Cortisol*

It would be expected that cortisol levels would differ across the days as time of data collection was different. The cortisol samples were taken at different times of the day due to university timetabling restrictions (on day 1 the first sample was approximately 10am and on day 3 the sample was at approximately 12 noon) and were taken at different stages of the cortisol diurnal curve (King & Hegadoren, 2002). Thus, day 1 and day 3 are not statistically compared in the following analyses; each day is analysed separately.

As gender differences have been identified in cortisol stress reactivity studies (Kajantie & Phillips, 2006; Kudielka & Kirschbaum, 2005) repeated measures ANOVA (time x gender) for day 1 and day 3 were used to examine gender difference to investigate whether it was necessary to control for gender. There was only a significant main effect of gender on day 1 ( $F(1,31) = 15.07, p = .001, \eta^2 = .38$ ). Post hoc tests revealed that men had higher levels of cortisol on day 1 than women

( $t(31) = 3.88, p = .001$ ). To explore the impact of gender on the results men were removed and the results remained the same, indicating that the inclusion of the three men in the data set does not influence analysis. Therefore, the male data was retained in the final data analysis (outlined below).

*Day 1 A 3* (Time: time 1, time 2, and time 3) x 2 (Lonely group: high and low lonely) mixed ANOVA was used to examine cortisol. The Greenhouse Geisser adjustment was used as Mauchley's test was significant. There was not a significant main effect of lonely group ( $F(1.55,54.57) = 1.22, p = .294, \eta^2 = .03$ ) or significant interaction between time and lonely group ( $F(1,35) = 1.49, p = .230, \eta^2 = .04$ ) on cortisol. There was a significant main effect of time ( $F(1.55,54.27) = 4.38, p = .025, \eta^2 = .11$ ) on cortisol.

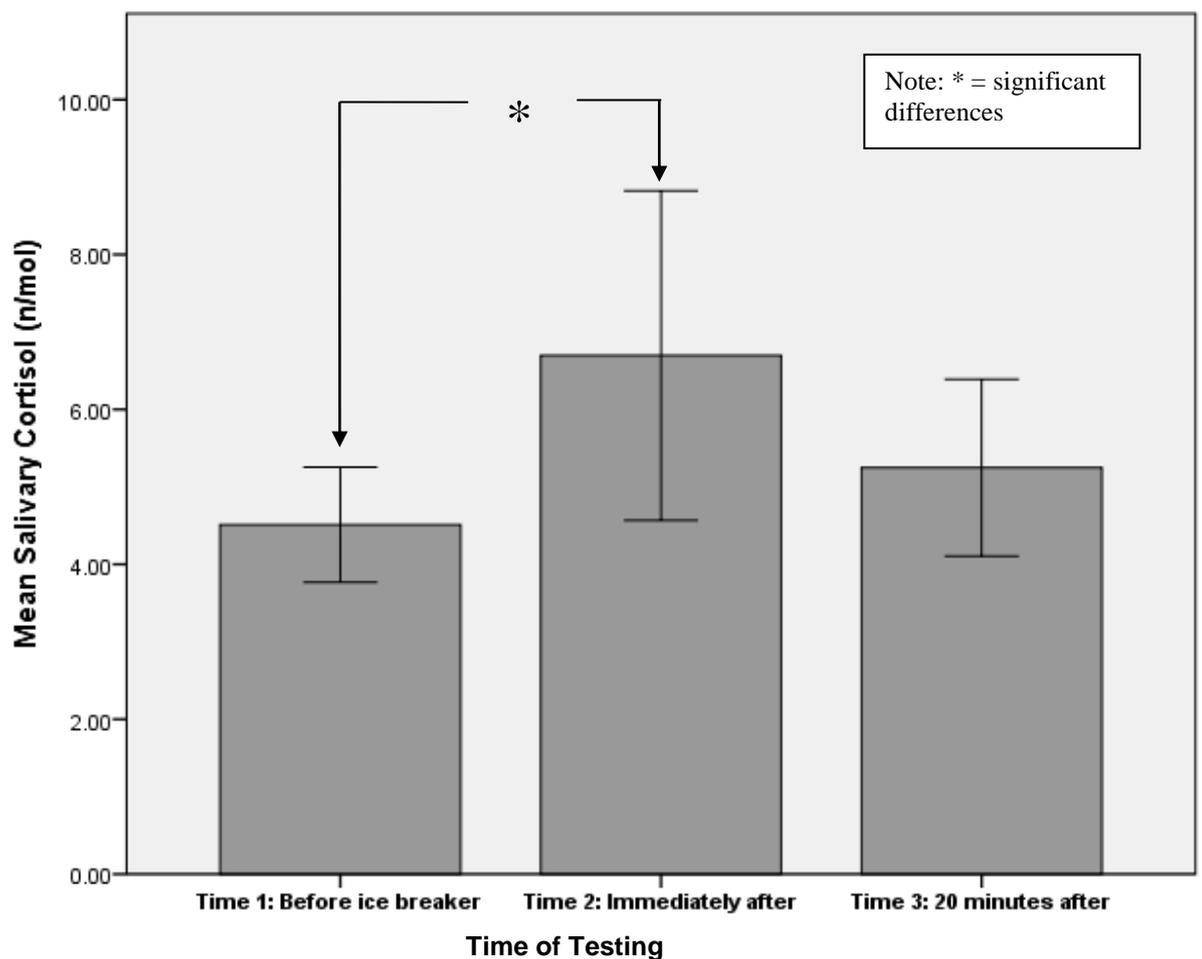
Post hoc comparisons, using paired samples t-tests, revealed that cortisol levels were significantly higher immediately after the ice breaker (time 2) than before the ice breaker (time 1,  $t(38) = 2.40, p = .011$ , one-tailed)<sup>5</sup>. There was no significant difference between cortisol levels at time 1 (before the ice breaker) and time 3 (20 minutes after,  $t(40) = 1.21, p = .117$ , one-tailed). There was a trend for a significantly higher level of cortisol 20 minutes after the ice breaker (time 3) than immediately following the ice breaker (time 2,  $t(37) = 1.94, p = .030$ , one-tailed). An examination of the relationships in Figure 4.1 demonstrates increased cortisol levels after the ice breaker session follow the trends typical of a stress response to the activity (Kudielka et al., 2004), with cortisol levels higher post-stressor (i.e. meeting strangers) than pre-stressor.

*Day 3 A 3* (Time: time 1, time 2, and time 3) x 2 (Lonely group: high and low lonely) mixed ANOVA was used to examine cortisol. The Greenhouse Geisser adjustment was used as Mauchley's test was significant. There was not a significant main effect of lonely group ( $F(1,23) = 0.10, p = .750, \eta^2 = .04$ ) or significant interaction between time and lonely group ( $F(1.52,34.91) = 0.38, p = .690, \eta^2 = .02$ ) on cortisol. But there was a significant main effect of time ( $F(1.52,34.91) = 8.10, p = .001, \eta^2 = .26$ ) on cortisol.

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<sup>5</sup> Using Bonferroni adjustment for multiple comparison alpha was reduced to  $p < .01$  (i.e.  $\alpha/3 = 0.01$ )

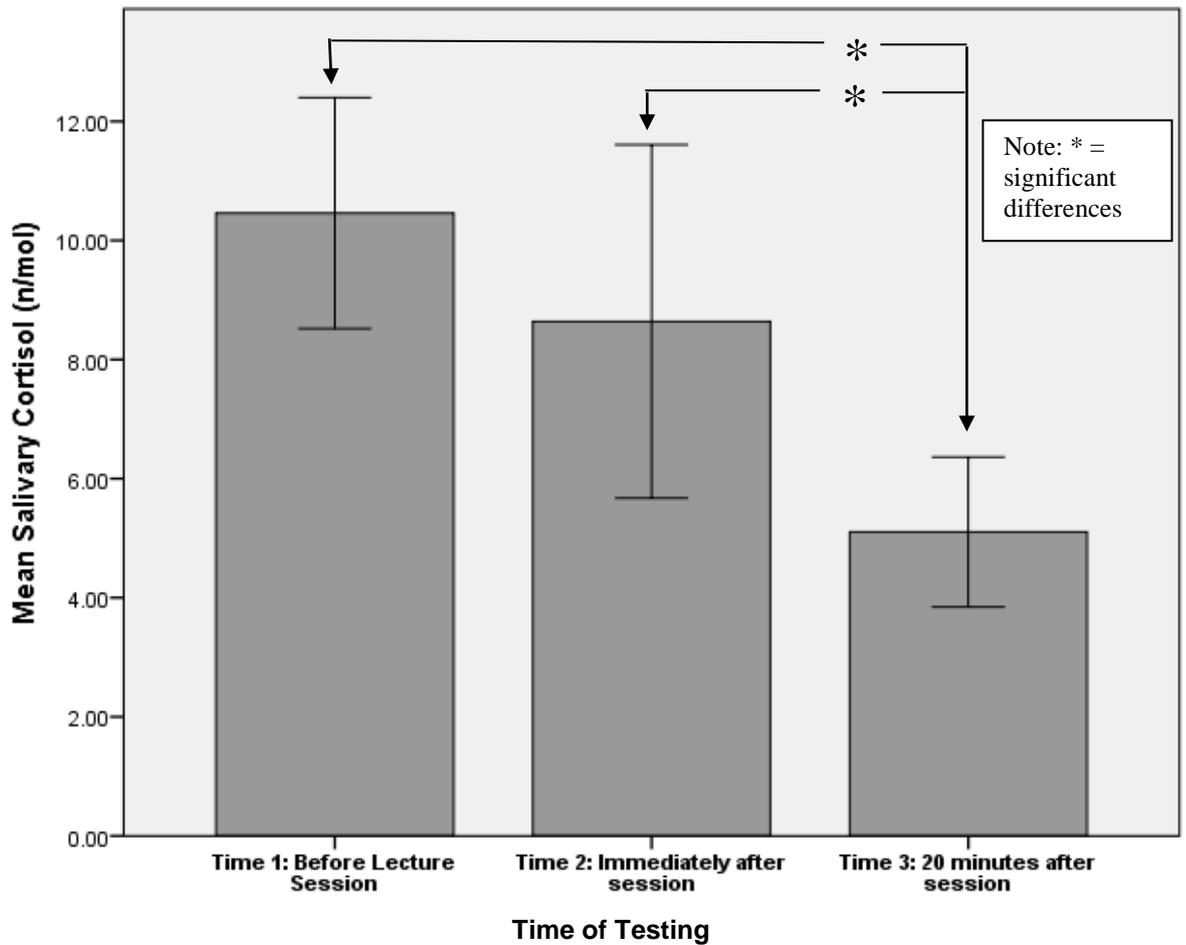
Post hoc tests, using paired samples t-tests, revealed that the cortisol level before the lecture (time 1) was significantly higher than 20 minutes after the lecture session (time 3,  $t(32) = 7.14, p < .001$ )<sup>6</sup>. Cortisol levels were not significantly higher before the lecture (time 1) than immediately following the lecture session (time 2,  $t(27)=1.38, p = .181$ ). Cortisol levels were significantly higher at time 2 (immediately after the session) than time 3 (20 minutes after the session,  $t(24) = 3.08, p = .005$ ). These results indicate that cortisol levels reduced over time. An examination of the relationships in Figure 4.2 demonstrates that cortisol levels reduced over the time period reflecting typical circadian decreases (King & Hegadoren, 2002).



Note: \*significant at  $p < .01$

Figure 4.1. Day one cortisol levels before, immediately after and 20 minutes after the ice breaker session (with 95% CI error bars)

<sup>6</sup> As footnote 5



Note: \*significant at  $p < .01$

Figure 4.2. Day three cortisol levels before, immediately after and 20 minutes after the lecture session

### *Self-reported Stress*

A 3 (Time: time 1, time 2, and time 3) x 2 (Day: day 1 and day 3) x 2 (Lonely group: high and low lonely) mixed ANOVA revealed no significant main effect of time ( $F(2,28) = 0.12$ ,  $p = .891$ ,  $\eta^2 < .01$ ) on perceived stress. But there was a significant main effect of day ( $F(1,14) = 11.67$ ,  $p = .004$ ,  $\eta^2 = .14$ ) on perceived stress. A comparison of means (see Table 5.2) reveals that self-reported stress was higher on day 1 (ice breaker) than day 2 (lecture). There was a significant main effect of loneliness group ( $F(1,14) = 38.03$ ,  $p = .031$ ,  $\eta^2 = .29$ ) on perceived stress. There were no significant interactions between time and lonely group ( $F(2,28) =$

0.16,  $p = .857$ ,  $\eta p^2 = .01$ , day and lonely group ( $F(1,14) = 0.68$ ,  $p = .424$ ,  $\eta p^2 = .05$ ), day, time, and lonely group ( $F(2,28) = 0.23$ ,  $p = .797$ ,  $\eta p^2 = .02$ ), and time and day ( $F(2,28) = 0.36$ ,  $p = .699$ ,  $\eta p^2 = .03$ ).

Table 4.2 displays the means of self-reported stress by lonely group for each day. An examination of means in Table 5.2 reveals that self-reported stress was highest for all participants on day 1, lowest on day 3, and over both days the high lonely group reported more stress than low lonely group. This indicates that day 1 was more stressful than day 3 and that the high lonely group were more stressed than low lonely on both days.

Table 4.2 Mean self-reported stress (and standard deviation) for all participants and each lonely group by day of testing

	High Lonely	Low Lonely	Total
Day 1	6.17 (1.19)	2.97 (0.92)	4.57 (0.75)
Day 3	3.28 (0.83)	1.20 (0.64)	2.24 (0.52)
Total	4.72 (0.87)	2.08 (0.67)	

#### *Perception of social threat*

Perception of social threat and sub-scales (participation anxiety, evaluation anxiety, and friendship formation) were compared for the ice breaker day and the lecture day, and by lonely group. A series of 2 (Day: day 1 and day 3) x 2 (Lonely group: high and low lonely group) mixed ANOVAs were carried out. Table 4.3 displays the mean scores and ANOVA results for perception of social threat and each of the sub-scales<sup>7</sup>.

<sup>7</sup> As there were multiple comparisons the alpha was adjusted to  $p < .006$  (i.e.  $\alpha/8 = .006$ ) using bonferroni's correction.

Table 4.3. Means (and standard deviations) and ANOVA results for perception of social threat by lonely group on day 1 and day 3

	Day 1		Day 3		#Main effects	Interaction
	High Lonely	Low Lonely	High Lonely	Low Lonely		
Perception of Social Threat	18.85(4.49)	15.77(3.98)	17.75(4.96)	13.62(3.09)	LG - F(1,36)=10.98, p =.002, $\eta^2$ =.23** DAY- F(1,36)=3649, p <.001, $\eta^2$ =.50**	NS
<i>Participation anxiety</i>	9.05(3.17)	6.59(2.92)	6.65(3.42)	3.76(1.70)	LG - F(1,36)=10.98, p =.002, $\eta^2$ =.23** DAY - F(1,36)=40.24, p <.001, $\eta^2$ =.52**	NS
<i>Evaluation anxiety</i>	8.00(2.18)	6.73(2.00)	7.10(2.17)	5.19(2.06)	LG - F(1,36)=7.56, p =.009, $\eta^2$ =.17* DAY - F(1,36)=20.85, p <.001, $\eta^2$ =.37**	NS
<i>Friendship formation anxiety</i>	2.70(1.17)	2.73(1.39)	3.00(1.30)	2.29(0.96)	LG - F(1,36)=0.07, p = .789, $\eta^2$ < .01 DAY - F(1,36)=0.75, p = .391, $\eta^2$ = .02	F(1,36)=4.14, p=.049, $\eta^2$ =.10

Notes: #LG =main effect of lonely group, DAY = main effect of day, \*\*significant at p < .006 (using Bonferroni's correction), \*Trend towards significance (at p < .01)

An examination of Table 4.3 reveals that all participants report higher levels of perception of social threat on day 1 than day 3. The high lonely group had higher levels of perception of social threat ( $F(1,36) = 10.98, p = .002, \eta p^2 = .23$ ), participation anxiety ( $F(1,37) = 12.00, p = .001, \eta p^2 = .25$ ), and evaluation anxiety ( $F(1,36) = 7.56, p = .009, \eta p^2 = .17$ ) on both days. Those higher levels reported by the high lonely group remained higher than the non-lonely group on day 3, despite these ratings reducing by day 3 for all participants (i.e. lower levels of anxiety on day 3).

There were different results for friendship formation anxiety: there was not a main effect of day or lonely group (see table 4.3), but there was a trend towards a significant interaction between day and lonely group ( $F(1,36) = 4.14, p = .049, \eta p^2 = .10$ ). This interaction effect between day and lonely group on friendship formation is displayed in Figure 4.3. Although this effect does not approach significance when Bonferroni's correction is used, it is significant at  $p < .05$  level. As this is a new area of research, to avoid making a type II error, and to explore an unexpected finding (Moran, 2003; Rothman, 1999) the interaction was examined. Post hoc tests using independent t-tests revealed that there were no significant differences in anxiety about forming friendships between the lonely groups on day 1 ( $t(37) 0.09, p = .931$ ). But by day 3 the high lonely group are more anxious about forming friendships ( $t(37) 2.30, p = .027$ ).

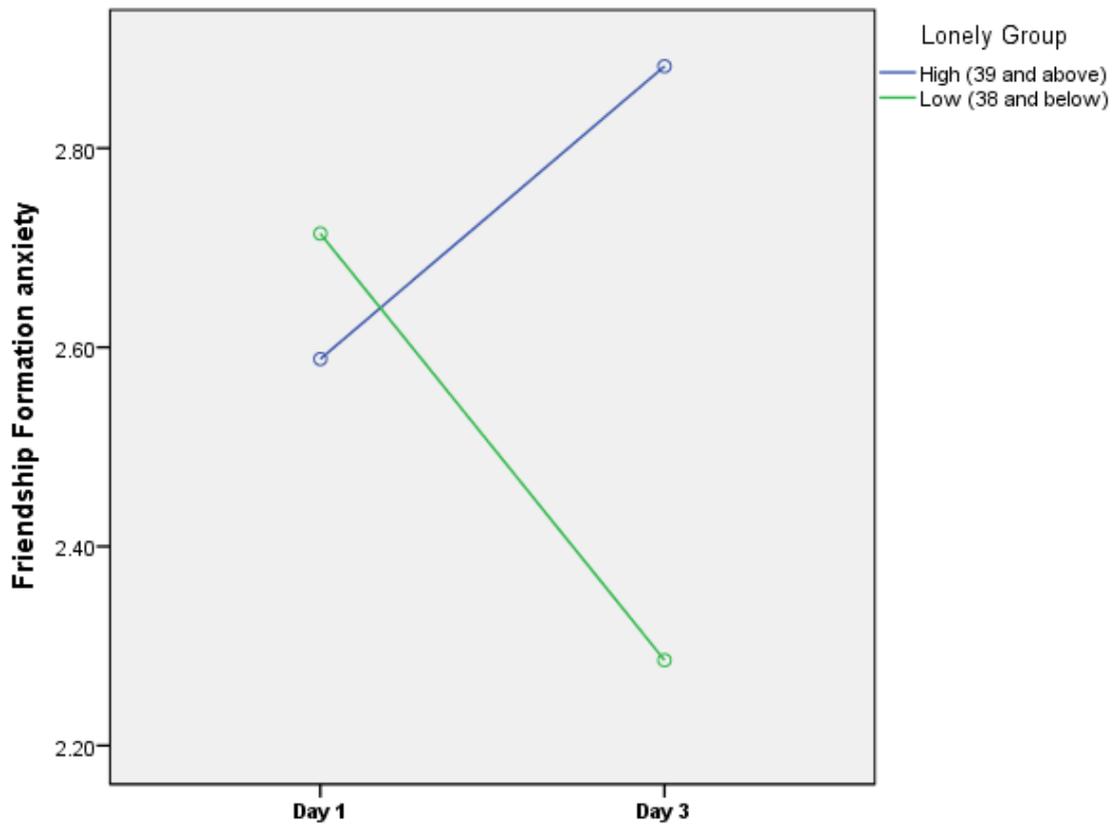


Figure 4.3. Friendship formation anxiety for each day by lonely group

## Discussion

The aim of the current study was the same as Study 1 that examined Cacioppo and Hawkley's (2009) proposition that lonely people experience a HSTH in social situations which leads to an increased activation of the HPA axis. The current study used a different real life social context: meeting strangers. As in Study 1, it was expected that there would be higher levels of HSTH and an increased HPA stress response to meeting people in high lonely people in comparison to low lonely people. Similar to Study 1, in the current study there were no differences in HPA axis stress response, but there were differences in perceived stress between high and low lonely groups. Also, similar in the current study to Study 1, the high lonely group reported higher perception of social threat than the low lonely group.

### *Cortisol*

This study is the first to examine whether meeting new people elicits a HPA axis cortisol response. The results in the current study show that meeting new people elicited a physiological stress response because a typical cortisol stress reactivity pattern for cortisol levels is shown for day 1 (Kudielka et al., 2004); in comparison, on day 2 the results demonstrate a typical diurnal rhythm of cortisol decline across the morning (King & Hegadoren, 2002).

In the current study there were no differences in cortisol levels between the lonely groups on either day. Other studies that have examined cortisol diurnal rhythms in lonely people in comparison to non-lonely people indicate an increased activation of the HPA axis (Cacioppo et al., 2000; Doane & Adam, 2010; Steptoe et al., 2004), but these studies differ from the current study because they examine cortisol diurnal patterns, rather than a HPA axis stress response. In a similar study involving the HPA axis response to a stressor Steptoe et al. (2004) examined responding to a mental stressor in a laboratory and did not find differences in cortisol levels in lonely people in comparison to non-lonely. It could be that although lonely people have atypical cortisol diurnal patterns, they do not have an increased stress reactivity to social stressors despite their increased HSTH.

### *Self-reported stress*

In the current study, self-reported stress has a different pattern to cortisol stress reactivity; cortisol peaks following the stressor and reduces 20 minutes later, whereas stress remains constant. Other stress reactivity studies have noted discrepancies between self-reported stress and HPA axis stress response (Robinson, Süram-Lea, Leach & Owen-Lynch, 2008; Hare, Wetherall, & Smith, 2013) and diary studies have demonstrated that the daily experience of stressors is associated with increases in cortisol, but the perception of stress is not (Van Eck, Berkhof, Nicolson, & Sulon, 1996).

Further, researchers have indicated that it is specific aspects of self-reported stress that are associated with fluctuations in cortisol. For example, the full measurement of self-reported chronic stress is not associated with increases in

cortisol, but sub scales of “worries”, “social stress”, and “lack of social recognition” are linked to increases in cortisol levels (Wüst, Federenko, Hellhammer, & Kirschbaum, 2000). These results indicate that an increase in perceived stress may need to relate specifically to social evaluation in order for it to be related to the cortisol response. In Dickerson and Kemeny’s (2004) meta-analysis of studies they concluded that perception of social evaluation is essential to activate the HPA axis. Therefore, it may be that the ice breaker activity in the current study involved a sufficient perception of social evaluation to be stressful enough to activate the HPA axis stress response, but the measurement of self-reported stress used in this study was not specific enough to social stress so it was not associated with the increase in cortisol levels in response to the social stressor. The self-reported stress measure in the current study is more likely to be measuring generalised stress on the day of testing.

What is important is that the self-reported stress levels are higher on the first day than the third day, indicating that participants are reporting more stress at the beginning of the university orientation course than on the final day. Participants were not asked about what they were stressed about, but the fact that they were less stressed on day 3 indicates that the stress was in relation to meeting people and the activities they were participating in.

There was a difference in stress reporting between the lonely groups. The high lonely group reported higher levels of stress than low lonely group on both days, indicating that lonely people typically experience more stress. These results are similar to those obtained in Study 2 (Chapter 4) which also found that the high lonely group reported higher levels of stress than the low lonely group typically in a real life social context, despite the social challenges in of the day. This relates to literature in the loneliness field that uses a diary methodology and demonstrates that lonely people report higher levels of stress in everyday life (Hawkley, Thisted, & Cacioppo, 2009; Pressman et al., 2005). The increased levels of self-reporting of stress in lonely people is important because chronic stress activates physiological mechanisms such as the autonomic nervous system and the HPA axis, so prolonged periods of stress will place cumulative wear and tear on these systems resulting in poor health (McEwen, 1998a; McEwen & Stellar, 1993). It is possible, then, that the increased perception of stress in lonely people may be a functional mechanism that explains the association between loneliness and health which would also lead to

atypical diurnal patterns of the HPA axis (and other physiological systems, such as the autonomic nervous system (ANS)) which are found in lonely people (Cacioppo et al., 2000; Doane & Adam, 2010). It may not be increased activation of HPA in response to HSTH in social contexts that is the functional mechanism in the association between loneliness and poor health, but the fact that the state of loneliness results in chronic stress that then leads to prolonged activation of the HPA resulting in poor health.

### *Perception of social threat*

Perception of social threat was higher in all participants on the first day, so all participants were more sensitive to social threat during the ice breaker session than the lecture session on the final day. Perception of social threat was higher for lonely people on both days, indicating that lonely people typically report higher levels of social threat in every day real life social challenges. Similar to findings in Study 1 perception of social threat was increased in lonely people across both days, offering partial support Cacioppo and Hawkely's (2009) model. The findings provide ecological validity for Cacioppo and Hawkley's (2009) model because HSTH in lonely people is observed in a real life context. But, taken together, the findings of Study 1 and the current study, indicate that HSTH may not be specific to a particular socially challenging situation; lonely people have increased levels of HSTH typically in everyday life, indicating that they are on a constant state of alert for social threat.

Friendship formation anxiety was not higher for the high lonely group on the first day of the programme, but is higher than the low lonely group by day 3. This indicates that on the first day, all participants were anxious about forming friendships with others; by the third day the low lonely group have reduced this anxiety, but the high lonely group remained anxious about forming friendships with others. This may indicate that the high lonely group get more anxious about forming friendships; in comparison, the low lonely group reduced their anxiety about friendships through positive interactions with others. Research has shown that lonely people have a tendency to interpret social interactions in a negative way, despite whether the interaction is rated negatively by others (Duck, Pond, & Leatham, 1994; Jones, Freemon, & Goswick, 1981; Jones, Sansone, & Heim, 1983). Thus, the way a lonely person perceives social interaction may not be a true reflection of the actual

behaviour of others. Hence, the result in the current study of friendship formation anxiety remaining high following social interaction in the high lonely group, could be explained by their negativity bias.

#### *Strengths and limitations of the current study*

The current study (Study 2) and Study 1 (see Chapter 3) are the first studies to examine HSTH situated in a real life context. They offer support for Cacioppo and Hawkley's (2009) proposition that lonely people have HSTH as they evidence that high lonely people have higher levels of perception of social threat than low lonely in naturally occurring social stressful situations.

The current study did not enable an examination of base line days (e.g. typical days when participants were not meeting strangers). Further research should examine differences in cortisol level between lonely and non-lonely people comparing days where it would be expected that cortisol would be increased, such as on a day when participants are meeting new people (as in the current study) and another more typical day that does not place additional social demands on participants. This would be important as it enables a comparison of a stressful day with normal cortisol functioning, but also would enable an examination of cortisol flexibility, which is considered important for health (Mikolajczak et al., 2010).

#### *Conclusion and links to other chapters*

The current study demonstrated increased levels of cortisol in response to the social challenge, meeting people in the ice breaker session, displaying a typical HPA stress response, but there was no difference between the responses of high and low lonely groups. This indicates that lonely people may not have increased HPA responses to specific social stressors in everyday life as Cacioppo and Hawkley's (2009) model proposes; instead lonely people appear to have a more general heightened stress response in everyday life. HSTH was found to be higher in lonely people than non-lonely people in a naturally occurring social stressor both in the current study and Study 1 (outlined in Chapter 3), giving ecological validity for Cacioppo and Hawkley's (2009) proposition of HSTH in lonely people.

The high lonely group reported higher levels of self-reported stress on both days, indicating that lonely people experience higher levels of stress in everyday life. These results are similar to those obtained in Study 1 which also found increased self-reporting of stress in the high lonely group, indicating that chronic stress may be a functional mechanism of the association between loneliness and health.

This study is the last in a series of studies in this thesis to address the gaps in the adult literature supporting Cacioppo and Hawkley's (2009) model of loneliness and health. The adult studies are discussed in more detail in the next chapter (Chapter 5) and examined in relation to Cacioppo and Hawkley's (2009) model. The following Chapters (6-11) turn to studies in this thesis with child populations. Those studies address gaps in the literature examining loneliness and health in childhood and examine the viability of using Cacioppo and Hawkley's (2009) model to explain associations between childhood loneliness and health.

## Chapter 5: Overview of adult studies

### *Summary of studies*

Cacioppo and Hawkley's (2009) model for loneliness and health was outlined in Chapter 2 and areas were identified that warranted further investigation. There was a need to examine physiological responding (hypothalamic-pituitary-adrenal (HPA) axis activation) and hypervigilance to social threat (HSTH) in real life social challenges rather than laboratory stress challenges that involve perception of social evaluation.

To address these gaps in the existing literature two studies were conducted with adult samples (details of adult populations used in each of the studies are outlined at the end of Chapter 2). Studies 2 (Chapter 4) and 3 (Chapter 5) measured physiological responding (HPA axis activation measured by levels of cortisol) and HSTH in relation two naturally occurring social stressors 1) public speaking (Study 2), and 2) meeting strangers (Study 3). Studies 2 and 3 aimed to extend the field by examining the proposed theoretical model for loneliness and health (Cacioppo & Hawkley, 2009) in a real life context. This is particularly important to offer ecological validity for Cacioppo and Hawkley's (2009) model; to date no examination of the physiological responding or HSTH in a real life context has been carried out.

Studies 1 and 2 examined HPA axis stress response and HSTH in everyday real life social contexts. In Study 1 participants gave a presentation to their peers, but the activity was not sufficiently stressful enough to elicit a HPA stress response. In comparison, meeting strangers during an ice breaker session in Study 2 was sufficiently stressful to elicit a HPA stress response, but there were no differences between high and low lonely groups. In both studies the high lonely groups reported higher levels of perception of social threat than the low lonely groups, indicating that HSTH is found in real life social contexts in lonely people offering ecological validity for Cacioppo and Hawkley's (2009) model.

In Study 2 participants took part in a 3-day university orientation programme and although there were no differences in anxiety about forming friendships on the first day between the lonely groups, by the final day high lonely adults were more

anxious about forming friendships in the group than low lonely adults. Lonely people have been shown to have negativity (Cacioppo et al., 2000) and passivity (Cacioppo et al., 2000; Steptoe, Owen, Kunz-Ebrecht, & Brydon, 2004) in their social interactions. Thus, the findings from Study 2 can be explained by this negativity bias: high lonely people focus on the negative information in social interaction so their anxiety about forming friendships in the group does not reduce. In comparison, low lonely people reduce their anxiety about forming friendships in the group through the experience of interaction with others because their perception is not biased and focused on the sum total of interactions with others (not dwelling on the negative information as the high lonely group do).

Self-reported stress was higher for lonely people in both studies on all days regardless of participation in the stressful social activity, indicating that lonely adults generally feel more stress in everyday life rather than having increased stress due to a specific social activity. These results are similar to those obtained in other loneliness literature using diary methodology where lonely people have not reported more stressful events but report higher stress levels than non-lonely people generally (Hawkley, Thisted, & Cacioppo, 2009; Pressman et al., 2005). Chronic stress itself could be a functional mechanism of the association between loneliness and health because lonely people consistently report more stress than non-lonely people across studies using different methodologies.

Chronic stress is an emotional state that persists for a prolonged period, when the person feels that they are unable to control their daily pressures. Experiencing chronic stress in everyday life places cumulative wear and tear on multiple physiological systems resulting in poor health (Justin, McEwen, & Lupien, 2010; McEwen & Stellar, 1993). Chronic stress has been linked with atypical diurnal cortisol patterns (Miller, Chen, & Zhou, 2007; Wüst, Federenko, Hellhammer, & Kirschbaum, 2000) indicating HPA axis dysfunction. It has also been linked to central nervous system (CNS) dysfunction affecting CNS circuits that regulate mood and reward centres in the brain, resulting in reduced pain perception and reductions or increases in appetite (Dallman et al., 2003; McEwen, 2001). In addition, dysfunction of the dopaminergic systems (in the CNS) as a result of chronic stress can lead to cognitive impairments, such as decreased working memory capacity (Lupien, McEwen, Gunnar, 2009; Pani & Gressa, 2000). Chronic stress is also linked to increased activation of the autonomic nervous system (ANS) and can result

in cardiovascular disease (Vitaliano et al., 2002). Decreased immune system functioning has also been linked to chronic stress (Segestrom & Miller, 2004). Thus, chronic stress can lead to increased risk of infections and viruses, reduced action of vaccinations, increased likelihood of age-related diseases, and prolonged wound healing via its effect on the immune system (Glaser & Kiecolt-Glaser, 2005). Given this evidence the associated chronic stress that is present in lonely people would have effects on multiple physiological systems and may be an important functional mechanism that links loneliness to poor health.

#### *Relation to current theoretical models*

The current theoretical model proposed by Cacioppo and Hawkley (2009) for loneliness and health (outlined in Chapter 2) suggests that loneliness leads to a hypervigilance for social threat (HSTH) which in turn results in increased activation of threat surveillance mechanisms (specifically the HPA axis). They propose that it is this chronic activation of the HPA axis that results in poor health in lonely people. In relation to Cacioppo and Hawkley's (2009) model it would be expected that lonely adults have an increased HPA axis response and HSTH in response to a social stressor.

Studies 1 and 2 (of this thesis) examined both HPA axis stress response and HSTH in a real life social context and found evidence of the HSTH, but no evidence of an increased HPA axis stress response in high lonely adults in comparison to low lonely adults. HSTH in lonely people in real life contexts was not dependent on the social stressor, lonely people were generally reporting higher levels of perception of social threat despite the stressful context. This indicates that lonely people typically are on a state of alert for social threat that is not responsive to the current social situation. The results show that lonely people do not display an increased HPA axis stress response in comparison to non-lonely people in real life social contexts, which included exposure to acute stressors, such as giving a presentation and meeting new people. However, as there is evidence that lonely adults have an atypical cortisol diurnal rhythm (Doane & Adam, 2010; Steptoe et al., 2004), and both studies demonstrate that lonely people typically experience increased stress in everyday life, it may be that lonely people have a prolonged activation of the HPA axis due to experiencing chronic stress. Cacioppo and Hawkley's (2009) model does not

mention chronic stress as a functional mechanism, but it may have an important role in the association between loneliness and health. It may have direct route from loneliness to poor health as it has been associated with poor health (Justin, McEwen, & Lupien, 2010) and/or it may have an indirect route as the result of prolonged HPA axis activation (Miller, Chen, & Zhou, 2007; Wüst, Federenko, Hellhammer, & Kirschbaum, 2000). Chronic stress also implicates other physiological mechanisms that are not mentioned in Cacioppo and Hawkley's (2009) model, such as ANS, CNS, and immune system (McEwen, 1998b; McEwen & Stellar, 1993), and these may be involved in the relationship between loneliness and health. These proposed relationships are demonstrated in Figure 5.1).

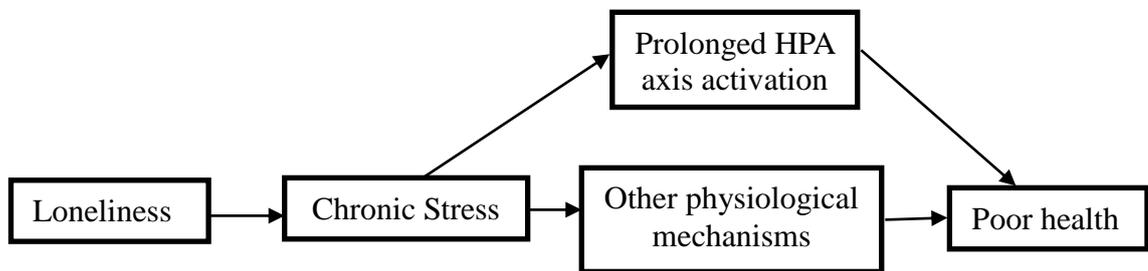


Figure 5.1 The impact of chronic stress in the association between loneliness and poor health

It appears then that lonely people view everyday life as more stressful and are typically on a heightened state of alert for social threat, indicating an expectation of social rejection. What is yet to be examined is how lonely people behave in social interaction as a result of these perceptions about the social world. Study 2 offered some interesting insight into the expectations of lonely adults in relation to social interaction: lonely and non-lonely people did not differ in their anxiety about forming friendships, but after three days of social interaction, the high lonely group were more anxious about forming friendships. This result indicates that lonely people do not reduce in their anxiety about forming friendship with others as they get more familiar with them. Lonely people have a negative (Cacioppo et al., 2000) and passive (Cacioppo et al., 2000; Steptoe et al., 2004) approach to social interaction and tend to rate social interaction negatively when non-lonely people do not (Duck, Pond, & Leatham, 1994; Jones, Freemon, & Goswick, 1981; Jones, Sansone, & Heim, 1983). Therefore, the results in study 2 may be explained by this negativity bias: lonely people may focus and dwell on the negative information in their

interactions with others, thus, their anxiety about forming friendships with others does not decrease.

Cacioppo and Hawkley (2009) make little reference to the impact of the social world on the lonely person. They propose that the heightened state of alert for social threat makes the lonely person behave in a negative and passive way in social interactions which most likely to lead to repulsion and isolation from other people in the lonely person's social world. The results of Study 2 indicate that the behavioural interactions may have an important role in the maintenance of loneliness (e.g. anxiety about friendship formation increased through interaction with others). It is essential that future work examines behavioural engagement and interpretation of social encounters in lonely people to establish the role that social interaction may play in maintaining loneliness.

#### *Impact and further research*

Studies 1 and 2 are important as they are the first studies to use a real life context to examine the HPA axis stress response and HSTH and offer ecologically validity for Cacioppo and Hawkley's (2009) model for loneliness and health. They offer support for Cacioppo and Hawkley's (2009) proposition of HSTH in lonely people in everyday social contexts, but they also present evidence that the functional mechanism for loneliness and health may lie in the chronic stress that lonely people experience rather than the HSTH directly. Therefore, the work in this thesis outlines the necessity for future work to examine the relationship between HSTH, chronic stress, and atypical HPA axis functioning.

Previous research has shown that lonely people interpret social interaction differently to non-lonely people; the studies in this thesis indicate that this negativity bias in lonely people may affect their ability to form friendships. Future work in this research area should examine lonely people's behaviour in social interactions alongside their interpretations of social interactions using self-reporting and/or observation methodology to examine mechanisms which are at play in social interactions that serve to maintain loneliness in lonely people.

## Chapter 6: Literature Review 2

### *Loneliness and Health in Children and Adolescents*

Loneliness is defined by researchers as a discrepancy between actual and desired social connection (Peplau & Perlman, 1982) resulting in negative affect, and pain and distress for the lonely person (Eisenberger, Lieberman, & Williams, 2003). Although, much of the research defining loneliness has been with adults, children also describe loneliness in this way, reporting a separation from others, a longing for contact, and pain and distress (Asher & Paquette, 2003; Liepins & Cline, 2011). The situations and events leading to loneliness for adults are also the same for children; for example, typical events are bereavement or moving home (Jones, Cavert, Snider and Bruce, 1985). Given that children experience loneliness in a similar way to adults it is important to establish if children also have the same related health difficulties as lonely adults. Loneliness in childhood and adolescence is complex because it displays changes reflecting social and cognitive development. Loneliness levels tend to remain stable in middle childhood and increase during adolescence (Van Roekel et al., 2010) when cognitions about loneliness move from being related to difficulties with friendships to a need for a sense of belonging or social identity (Parkhurst & Hopmeyer, 1999). Despite these developmental changes, some children experience stable and chronic loneliness for a number of years (Qualter et al., 2013b; Van Roekel et al., 2010). This section of the thesis outlines the existing literature on loneliness and health in relation to childhood and adolescence, identifying gaps in the literature. It also outlines the studies in this thesis that aim to address these gaps in childhood literature.

#### *Loneliness in children*

Loneliness is reported in very young children: children as young as 5 years have demonstrated an understanding of loneliness (Coplan, Closson & Arbeau, 2007; Cassidy & Asher, 1992; Liepins & Cline, 2011; Qualter & Munn, 2002). In interviews, children describe loneliness as “*having no one to play with*” and “*as feeling sad and staying alone*” (Asher & Paquette, 2003). Children are able to distinguish between solitude and loneliness and are able to respond negatively to the

question, “Does someone who is alone necessarily feel lonely?” (Hymel, Tarulli, Hayden, Thomson, & Terrell-Deutsch, 1999). Hayden, Tarulli and Hymel (1988) interviewed 8-13 year olds and found affect and cognitive dimensions to their descriptions of loneliness demonstrating children are aware of the feeling aspects and the appraisal of loneliness. Hayden et al. (1988) also identified a range of contexts for childhood loneliness: loss and bereavement, being a newcomer to a social group, temporary separation from others, conflict with others, rejection, broken loyalties, exclusion from a group of people or activity, and being ignored or not noticed by others. In a similar study, Kirova (2003) used a game format to identify themes underlying children’s understanding of loneliness. She found three dimensions to their understanding: spaces, affect, and cognitions. Children described the distance between them and others, the importance of being loved, and their need to be considered worthy by others. They were also able to describe experiences when they felt separated and excluded by others.

Similar to adults, lonely children are not necessarily isolated or rejected (Qualter & Munn, 2002) and children describe loneliness as not necessarily meaning aloneness (Liepins & Cline, 2011). Some children who express loneliness feel rejected and have few friends; others who are lonely do not feel rejected and report having friends (Qualter & Munn, 2002). This is similar to the distinction that Wiess (1973) made for social and emotional loneliness in adulthood; that loneliness can be an insufficient contact with others (social loneliness), but also involves a lack of meaningful or intimate relationships (emotional loneliness). For these lonely, but not rejected children it is likely that their loneliness is due to quality of their friendships rather than social isolation: observations of their play demonstrate that they are not socially isolated and their interactions with others are generally positive (Qualter & Munn, 2005).

Friendship durability and quality is an important predictor of loneliness in children and makes separate contributions to loneliness than having a friend and group acceptance (Asher & Paquette, 2003; Parker & Asher, 1993). In fact, reciprocal friendships have been demonstrated to act as a buffer from loneliness for rejected children (Nangle, Erdley, Newman, Mason, & Carpenter, 2003; Sanderson & Siegal, 1995; Renshaw & Brown, 1993; Parker & Asher, 1993). In comparison, victimisation of rejected children facilitates loneliness (Boivin & Hymel, 1997; Ladd, Kochenderfer, & Coleman, 1997). Therefore, children who are rejected by

others are vulnerable to feeling lonely and are more likely to report loneliness if the rejection also results in victimisation; however, when the child has strong mutual friendships with others they are less likely to become lonely.

### *Prevalence of loneliness in childhood*

Loneliness affects around 10-15% of children (Iverson & Eichlet, 1992, cited in Margalit, 2010; Asher, Hymel & Renshaw, 1984) and children experience great distress when they are lonely. A report published in March 2010 (Hutchinson & Woods, 2010) by NSPCC found that in 2008-9 almost 10 thousand children were counselled by ChildLine about loneliness. Half of this number telephoned about loneliness as their main problem, and this has tripled in five years, from 1,852 to 5,525<sup>8</sup>. This evidence indicates that loneliness is prevalent in childhood and, for those children who feel lonely, it is a significant problem.

### *Characteristics of lonely children*

It also seems that lonely children have characteristics that are similar to lonely adults. Lonely children have low self-worth, a non self-serving attribution style, lack sociability, and also have an inaccurate perception of themselves and their relationships (Qualter & Munn, 2002). Young children who report loneliness also report less school liking and greater school avoidance (Coplan et al., 2007). Lonely children tend to blame themselves for their lack of social success and report negative outcomes of social interaction to stable-internal attributions (Renshaw & Brown, 1993). This reflects similarities with the negativity (Duck, Pond, & Leatham, 1994; Jones, Sansone, & Heim, 1983; Jones & Freeman, 1981) and passivity (Step toe, Owen, Kunz-Ebrecht, & Brydon, 2004; Cacioppo et al., 2000) to social relationships that is demonstrated in lonely adults (outlined in Chapter 2). However, lonely children do not seem to respond to the state of loneliness uniformly, some children become withdrawn, self-conscious and shy, whereas others become hostile and aggressive (Qualter et al., 2013b; Qualter & Munn, 2005). Although, withdrawal

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<sup>8</sup> This increase in contacting NSPCC could indicate that loneliness is increasing in childhood, but may also indicate increasing levels of children willing to contact NSPCC about loneliness. Factors that may be involved in this increasing of telephone contacts with NSPCC about loneliness have not been examined.

from social activity is generally found in adults rather than the hostility and aggressiveness that is found in a 'sub-group' of lonely children, this may reflect the differences in methodology used in adult and child studies. In child studies actual behaviour is often observed and reports provided by parents and teachers are also obtained; adult studies have tended to rely on self-reporting alone. Lonely children appear to demonstrate the negativity and passivity towards social interactions that lonely adults do, but, some lonely children may also act in an aggressive way towards others. It may be that adults behave in this way too, but similar observation studies have not been carried out using adult samples.

Recently, Qualter et al., (2013) demonstrated that lonely children (9-11 year olds) report higher levels of sensitivity to rejection than non-lonely children. Lonely children also report hostility towards social exclusion scenarios, but not towards direct verbal or physical provocation. Lonely children also differ in visual attention to social rejecting stimuli, showing an initial increase in attention to social threat information in a socially rejecting scene and then avoid visual gaze to such cues. This evidence suggests that the hyper-vigilance to social threats suggested in adults (Cacioppo & Hawkley, 2009) outlined in Chapter 2 may occur early in development.

#### *Loneliness: A developmental perspective*

Although children experience loneliness in a similar way to adults and with similar prevalence, in order to fully understand childhood loneliness it is important to take a developmental perspective because loneliness levels change throughout childhood and adolescence (Van Roekel et al., 2010). Theories of how loneliness develops have been dominated by attachment theory, which suggests early attachments to parents effects later abilities to form close satisfying relationships with others (Cassidy & Berlin, 1999). These early relationships are believed to create internalised working models for future relationships. Loneliness has been found to be at its highest in children who formed insecure-ambivalent attachments in infancy (Berlin, Cassidy, & Belsky, 1995) and adult loneliness has been linked to difficulties with childhood attachment (DiTommaso, Brannen-McNulty, Ross & Burgess, 2003; Hecht & Baum, 1984; Shaver & Rubinstein, 1980).

However, recent studies challenge attachment theory as an explanation for loneliness and demonstrate a genetic propensity to loneliness and have implicated

polymorphisms of serotonin (Van Roekel, Scholte, Verhagen, Goossens & Engels, 2010) and oxytocin (Lucht, Barnow, Sonnerfeld, Rosenberger, Grabe, Schroeder, Volzke, Freyberger, Herrman, Kroemer, & Rosskopf, 2009) receptors (see Chapter 2). Van Roekel et al.'s (2010) study indicates that maternal parental support can buffer the impact of a genetic susceptibility of loneliness. Further, those with the genotype who experience high levels of maternal relational support do not exhibit high levels of loneliness. This indicates that high maternal relational support may buffer the impact of a genetic propensity for loneliness so children with this genotype do not experience loneliness. This study highlights the importance of the parent's role in supporting childhood friendships.

Another mechanism that has been implicated in childhood loneliness is the parent's own levels of loneliness. Research has shown that a mother's loneliness can be transmitted to her offspring (Lobdell & Perlman, 1986; Henwood & Solano, 1994; Junttila & Vauras, 2009; Qualter et al., under preparation). Lonely parents have difficulty giving children advice and support with their peer relationships and fail to teach them appropriate social skills including those related to problem-solving of conflicts (Feeney, 2006) and peer cooperation (Junttila & Vauras, 2009). Lonely parents may also transmit a cognitive style to their offspring that promotes loneliness. Loneliness in adults has been linked to a cognitive mind-set of hypervigilance to social threats (HSTH) (Hawkley & Cacioppo, 2010), and this cognitive mind-set is also evidenced in lonely children aged 8-11 years (Qualter, et al., 2012). Henwood and Solano (1994) indicate some mechanisms for this transmission of maternal loneliness to the child: it is linked not only to fewer relationship enhancing strategies taught by parents, but also to mothers' negative attitudes towards others which they use in their relationship discourse with their children.

It is not just parents that can impact on loneliness: peers also play an important role in childhood loneliness. Loneliness also appears to be transmitted through peer friendships. Lonely children become as lonely as their friends over time (Harris & Qualter, under review; Mercer & DeRosier, 2010). Peer rejection has also been shown to influence levels of loneliness in childhood (Asher, Parkhurst, Hymel & Williams, 1990). Mutual friendships buffer the influence of peer rejection (Nangle et al., 2003; Sanderson & Siegal, 1995; Renshaw & Brown, 1993; Parker & Asher, 1993) on loneliness, whereas, victimisation facilitates the influence of peer rejection (Boivin & Hymel, 1997; Ladd et al., 1997). This demonstrates the

influence of the social context on a child's loneliness, but also highlights the influence of mutual friendships in childhood on buffering the effects of rejection on loneliness in peer situations. The impact of peers on children's loneliness has an increasing impact on children as they get older as the role of parents in the child's life decreases (Lila, van Aken, Musitu, & Buelga, 2006).

There may be a number of factors that play a role in the development of loneliness: 1) genetic susceptibility to loneliness, 2) maternal relational support, 3) parental levels of loneliness, 4) friend's level of loneliness, and 5) peer rejection. It is likely that an interaction of these risk factors results in loneliness. A summary of these factors and how they interact and change as the child develops is displayed in Figure 6.1. It may be that these factors vary in their impact depending on the age and stage of development of the child. For example, peer relationships and rejection may be an important influence during middle childhood when children are starting to form close and mutual friendships with peers; in the early school years parental support may still play an important role as parents are more in control of their child's friendships.

An important factor in understanding childhood loneliness is that not only do the influences on loneliness change over time but the understanding of loneliness changes as the child matures. Parkhurst and Hopmeyer's (1999) have proposed a model of developmental changes in loneliness (see Table 6.1) suggesting that loneliness is influenced by cognitive-developmental changes through childhood. Children and adolescent's abilities to think about relationships with others are influenced both by what they want in their relationships and what makes them feel lonely. Young children experience loneliness in relation to lack of physical contact and proximity to other children. When the child is able to reflect on and represent simple relationships between individuals, similarity, joint engagement, sharing, and enjoyment become important. In middle childhood the child is able to reflect on complexity of their relationships and they begin to explore loneliness relative to their past treatments by others. In early adolescence abstract thought develops and relationships are defined in terms of constructs, such as, friendship, popularity and prestige. Older adolescents can review these abstractions in a coordinated way; thus, they describe and experience loneliness in relation to psychological distance from others.

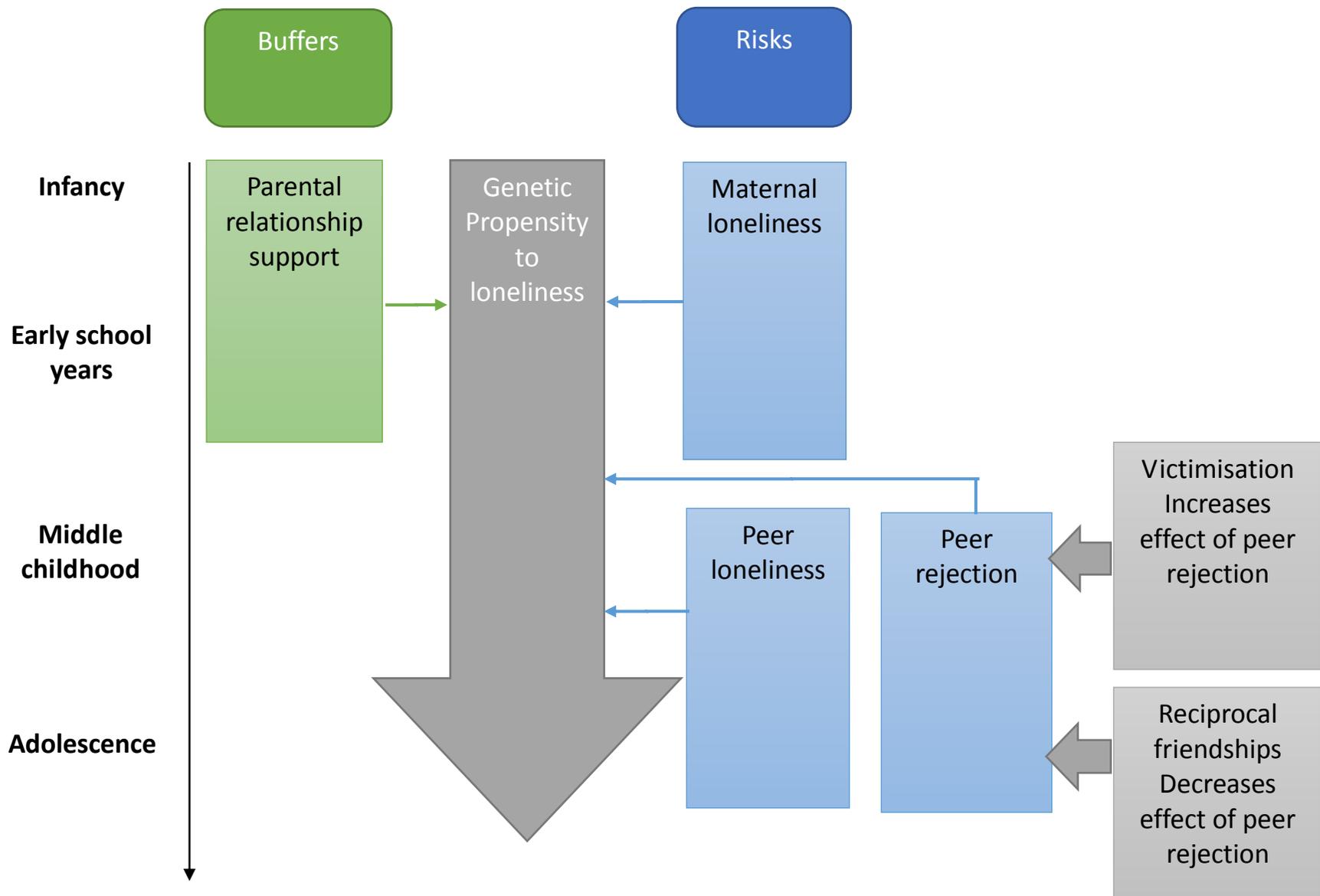


Figure 6.1 Buffers and risk on the genetic propensity to loneliness through life stages in childhood

Table 6.1. Parkhurst & Hopmeyer's Model of Development changes in loneliness (from Parkhurst & Hopmeyer, 1999)

Age range	New peer relationships	New valued functions and activities provided by peers	New cognitions producing loneliness	New routes to lonely feelings through other emotions
Toddler and early preschool	Attachments to peers	Reassurance, affection, attention, and companionship	Alone in strange place, want affection, no attention from others, and miss friend	Fear and distress
Preschool, kindergarten, and early primary school	Dyadic friendships	Fun of coordinated play, shared fantasy, deviance and humour, and sense of "we-ness"	No one to play with and no one will be your friend	Boredom
Primary school and elementary school	Cliques	Helpers, allies, defenders, gossips, and people to play group games and sports with	Conflict with friend; ostracism; rebuff; left out, let down, slighted, ignored, or disregarded by group; no one to go for help; and treated meanly or unfairly by friends	Social anxiety; humiliation from slights, insults, unfair treatment, ridicule, or abuse and shame over lack of competence in areas valued by peers
Upper elementary grades, middle school and junior high school	Crowds, prestige, acceptance, romantic flirtations, and crushes	Confidants, banter, sense of belonging, models, sense standing, sense of worth, meaning, and identity based on association with group	Breach of confidence, friendship betrayed, no one to confide in, feel socially distanced, don't belong, lack group to identify with, despised, nobody in others' eyes, not valued or important, and not likeable or attractive	Shame because unattractive, unlikeable, unacceptable, and unpopular and humiliation of felt damage to social standing or loss of face
High school and college	Romantic relationships	Fellow-explorers in search of identity based on self-understanding, ideology, values, goals, social roles, etc., and intimacy	Feel psychological distance, no rapport with others, no one to talk to about philosophical issues, not understood, feel like a social misfit, lack or loss of intimate relationship, and feel that will never find anyone to share intimate relationship with	Emptiness and alienation

This model indicates that levels of loneliness may change with age and stage of development of the child, and hence may not be consistent and static in childhood.

Cross sectional studies have explored self-reporting of loneliness at different ages to examine whether loneliness levels change across childhood and adolescence. Loneliness in middle childhood appears to be relatively stable, remaining at a similar level over time (Bartels, Cacioppo, Hudziak, & Boomsma, 2008; Renshaw & Brown, 1993). Cross-sectional studies demonstrate conflicting results for loneliness in adolescence: some studies indicate that loneliness increases (Parkurst & Asher, 1992), whereas others suggest that loneliness decreases in adolescence (Luftig, 1988) in comparison to levels of loneliness at other childhood ages. Margalit (2010) suggests that the decrease in loneliness sometimes found in cross sectional studies is not necessarily representative. She argues that adolescents are particularly reluctant to admit loneliness than younger children. There is also the possibility that adolescents are more accepting of times of solitude and may look on lonely times more positively than younger children. Adolescents spend increasing time alone and have learnt how to deal psychologically with aloneness (Long & Averill, 2003). Larson (1997) suggests adolescents may experience loneliness more positively than younger children because 1) they have developed advanced reasoning skills that allow them to use solitude constructively, 2) their social environment is characterised by increased self-consciousness and conformity pressure, and 3) solitude provides a special opportunity to struggle with pressing issues of identity formation.

Cross-sectional studies do not examine the way loneliness in children changes over time and are merely reporting numbers of each age group who are lonely. There is a need for longitudinal studies that examine first, the growth of loneliness over time in all children, and second, the variability in loneliness across time for different people. Trajectory studies enable examination of growth of loneliness over time, but also the examination of unique growth patterns for clusters of individuals. There are currently only a few trajectory studies on loneliness and these identify that, for at least some children, the experience of loneliness is stable and chronic.

Jobe-Shields, Cohen, and Parra (2011) examined loneliness over a 3-year period in middle childhood (9-11 years) and demonstrated that there were three distinct groups of children: a large group of low and stable lonely children, a moderate and increasing group, and a small group of children who had elevated and

decreasing loneliness. It is likely that the stable low loneliness group may be over-represented in previous research indicating that loneliness in middle childhood remains stable. Jobe-Shields et al. (2011) suggest that the decreasers are children in transition and their loneliness may be context-specific relating to peer difficulties they may have experienced. A more recent trajectory study (Qualter et al., 2013b) examined loneliness over a much longer period from childhood through to adolescence (5-17 years) and found similar trajectories to Jobe-Shields et al. (2011): increasers, decreasers, and stable low loneliness, but also found a high stable loneliness group. Predictors (at age five) for the high stable lonely trajectory group included low trusting, low peer acceptance, parent reported negative reactivity, an internalizing attribution style, low self-worth, and passivity during observed play. In a sample of older adolescents (15-20 years) Vanhalst, Goossens, Luyckx, Scholte, and Engels (2012) also found increasers, decreasers, low stable, and high stable lonely groups. Membership of the lonely groups was determined by personality factors at age 15 years and psychosocial functioning at 20 years old. Van Roekel et al. (2010) examined loneliness over a 5-year period in adolescence (12-18 years) and demonstrated that loneliness levels remained stable for those who had the serotonin transporter genotype associated with loneliness susceptibility (see Chapter 2) and received little maternal support. But for those who received high maternal support their high loneliness levels reduced over time. It appears, then, that loneliness is particularly complex in adolescence and may depend on parental relational support.

To further complicate the understanding of loneliness in adolescence it may be that the nature of loneliness also changes within the adolescent period. Marcoen, Goossens, and Caes (1987) examined changes in loneliness during adolescence (from 11-17 years in a sample studied cross sectionally) and found that loneliness in relation to parents increased with age, but there was a sudden drop at seventh grade. The authors suggest that this drop in parent loneliness may be the result of increased parental involvement with adolescents at a time of transition from primary to secondary education to support their transition. In comparison, peer related loneliness and aversion to aloneness decreased with age. This is supportive of the suggestion that adolescents may view solitude more positively and this impacts on their reporting of loneliness (Long & Averill, 2003; Larson, 1997). In Vanhalst et al's (2012) sample of older adolescents (15-20 years) loneliness reduced at a group level. Interestingly, in another study with older adolescents (15-18 years), Goossens

et al. (2009) demonstrated a positive association between peer-related loneliness and affinity to loneliness, indicating that there is a relationship between peer-related loneliness and a positive attitude to solitude. Together these studies highlight the need to examine childhood loneliness longitudinally as there may be children who experience chronic and stable loneliness for a number of years. The health effects of loneliness may be cumulative (Cacioppo & Hawkley, 2009; McEwen, 1998; Seeman, Singer, Ryff, Love, & Levy-Storms, 2002, also see Chapter 2) and will be evident in children who experience chronic and stable loneliness for a number of years.

### *Transient and chronic loneliness and health*

Studies have begun to demonstrate health differences in adults who have experienced loneliness chronically and those where the experience has been short term (Shioitz-Ezra & Ayalon, 2010). Researchers suggest that it is the chronicity of loneliness that is a cause for concern (Luanaigh & Lawlor, 2008; Page, Wrye & Cole, 1986). Given the complexity of loneliness in adolescence, it is essential to explore trajectories of loneliness throughout childhood and adolescence using longitudinal designs. These studies also give opportunities to examine differences between chronic and transient loneliness. Research has demonstrated a genetic factor to loneliness (Boomsma, Willemsen, Dolan, Hawkley & Cacioppo, 2005; McGuire & Clifford, 2000) and some mechanisms have been implicated, such as polymorphisms in receptors for serotonin (van Roekel, Scholte, Verhagen, Goosens, & Engels, 2010) and oxytocin (Lucht, et al., 2009) (outlined in Chapter 2). It may be that some children have a disposition towards loneliness (i.e. trait loneliness, Jones & Carver, 1991; Jones, Rose & Russell, 1990) and, therefore, experience it chronically. Some children may have a genetic risk for loneliness, but have these effects buffered by a number of factors: 1) maternal parent support, 2) parents who are not lonely, and 3) best friends who are not lonely. It is also possible that those with the genetic propensity for loneliness will have the likelihood of experiencing loneliness longitudinally increased if they have 1) limited maternal relational support, 2) a parent who is lonely, 3) peers who are lonely, and/or 4) experience peer rejection. If health differences occur in relation to childhood loneliness it is most likely that children who experience loneliness over a number of years would experience poor

health. These factors that either buffer or increase the risk of experiencing long term loneliness in childhood are displayed diagrammatically in Figure 6.1.

### *Assessment of loneliness in children*

Research into loneliness in childhood and adolescence has tended to use questionnaire measures or adapt these for use in an interview for the youngest children. Two main questionnaire measures for self-reports of loneliness are generally used; Loneliness and Social Dissatisfaction Measure (Asher & Wheeler, 1985) and the Loneliness and Aloneness Scale for Children and Adolescents (Marcoen & Brumage, 1985), although others have been developed (such as the Relational Provision Questionnaire, Hayden, 1989). These are compared in Table 6.2. The Loneliness and Social Dissatisfaction measure (Asher & Wheeler, 1985) involves assessment of loneliness and appraisal of peer relationships. This has two problems: 1) it focuses on social activities and relationships so emotional loneliness is not assessed and is, therefore, really a measurement of social rejection rather than loneliness, and 2) it measures only loneliness in school, not peer or family loneliness (Qualter, 2003).

Marcoen and Brumage (1985) developed the Loneliness and Aloneness Scale for Children and Adolescents (LACA). This is a better assessment than the other scales because it measures the discrepancy between actual and desired social relationships (emotional loneliness) which is part of the ideology of loneliness. Hence, the measure is better at assessing emotional loneliness than social loneliness (see Chapter 2). It is also a useful measure as it assesses levels of loneliness in different contexts, for example, peer relationships, and family relationships which may vary dependent on the child's age and developmental stage. It also includes a measure of aversion to and affinity to loneliness that examines liking and disliking of aloneness. This is an important measure for longitudinal studies because the multiple categories of loneliness give an opportunity for structural changes in loneliness to be measured. The LACA scale also enables the complexity of loneliness in adolescence to be explored because it includes the measure of affinity for and aversion to aloneness.

Table 6.2. Assessment of loneliness in children and adolescents

Loneliness assessment measure	Reference	Description	Psychometric properties
Loneliness and Social Dissatisfaction Measure	Asher & Wheeler (1985); Asher, Hymel & Renshaw (1984)	Uni-dimensional measure of loneliness, 24 item Likert scale (16 items for loneliness and 8 filler items), numerical responses between “that’s not true about me” and “that’s always true about me”	High internal consistency, $\alpha = .90$ , good internal reliability (split-half) .83-91
Louvian Loneliness Scale for children and adolescents (renamed Loneliness and Aloneness Scale, LACA)	Marcoen, Gooseens, & Caes (1987) Marcoen and Brumage (1985)	Multi-dimensional measure of loneliness, 48 item 4 point scale (often, sometimes, seldom and never), 4 subscales of parent loneliness, peer loneliness, aversion to aloneness, and affinity to aloneness	Good internal consistency $\alpha = .80$ , low shared common variance in subscales

### *Loneliness and health in children and adolescents*

In comparison to the wealth of research literature on health and loneliness in adults (outlined in Chapter 2), there is limited research on loneliness and physical health in childhood. A few studies have examined specific health risk behaviours in childhood, but only in adolescence, findings show that loneliness is associated with less physical activity (Page & Tucker, 1994), reporting more symptom patterns of psychological, physical, and psychosomatic manifestations of psychological distress (such as headaches, loss of appetite), and reporting low general perceived health status (Mahon & Yarcheski, 2003; Mahon, Yarcheski, & Yarcheski, 1993). Lonely early and middle adolescents also report greater sleep disturbance, such as midsleep awakenings, movements during sleep, and soundness of sleep than non-lonely, but no difference in sleep patterns is found between lonely and non-lonely late adolescents (Mahon, 1994). These cross-sectional studies are limited because they do not explore the impact of long term loneliness on children's health and focus only on adolescent loneliness.

Page, Frey, Talbert, and Falk (1992) demonstrated that children who report being lonely are less physically fit and physically active than those who were not lonely and this relationship is most pronounced in ages 8-10 years. Løhre, Lydersen, and Vatten (2010) demonstrated that loneliness has strong positive associations with sadness, anxiety and headaches in children aged 7-16 years. There are some difficulties with this study. First, depression was not controlled, which has independent effects on health (Bradley, Burns, Tweed, & Erickson, 2002; Glassman, 2007; Pariante & Lightman, 2008); second, the study used a limited measure of frequency of headaches to measure health, which could indicate emotional turmoil rather than poor health. Further research is necessary with more objective health measures and self-reporting that involves a variety of health indicators.

Recently, a few studies have examined mental health in younger children experiencing long term loneliness. Qualter, Brown, Munn, and Rotenberg (2010) demonstrated that, like adults, long term loneliness in childhood can lead to difficulties with mental health during adolescence. This is an important study because it also demonstrates the impact of the chronicity of loneliness on mental health in childhood, highlighting the limitation of existing studies on childhood loneliness and physical health which are all cross-sectional studies and restricted to

adolescence. This thesis aims to address this gap in the childhood literature by examining longitudinal loneliness and physical health, to determine whether, similar to adults, (Cacioppo, Hawkley, & Thisted, 2010; Shioitz-Ezra & Ayalon, 2010) it is the long term experience of loneliness that is the risk factor for poor health in childhood.

In addition, there is evidence to suggest that there may be a developmental life course to the health risks associated with loneliness. Caspi, Harington, Moffitt, Milne, and Poulton (2006) have implicated social isolation in childhood as an increased risk for cardiovascular disease in adulthood. They controlled for other risk factors (i.e. low social economic status) and other factors that could lead to social isolation (i.e. obesity or aggression) and demonstrated peripheral and isolated roles in peer groups in childhood had persistent and a cumulative effect on poor adult health. What is yet to be examined is whether long term loneliness has an impact on children's health or whether these health effects occur later on in adulthood. Thus, it is important to examine loneliness over a number of years in childhood to establish associations between particular growth patterns of loneliness over time and poor physical health.

#### *Loneliness and health in children and adolescents: Theoretical Implications*

Cacioppo and Hawkley's (2009) model for loneliness and health (outlined in Chapter 2) suggests that lonely individuals have a hyper-vigilance for social threats which in turn increases activation of physiological alert systems, such as the hypothalamic-pituitary-adrenal (HPA) axis. This heightened activation of the HPA causes cumulative wear and tear on physiological systems resulting in poor health (McEwen & Stellar, 1996). As hypersensitivity to rejection has been demonstrated in lonely children (Qualter et al., 2013a) it may be that the HPA axis is also activated in social encounters that impact directly on health in childhood. Cacioppo and Hawley's (2009) model examines the developmental aspects of loneliness. Given there is evidence to indicate particular growth patterns of loneliness across childhood and adolescence and developmental factors increase the risk or buffer the experience of loneliness, it is essential that Cacioppo and Hawley's (2009) model of loneliness and health is examined from a developmental perspective.

*1) Studies examining HPA axis*

There is vast literature on the impact of loneliness on HPA axis functioning in adulthood examining the cortisol diurnal rhythm (Cacioppo et al., 2000; Doane & Adam, 2010; Steptoe, Owen, Kunz-Ebrecht, & Brydon, 2004,) but there are currently no studies examining HPA axis diurnal rhythm in children. This thesis aims to address this gap in the literature, examining daily HPA axis rhythm in lonely and non-lonely children. Assessment of cortisol in childhood is similar to that of adults (outlined in Chapter 2). Cortisol studies on child populations also examine 1) the cortisol awakening response (CAR), 2) investigate the steepness of the cortisol slope across the day, 3) measure the total cortisol output, 4) measure cortisol at specific time points, and 5) measure cortisol response to momentary experience, using the same methodology used in adult studies (see Chapter 2). Although, concerns have been raised about compliance and adherence to protocol in cortisol research with younger populations (Jessop & Turner-Cobb, 2008), studies demonstrate good compliance and adherence rates in child populations (Rotenberg & McGrath, under review) perhaps because parents typically assist children with saliva sampling.

Factors to control for in analysis of data when measuring cortisol in children are also similar to those in adults (see Chapter 2), i.e. sleep patterns, menstruation, and food and drink. There is some evidence that indicates that cortisol may be age and gender-dependent, but it has not been systematically investigated (Jessop & Turner-Cobb, 2008). To ensure reliability of measurement, researchers should ensure that there are strict age ranges and gender differences should be explored as current results are contradictory; some studies find gender differences (e.g. Sondejker et al., 2007, particularly in morning saliva samples) and some do not (e.g. Chryssanthopoulou, Turner-Cobb, Lucas, & Jessop, 2005). One factor that is important to control for within child populations is body mass index (BMI) because obesity in children has been linked to HPA dysfunction (Dockray, Susman, & Dorn, 2009; Hershberger, McCammon, Garry, Mahar, & Hickner, 2004). Therefore, it is important to avoid recruitment of obese children in cortisol studies (Jessop & Turner-Cobb, 2008).

In adulthood, studies have shown that lonely adults have a higher cortisol awakening response (Steptoe et al., 2004), increased levels of total cortisol output

(Cacioppo, et al., 2000) in comparison to non-lonely people. In addition, prior day feelings of loneliness are also associated with a higher cortisol awakening response the next day in the general population (Adam, Hawkley, Kudielka & Cacioppo, 2006), demonstrating that the state of loneliness increases cortisol. Doane and Adam (2010) found that trait loneliness was associated with a flattened diurnal cortisol rhythm in 17-20 year olds. In that study, both daily and state loneliness was related to momentary increases in cortisol; feeling lonely on the previous day increased the cortisol awakening response the following day, and expressing loneliness at one time point increased cortisol at the next time point. This evidence suggests that the daily function of the HPA axis is significantly different in late adolescents/young adults who are lonely, indicating that this may also occur for children and early adolescents.

There is evidence to suggest that HPA axis functioning in lonely children could be heightened. Cortisol levels are higher when adolescents (13-19 years) are alone than when with others. This effect is mediated by age with less effect for the oldest adolescents (Adam, 2006). Preschoolers who spend more time playing in isolation at pre-school also have higher morning levels of cortisol (Sanchez-Martin et al., 2001). These studies demonstrate that HPA axis activation is associated with aloneness. In addition, cortisol levels have been shown to rise in children in response to social encounters and challenges. For example, two-year old children starting day care had an increase in cortisol levels that was dependent on their previous levels of experience of social interaction with others (Ouellet-Morin et al., 2010). Also, Schmidt, Fox, Sternberg, Gold, Smith, and Schulkin (1999) demonstrated a greater decrease in salivary cortisol from 20 minutes to 35 minutes following a self-presentation task in seven year olds scoring high on perceived social competence, indicating increased stress recovery. Taken together the studies on solitude and social challenges indicate that HPA axis functioning increases in relation to the social context. Therefore, lonely children may find social challenges more demanding and display a heightened activation of physiological alert systems than non-lonely children. Cacioppo and Hawkley's (2009) model of loneliness and health would predict that lonely children would have an increased alertness for social threat in everyday life resulting in increased HPA axis activation.

This thesis aims to address this gap in the loneliness literature by examining HPA functioning in children who have experienced loneliness for a number of years and children who are currently lonely.

## 2) *Studies examining hypervigilance to social threat (HSTH)*

Similar to adults, lonely children display negativity (Qualter & Munn, 2002; Renshaw & Brown, 1993) and passivity (Coplan, Closson, & Arbeau, 2007) to social encounters. Some lonely children also display hostility and aggression (Coplan et al., 2007; Qualter & Munn, 2002) in their social interactions. Qualter et al.'s (2013a) eye tracker study indicates that lonely children (as young as 8 years old) have difficulty disengaging from socially threatening stimuli in comparison to non-lonely children. This demonstrates that children are displaying the HSTH (Cacioppo & Hawkley, 2009) because they are initially focused on the social threat information (hypervigilance) and continue to have a difficulty to disengage from this threat information. This differs to eye tracker results with adults that shows that lonely adults display an initial vigilance (evidenced by attention fixation) followed by avoidance of the stimuli (Bangee, Harris, Bridges, Rotenberg, & Qualter, under review). These findings indicate that there may be developmental changes in attention processing of social threat stimuli for lonely people. Lonely adults initially fix their attention on social threat stimuli, but they are able to disengage much quicker than lonely children. Changes in cognitive ability, particularly the ability to relocate attention (Casey, Galvan, & Hare, 2005), are likely to be implicated in these changes in information processing.

There are no studies to date that examine HSTH within a real life context in childhood. The thesis aims to address this gap examining a real life social challenge for children: transition to secondary school. This transition places additional demands on social interaction and is comparable to the adult studies in this thesis that compare HPA axis functioning and HSTH in relation to real life social challenges (see Chapters 5 and 6). In relation to Cacioppo and Hawkley's (2009) model it would be expected that lonely children will experience increased stress during a transition period, display more HSTH, and have poor adjustment to the transition. The adult and child literature and studies within this thesis are compared in the discussion following the child section (Chapter 11) and Cacioppo and Hawkley's (2009) model is re-examined in the general discussion (Chapter 12).

### *3) Studies examining cognitive biases*

Cacioppo and Hawkley (2009) indicate that HSTH leads to cognitive biases. Although, eye tracker studies carried out with children display evidence of the HSTH in childhood, no studies have examined whether lonely children display cognitive biases. What is also yet to be examined is whether children display the cognitive impairments/deficits that lonely adults experience, such as increased memory for social information (Gardner, Pickett, Jeffries, & Knowles, 2005) and difficulties with voluntary attentional control (Cacioppo et al., 2000). This thesis aims to address this gap in the literature by detailing a series of cognitive studies that examine cognitive biases and deficits in childhood in relation to loneliness.

### *Gaps in loneliness and health literature in children*

There are a number of areas that warrant further investigation in the child literature that are addressed in this thesis:

*First, examination of whether it is the long term experience of loneliness in childhood that is associated with poor health.* Research indicates that loneliness has a cumulative effect on health through increased physiological responding to social threats (Cacioppo & Hawkley, 2009). Therefore, it is likely that, because loneliness is reported in very young children (Coplan et al, 2007; Cassidy & Asher, 1992) and hypersensitivity to rejection is present in lonely children (Qualter et al., 2013a), heightened response to social threats and increased activation of the HPA axis may also occur in lonely children. The adult loneliness literature suggests that the cause for concern is with loneliness that is chronic and persistence (Luanaigh & Lawlor, 2008; Page, Wrye & Cole, 1986). Thus, it is important to compare transient and chronic loneliness in children because health differences may only be apparent in children that have experienced loneliness consistently for a long period of time.

*Secondly, examination of whether there are cognitive biases for social information and cognitive impairments in relation to childhood loneliness.* Cacioppo and Hawkley (2009) indicate that this HSTH leads to cognitive biases. Although, eye tracker studies carried out with children display evidence of the HSTH in childhood, no studies have examined whether lonely children display cognitive

biases, such as increased memory for social information and display the cognitive impairments/deficits that lonely adults experience.

*Third, examination of social threat evaluation in real life social challenges for children.* There are no studies to date that examine HSTH within a real life context in childhood. The thesis aims to address this gap examining a real life social challenge for children: transition from primary to secondary school. Childhood transition places additional demands on social interaction and is comparable to the studies in the adult section of this thesis that compare physiological functioning and HSTH in relation to real life social challenges (see Chapters 3 and 4), thus, this study enables a comparison between the results in the adult and child sections of this thesis.

### *Research Aims*

Research aims for the child section are as follows:

- To extend existing childhood literature to examine loneliness longitudinally and its impact on physical health.
- To advance theoretical understanding of models of loneliness and health by examining differences in 1) health, 2) physiological and 3) cognitive functioning in lonely and non-lonely children, thus offering a developmental, life span approach to current literature.
- To further advance loneliness and health literature by exploring differences in health and HSTH in response to a real life social challenge (the transition to secondary school) between lonely and non-lonely children to offer ecological validity for Cacioppo and Hawkley's (2009) model.

### *Outline of Child Studies & Research Populations*

Four studies were carried out in the child section of the thesis to address the research aims. To address the weaknesses in the existing literature the studies used a longitudinal design and used two independent research samples: Lancashire Longitudinal Study of Emotional and Social Development (LLSED) and the North West Child Transition Study (NWCTS).

*Lancashire Longitudinal Study of Social and Emotional Development (LLSED)*

The Lancashire Longitudinal Study of Social and Emotional Development (LLSSED) is a prospective study of 417 children recruited from 32 schools in Lancashire, UK in 2006. Data were collected over three collection waves at least 18 months apart. Children were 8-10 years at the commencement of the study. The first two child studies were carried out with this child population. The first study (Study 3, outlined in Chapter 7) examined growth patterns of loneliness over a 4.5 year period in 8-10 year old children and health outcomes (self-reported health and sleep dysfunction). The second study (Study 4, outlined in Chapter 8) uses a sub-group of the same child population (LLESD) and examines diurnal cortisol patterns over a two-day period (one school day and one non-school day). The inclusion of this sample, enables a comparison between children who experienced long term loneliness and children who did not. Study 4 also examines current state of loneliness and diurnal cortisol patterns to examine whether it is the long term experience of loneliness or the current state of loneliness that results in an atypical cortisol diurnal rhythm.

*North West Child Transition Study (NWCTS)*

The North West Child Transition Study (NWCTS) involves a child population recruited from Year 6 classes (the final year of primary school) from 15 primary schools in Lancashire, UK in 2012. Children were recruited shortly before their transfer from primary to secondary schools when the children were 10-11 years old. Data were collected in July in the children's final year of primary school and October and January in the children's first year of secondary school. The final two studies in the child section of this thesis used this cohort of children. The third child study (Study 5 outlined in Chapter 11) examined differences in cognitive processing style (memory and attention for negative social information) in high lonely children in comparison to low lonely children. The fourth child study (Study 6, outlined in Chapter 10) examined patterns of growth of loneliness across the transition from primary to secondary school and associated adjustment, health, stress response, and evaluation of social threat to patterns of high stable loneliness across the transition period.

## Chapter 7: Study 3 – Long term experiences of loneliness and health in pre/early adolescence

### Introduction

There is vast research that links loneliness to poor health in adulthood, but there are few studies that examine whether there is a link between loneliness and poor health in childhood. Recent adult studies have demonstrated that it is the chronicity of loneliness that is linked to poor health. What is missing from the childhood literature is an examination of whether loneliness that persists over time is also associated with poor health. To address gaps in the current literature Chapter 8 outlines a study that examined loneliness trajectories in middle childhood to adolescence and health outcomes at 11 years.

#### *Loneliness and health in adulthood*

Loneliness in adults has been linked to poor health (Cacioppo & Hawkley, 2003), poor mental well-being (Cacioppo, Hughes, Waite, Hawkley, & Thisted, 2006), higher risks of cardiovascular disease (Hawkley et al 2010; Caspi, Harrington, Moffitt, Milne, & Poulton, 2006), higher blood pressure (Hawkley, Thisted, Masi & Cacioppo, 2010), greater sleep dysfunction (Cacioppo, Hawkley, Bernston, Ernst, Gibbs, Stickgold, & Hobson, 2002; Steptoe et al., 2004), and reduced physical activity (Hawkley, Thisted, & Cacioppo, 2009; Page & Hammermeister, 1995). Recent research in adulthood has demonstrated that those who experience long term loneliness are more likely to experience poor health than those who experience short term loneliness (Shiotiz-Ezra & Ayalon, 2010).

#### *Loneliness and health in childhood*

A few cross-sectional studies indicate that poor health may also be evident in lonely children. In line with adult literature, lonely adolescents report lower perceived health status and increased symptoms of psychosomatic manifestations of psychological distress, such as headaches and loss of appetite (Løhre, Lydersen, &

Vatten, 2010; Mahon & Yarcheski, 2003; Mahon, Yarcheski, & Yarcheski, 1993). These studies indicate that health differences between lonely and non-lonely may be evident in childhood and adolescence as well as adulthood. However, evidence for links between loneliness and poor health in childhood is sparse and empirical evidence has not examined health differences in children who experience chronic and stable loneliness. Long-term experiences of loneliness in adulthood are associated with increased mortality risk (Shiovitz-Ezra & Ayalon, 2010) and poor self-reported health (Tijhuis et al., 1999), but analyses of loneliness over time and its association with health outcomes is missing from the pre- and early-adolescence literature. The current study examines whether poor health is associated with a particular pattern of loneliness over time. Based on past research, it is expected that poor physical health outcomes will be associated with a high developmental trajectory of loneliness in middle childhood to pre-/early adolescence.

#### *Importance of examining loneliness longitudinally*

Given evidence that even young children are able to report on their loneliness feelings (Coplan, Closson, & Arbeau, 2007; Cassidy & Asher, 1992; Qualter & Munn, 2002), it is important to examine the time course of loneliness before adolescence. Often researchers simply consider the growth in a given phenomenon in terms of mean average across the whole sample. Using a mean approach to modelling behaviour assumes that the growth trajectories of all individuals in the sample can be adequately described using a single estimate in growth parameters; the assumption is that all participants are drawn from a single population with common experiences. However, this may not be the case, and there is a need to examine inter-individual differences in loneliness over time. Such an examination with children in America was completed by Jobe-Shields, Cohen, and Parra (2011). They found distinct trajectories of loneliness from 9-11 years of age. These three distinct loneliness trajectories included (1) the majority group that had low, stable loneliness, (2) a group that increased in loneliness, and (3) a final group that decreased in loneliness across middle childhood to pre-adolescence. This study is important as it identified different subgroups of lonely children/early adolescents and loneliness with different growth patterns of loneliness. However, growth mixture modelling is a sample-specific technique and replication in other samples is essential. Thus, the

current study, examines first, the general course of loneliness from middle childhood to pre-adolescence in a UK sample. Second, individual differences in the trajectories of loneliness are investigated for these children.

### *Loneliness and Sleep*

Loneliness is associated with sleep dysfunction in adults: lonely adults spend similar amounts of time in bed to non-lonely peers, but they spend more of this time awake (Cacioppo et al., 2002; Steptoe et al., 2004) and they report more daytime dysfunction linked to poor sleep efficiency (Hawkey et al., 2010). Patterns of sleep dysfunction have also been reported in lonely early and middle adolescents: greater sleep disturbance, such as mid-sleep awakenings, movements during sleep, and soundness of sleep are reported in lonely adolescents in comparison to their non-lonely peers (Mahon, 1994).

Missing from the research with children is an attempt to differentiate between the sleep efficiency of people who experience transient versus chronic loneliness. As loneliness trajectories differentially predict health outcomes in adults (Shiovitz-Ezra & Ayalon, 2010; Tjihuis et al., 1999), it is important to determine whether sleep dysfunction is associated with a specific trajectory of loneliness in childhood and pre-/early adolescence. The longitudinal design of the current study enabled an examination of how developmental trajectories of loneliness are associated with sleep dysfunction. Given that previous literature has identified a special significance to loneliness experienced over time, it is expected that reduced quality of sleep and time spent asleep are associated with high loneliness in pre-/early adolescence.

### *Loneliness and depression*

Loneliness tends to be co-morbid with depression (Cacioppo, Hughes, Waite, Hawkey, & Thisted, 2006; Segrin, 1998) and chronic loneliness is longitudinally predictive of depression in adults (Cacioppo, Hughes, Waite, Hawkey, & Thisted, 2006) and adolescents (Qualter et al., 2010). Similar to loneliness, depression is associated with poor health related quality of life (Bradley, Burns, Tweed, & Erickson, 2002), cardiovascular disease (Glassman, 2007) and dysregulation of the HPA axis in adults (Pariante & Lightman, 2008). Given the

association between depression and poor health it may be the co-morbidity of depression in loneliness that results in the poor health demonstrated in lonely individuals. However, previous research has shown that the health effects of loneliness remain when depression is controlled in analyses (Cacioppo et al., 2002b; Hawkey, Burleston, Bernston, & Cacioppo, 2003).

Depression has also been associated with sleep difficulties (Thase, Kupfer, Fasiczka, Buysse, Simons, & Frank, 1997; Tsuno, Besset, & Ritchie, 2005). However, previous studies with both adult and adolescent samples that have examined the association between loneliness and sleep quality have not controlled for depression (Mahon, 1994; Steptoe et al., 2004). A more recent study suggests that loneliness may have an impact on recuperative processes that is distinct from the effect of co-variables, such as depressive symptoms (Hawkey et al., 2010). The current study, therefore, examines the impact of high loneliness on health and sleep in pre-/early adolescents, and considers whether loneliness has a distinct impact on health and sleep quality by controlling for depression in all analyses.

#### *The current study*

The aims of the current study were to (1) examine the course of loneliness from middle to pre-/early adolescence, and (2) examine the association between loneliness over this time period and associated health outcomes. First, the general course of loneliness over time from middle to pre-/early adolescence was examined. Second, the inter-individual differences in loneliness trajectories were identified in this sample. As the children in the current study are similar in age to those in Jobe-Shields et al. (2011), it was hypothesised that most children would follow a trajectory of loneliness characterised by low levels of loneliness. In addition, it was expected that two further groups would emerge: one with a decreasing trajectory of loneliness and one with an increasing one. Finally, the current study investigated whether health outcomes were associated with unique growth patterns. Based on previous work with adults (Shiovitz-Ezra & Ayalon, 2010; Tjshuis et al., 1999), it was hypothesised that poor health would differentiate between the loneliness trajectories.

## Method

### *Participants and Procedure*

The participants were a sample of children from the Lancashire Longitudinal Study of Social and Emotional Development (LLSSED), which is a prospective study of 417 children recruited from schools in Lancashire, UK. Self-reports of loneliness, depressive symptoms, and health were included at three waves that took place 18 months apart. Only children who were 8-10 years at the commencement of the study and had provided health data at two or more data collection waves (including time 1) were included, resulting in inclusion of 224 children in the current study. At Time 3, a small group of these children ( $N = 15$ ) were not available for data collection within the schools due to moving away from the area and completed the questionnaires at home. However, this resulted in low reliability of the loneliness measure (alphas of less than .20), so these children were removed from the sample. Thus, the final sample used in the present study is 209 children. Mean age of these children at the first measurement wave was 8.13 years ( $SD = .80$ ) and 50.7% were male. The participant's primary care-giver gave written consent at each wave of data collection, and all participants were tested in accordance with the national and local ethics guidelines according to the Declaration of Helsinki.

### *Measures*

*Peer-related loneliness.* Loneliness in relation to peers was measured using the peer subscale of the Loneliness and Aloneness Scale for Children and Adolescents (LACA; Marcoen & Brumage, 1985). This subscale includes 12 items, including "I feel isolated from other people" and "I feel excluded by my classmates". Participants are asked to indicate how often each item applies to them on a 4-point scale: "often", "sometimes", "rarely", or "never". A mean score was calculated for this sub-scale, so possible scores ranged from 1 to 4. Higher mean scores on the scale are indicative of greater loneliness in relation to peers. The LACA has been found to display acceptable internal consistency, reliability, and validity (Goossens & Beyers, 2002; Marcoen & Goossens, 1993; Marcoen, Goossens, & Caes, 1987). Although originally used with Dutch-speaking children, it has also been used with

English-speaking children (De Roiste, 2000; Qualter & Munn, 2002, 2005; Terrell-Deutsch, 1999). In the current study, this sub-scale demonstrated acceptable internal consistency across the three time points ( $\alpha = .79, .82$  and  $.84$  for T1, T2, and T3 respectively).

*Overall perceived physical health.* The Pediatric Quality of Life Inventory (PedsQL: Varni, Seid, & Rode, 1999) is an American measure of health-related quality of life, which has been validated for use in the UK (Upton et al., 2005). The PedsQL has acceptable internal consistency, reliability, and validity (Varni, Limbers, & Newman, 2009; Varni, Seid, & Kurtin, 2001). The scale has 4 sub-scales, but only the physical functioning sub-scale was used in the current study. This sub-scale has 8 items. Examples include “It is hard for me to run”, and “It is hard for me to do sports activity or exercise”. Participants are asked to indicate how often each item has been a problem for them in the last month on a 5-point scale (0-4): “never”, “almost never”, “sometimes”, “often” and “almost always”. Possible scores ranged from 0 to 32. For clarity and ease of explanation the PedsQL health sub-scale has been reversed so lower scores relate to poorer health quality of life. In the current study, the physical functioning sub-scale demonstrated acceptable internal consistency across the 3 time points ( $\alpha = .82, .86$  and  $.64$  for T1, T2, and T3 respectively).

*School absence.* At each of the three time points, children were asked to answer an item from the school subscale of the PedsQoL (Varni et al., 1999) that asks about days absent from school due to illness. Rather than use the data provided by the schools on actual school absence, we used this item (“I miss school because of not feeling well”) because it better reflects why children are not at school as it does not include other activities such as holidays, birthdays and family events, where children are absent from school for reasons not related to poor health. Higher scores on this PedsQL item indicate more days off school due to illness.

*Sleep.* At all time points, children answered the item from the emotional sub-scale of the PedsQoL (Varni et al., 1999) that asks about difficulty with sleeping (“I have trouble sleeping”). Participants are asked to indicate how often this item has been a problem for them in the last month on a 5-point scale (0-4): “never”, “almost never”, “sometimes”, “often” and “almost always”. Possible scores ranged from 0 to 4. Higher scores on this item indicate more trouble sleeping.

At Time 3 children were considered more able to articulate their sleep patterns so sleep dysfunction was addressed further using the sleep duration and sleep disturbances sections of the Pittsburgh Sleep Quality Index (PSQI), which is a 19-question self-report questionnaire that assesses the sleep quality over a 1-month time frame (Buysee, Reynolds, Monk, Berman, & Kupfer, 1989). This was used as it asks participants specific questions about difficulties with their sleep. Participants are asked to report on their sleep over the past month, specifically, their usual bed time, how long they take to get to sleep, usual getting up time and hours spent asleep. From these items, time spent in bed and time spent asleep was calculated. Participants were also asked to rate a series of statements regarding sleep disturbance using the following scale: not during the past month, less than once a month, once or twice a week or three or more times a week. Sleep disturbance statements used were “Cannot get to sleep within 30 minutes”, “wake up in the night” and “had bad dreams”. Participants are asked to indicate how often each item has been a problem for them in the last month on a 4-point scale (0-3): “not during the past month”, “less than once a month”, “once or twice a week”, and “three or more times a week”. Possible scores ranged from 0 to 4. Higher scores for each sleep disturbance indicate higher frequency of sleep disturbance.

The PSQI has been found to display acceptable test-retest reliability and validity (Backaus, Junganns, Broocks, Riemann & Hohagen, 2002; Carpenter, & Andrykowskia, 1998) and, although designed as a scale for adults, it has been used with adolescents (Ertan, Yilmaz, Caglayan, Sogut, Aslan, &Yuksel, 2009; Gozman, Keskin & Akil, 2008; Tan, 2004).<sup>9</sup>

*Depressive symptoms.* This was assessed by the 10-item short-form of the Child Depression Inventory (CDI; Kovacs, 1992). Each item consists of three choices (0, 1, 2). Scores range from 0 to 20 with higher mean scores corresponding to higher depressive symptoms. An example item is “I do most things okay” (0), “I do many things wrong” (1), and “I do everything wrong” (2). The short-form of the CDI scale has been found to display acceptable internal consistency, reliability, and validity (Kovacs, 1992; Kovacs & Beck, 1977). In the current study, this scale demonstrated acceptable internal consistency ( $\alpha = .82, .80$  and  $.85$  for T1, T2, and T3 respectively).

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<sup>9</sup> Internal consistency is not calculated because it measures specific aspects of sleep rather than reflecting on sleep quality i.e. each question measures a separate aspect

## *Data Analysis Plan*

Data analyses proceeded in three stages. First, the mean trend in loneliness was examined using latent growth curve modelling (LGCM). Multiple fit indices were consulted to assess model fit: the chi-square index, the root mean square error of approximation (RMSEA) and the comparative fit index (CFI). Hu and Bentler (1999) suggest that cut-off criteria indicative of good fit are  $RMSEA < 0.06$ , and  $CFI > 0.95$ ; chi-square should be as small as possible. Variance in the estimates related to the intercept and slope for loneliness were also explored, which would justify an examination of inter-individual differences in the trajectory of loneliness over time.

Second, the developmental trajectories of loneliness were examined using growth mixture modelling (GMM). Two-five group trajectory models were examined. Determining the number of latent profiles in the data is challenging and several criteria were used in making the decision: one set of criteria used to guide this decision had to do with the substantive meaning and theoretical conformity of the extracted classes (Muthén, 2003), but a number of statistical tests and indices were also used to help in this decision process (McLachlan & Peel, 2000): the Bayesian Information Criterion (BIC), the Adjusted BIC, Akaike information criteria (AIC), entropy, the Lo-Mendell-Rubin likelihood ratio test (LMR p-values). Recommendations suggest that the model with the smallest BIC, Adjusted BIC, and AIC (i.e., closest to zero), significant LMR p-value comparing the  $k$  and  $k-1$  class model, and entropy with values closer to 1 (range, 0-1) should be selected (Lo, Mendell, & Rubin, 2001; McLachlan & Peel, 2000; Nagin, 1999; Nylund et al., 2007).

In the third stage, differences between the trajectory groups in health outcome at age 11 were determined using Analysis of Co-Variance (ANCOVA). The longitudinal design of the study meant that earlier reported health problems could be controlled for in these analyses. Further, age 11 depressive symptoms and loneliness were also controlled for to ensure that any effects were a function of membership of the loneliness trajectories, and not determined by the end point of loneliness or depression.

## Results

### *Missing Data Analyses*

To minimize the bias associated with attrition and missing data, the expectation maximization (EM) algorithm was used to impute missing data (Schafer & Graham, 2002). This algorithm assumes that the data are missing completely at random (Little & Rubin, 1987; Schafer & Graham, 2002), but where these assumptions are not met, EM parameter estimates are still typically less biased than those estimated using ad hoc procedures such as pairwise or listwise deletion of missing data (Collins, Schafer, & Kam, 2001; Schafer & Graham, 2002). EM is appropriate when a moderate amount of missing data is noted as < 30% missing (Little & Schneker, 1995). In the current study, only children who participated in at least two of the three measurement waves (one of which had to be wave 1) were included in the present study. A total of 209 ( $M = 106$ , 50.7%) children met these criteria, with 33% of data missing. Little's (1988) Missing Completely At Random (MCAR) test was non-significant [ $\chi^2 = 344.799$ ,  $p = .447$ ], suggesting that missing values could be reliably estimated for this sample.

### *Development of loneliness at the group level*

LGCM was used to examine mean level changes in loneliness. Factor loadings were fixed at 0, 1, 2.<sup>10</sup> Results revealed a large decrease in loneliness across time ( $M$  intercept = 31.51, slope = -9.56,  $p = < .001$ ;  $\chi^2(3) = 126.56$ ,  $p < .01$ , CFI = .90, RMSEA = .069 ( $CI = .063-.074$ ). The results also showed significant variance in the intercept (unstandardized estimate = 14.36,  $p = < .001$ ) and slope (-16.76,  $p = < .001$ ), which justified an examination of inter-individual differences in loneliness over time.

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<sup>10</sup> When running the GMM, recommendations by Jung and Wickrama (2008) were followed to specify a latent class growth analysis (LCGA) model before moving to a growth mixture model (GMM). LCGA was used at the initial exploratory stages in the model building to determine whether any class needed its own class-specific variance. After running the LCGA, GMM was used where the within-class variances were freely estimated instead of fixed to zero.

*Trajectory Analysis*

The results from the GMM revealed that a two-group model showed the best fit to the data compared to a 1, 3, 4, or 5- group model<sup>11</sup> on three of the five fit statistics. Table 7.1 provides fit statistics and entropy values for the one- through five-class solutions.

Figure 7.1 presents the two class peer loneliness model, which includes (1) adolescents who followed a relatively high, reducing loneliness trajectory (N =100, 48% of sample), and (2) adolescents low on loneliness from middle childhood to early adolescence (N = 109, 52% of the sample). These two trajectory classes are presented in Figure 8.1, with means presented in Table 7.2.

Table 7.1. Conditional Latent Class Analysis for Peer Loneliness: Global Fit Statistics

	AIC	BIC	Adj. BIC	Entropy	LRT <i>p</i> value
Class					
1	2192.54	2212.17	2186.93		
2	2175.23	<b>2202.23</b>	2167.52	<b>.93</b>	<b>.0007</b>
3	<b>2174.74</b>	2209.09	<b>2164.93</b>	.87	.43
4	2176.87	2218.59	2164.95	.89	.27
5	2177.59	2226.68	2163.58	.91	.59

Notes: N = 217, AIC = Akaike information criterion; BIC = Bayesian information criteria; Adj. BIC = Adjusted BIC (Bayesian information criteria); LRT = Lo-Mendell-Rubin test. AIC, BIC, Adjusted BIC = lower values indicate a more parsimonious model; Entropy = values closer to 1 index greater precision (range: 0-1). The LRT = a low *p* value indicates a better fit to the data. Bold figures are those suggesting best fit.

<sup>11</sup> There were no more than 1% of children in the sample in classes above 5 groups

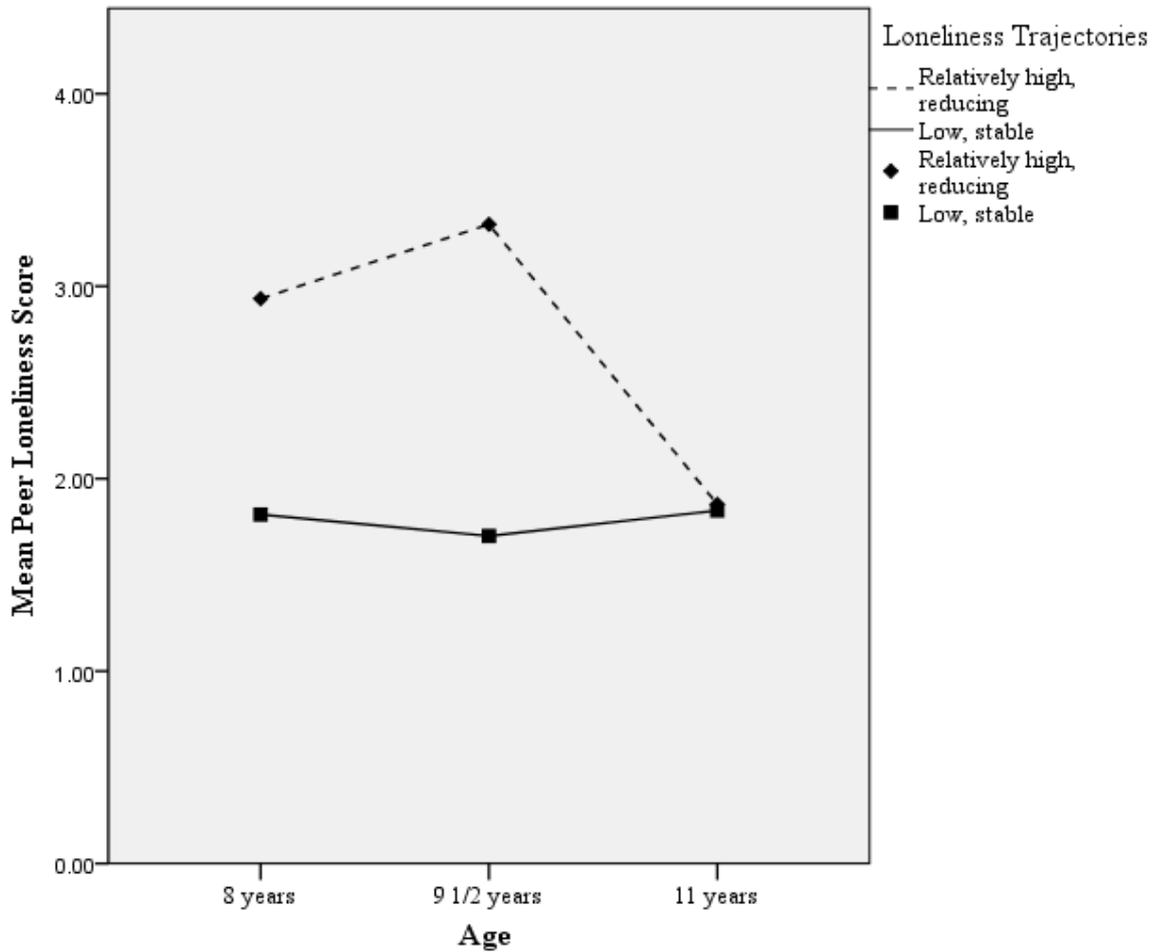


Figure 7.1. Two class solution for peer loneliness

Table 7.2. Mean Peer loneliness (and standard deviation) by time point and latent class

	Time 1*	Time 2*	Time 3
Mean age (years)	8.12	9.59	11.18
Relatively, high reducing lonely	2.92 (.55)	3.31 (.48)	1.87 (.34)
Low, stable lonely	1.81 (.39)	1.70 (.45)	1.82 (.35)
<i>MS</i>	66.36	141.95	.14
<i>F</i>	283.93	652.43	1.22
$\eta^2$	.57	.75	.006
Overall sample means	2.40 (.73)	2.56 (.93)	1.85 (.34)

Notes:  $df_1$  and  $df_2 = 1, 216$  respectively. \*The latent classes are significantly different from one another only at Time 1 and Time 2,  $p < .001$ .

### *Health Outcomes*

Differences in perceived general health, sleep duration and sleep disturbance, school absence due to illness, and depressive symptoms were examined by latent loneliness class. Correlational analyses (see Table 7.3) showed significant relationships between health outcomes and current mental health variables (depressive symptoms and loneliness at Time 3) and/or previous health reports for the whole sample. Thus, these variables were controlled in subsequent analyses. Depressive symptoms and loneliness showed similar relationships to the physical health variables.

Descriptive statistics and results for the series of ANCOVAs looking at health measures by peer loneliness latent class are summarized in Table 7.4. When controlling for earlier reports of poor health, and current loneliness and depressive symptoms, there were significant differences between the two loneliness classes on overall perceived health, PedsQL ‘trouble sleeping’, and sleep disturbance items from the PSQI. Adolescents with relatively high, reducing loneliness reported poorer perceived health, more trouble sleeping, took longer to get to sleep, and were more likely to wake up during the night than adolescents with low stable loneliness. Further, the groups differed significantly on depressive symptoms at T3, even when earlier depressive symptoms were controlled.

Table 7.3. Correlations between Time 1 and Time 3 loneliness, depression and physical health measures.

Health Measure	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<b>PedsQoL</b>														
1. General Health T1 <sup>§</sup>	.65***	-.31	-.11	-.28**	-.24**	.05	-.18**	-.28***	.11	.01	.11	-.26***	-.23***	-.19**
2. General Health T3 <sup>§</sup>		-.02	-.25***	.10	.19**	.13	-.19**	-.50***	-.20**	-.19	-.25**	-.29***	-.09	-.21**
3. Trouble Sleeping T1			.21***	.20**	.09	.08	.10	.17**	.18**	.31***	.18**	.01	.14*	.26***
4. Trouble Sleeping T3				.01	.01	.61***	.19**	.59**	.42***	.32***	.09	.51***	.06	.16*
5. Absent from School T1					.27***	.08	.06	.02	.01	.32***	.26***	.12	.06	.23**
6. Absent from School T3						.08	-.36	.09	-.33***	.04	.13*	.10	.02	.05
<b>PSQI<sup>†</sup></b>														
7. Minutes to sleep							.09	.49***	.22**	.18**	.21**	.36***	.33***	.04
8. Hours slept								-.17*	.19**	.25***	.18**	.11	.05	.03
9. Cannot get to sleep within 30 minutes									.49***	.12	.12	.51***	.17**	.14
10. Wake up in the night										.28***	.11	.33***	.22**	.23***
11. Had bad dreams											.22**	.32***	.01	.18**
<b>CDI</b>														
12. Depressive symptoms T1												.14*	.65***	.07
13. Depressive symptoms T3													.23***	.34***
<b>Loneliness</b>														
14. Loneliness T1														.04
15. Loneliness T3														

Notes: <sup>§</sup>Reversed scored so lower score indicative of poor health. <sup>†</sup>PSQI only taken at Time 3.

Table 7.4. Adjusted Means (and standard error) for depressive symptoms and physical health measures at Time 3 by loneliness latent class

Health Measure	Low, Stable Lonely	Relatively High, Reducing Lonely	<i>MS</i>	<i>F</i>	$\eta p^2$
<b>CDI</b>					
Depressive symptoms	2.49 (.21)	3.42 (.19)	32.62	8.65**	.05
<b>PedsQL</b>					
PedsQL Physical Health†	85.43 (.77)	81.20 (.72)	897.51	15.41***	.08
Emotion Q4 “I have trouble sleeping”	64.69 (2.57)	71.08 (2.42)	3700.72	5.57*	.03
School Q4 “I miss school because of not feeling well”	74.53 (1.77)	75.86 (1.66)	92.53	.30	.001
<b>PSQI</b>					
Minutes to sleep	24.20 (1.41)	28.09 (1.50)	798.15	3.52*	.02
Hours asleep	9.78 (.17)	9.46 (.16)	4.98	1.73	.008
Cannot get to sleep within 30 minutes	1.15 (.06)	1.28 (.06)	.36	.85	.004
Wake up in the middle of the night	.88 (.06)	1.20 (.06)	2.51	6.58**	.03
Had bad dreams	.77 (.05)	.81 (.05)	.07	.23	.001

Notes: Results are from ANCOVA, where previous health reports and current loneliness and depressive symptoms were controlled;  $df_1$  and  $df_2 = 1, 216$  respectively; *MS* = Mean Square; *F* = F statistic;  $\eta p^2$  = partial eta squared statistic. \* significant at .05 level, \*\*significant at .01 level, \*\*\*significant at .001 level. † Lower scores on the PedsQoL are indicative of more health-related problems; single PedsQL items ‘I have trouble sleeping’ and ‘I miss school because of not feeling well’ are unreversed so higher scores are indicative of more health-related problems.

## Discussion

The current study investigates whether high loneliness in childhood and pre-adolescence is associated with poor health and sleep dysfunction by examining developmental trajectories of loneliness from middle childhood to pre-adolescence (8 – 11 years of age). Two groups of children with different growth patterns were identified: (a) relatively high, reducing loneliness (48%), and (b) low, stable loneliness (52%). These two developmental patterns of loneliness were also found in previous trajectory research (Jobe-Shields et al., 2011) that used a sample of similar aged children and pre-adolescents. The resulting loneliness trajectories in this study differ from those found in the Jobe-Shields et al.'s (2011) study as no increasing loneliness group was identified. This suggests that there are differences between specific cohorts in how loneliness develops and changes over time. Despite no evidence for an increasing or chronic lonely group in the current sample, there were health differences between children following different trajectories of loneliness in the current study. Specifically, the group who started relatively high on loneliness and dropped at age 11 years reported poorer health than the low, stable loneliness group, indicating that high loneliness in middle childhood is associated with poor health and sleep dysfunction in pre-adolescence, even when high loneliness is not maintained into pre-adolescence.

### *The Importance of Loneliness during Adolescence*

It has been suggested that adolescence is a period of life when loneliness is particularly prevalent (Goossens, 2008a). Following this line of enquiry, an increase in loneliness was expected for this sample as the children entered pre-/early adolescence. This pattern was not found; instead, these data showed that the majority of children decreased in loneliness over the course of the study and into pre-/early adolescence, whilst the remaining sample shows consistently low levels of loneliness. Thus, it seems that for participants in this sample, loneliness was not a feeling they experienced as they entered adolescence; instead, pre-adolescence was characterised by low levels of loneliness for both groups. It is possible that something specific occurred in this sample that meant those children who would have followed a trajectory of relatively high loneliness no longer did so at 11 years of

age. For example, there may have been local school-based interventions that reduced loneliness feelings which meant children changed their loneliness trajectory. Future research will want to determine factors that can re-direct relatively high lonely children to decrease in loneliness levels, such as cognitive re-appraisal (Qualter & Munn, 2002), those related to personality and behaviour (Jones & Carver, 1991), and/or specific events that offer opportunities to establish new friendships.

An example of an event in the UK that offers an opportunity for children to form new friendships is the transition from primary to high school. The transition to high school occurs at 11 years and represents an opportunity for children who have previously experienced difficulties with friendships in their primary school to establish new peer relations. It is also a time when there is refocus of parental involvement in their child's ability to settle into a new environment and establish new friendships and school based support for peer relationships (Bohert, Aikens, Wargo, & Arola, 2013; Güroglu, Cillessen, Haselager, & van Lieshout, 2012). Chapter 11 of this thesis outlines a study that examines the transition from primary to secondary school. The study examines loneliness across the move to secondary school as it is measured prior to (at the primary school), during and after the transition (at the secondary school).

### *Health Outcomes*

The current study aimed to examine whether health problems found in lonely adults were evident in a sample of young adolescents. Research has shown an association between high levels of loneliness and poor health in adulthood (Hawkley & Cacioppo, 2003; Steptoe et al., 2004), with more marked health effects being seen in elderly lonely adults (Luo, Hawkely, Waite, & Cacioppo, 2012). Further, studies examining health outcomes in late adolescence (aged 17) have found indicators of poor health (e.g. more visits to the doctor) to be more prevalent in those following a high, stable lonely trajectory (see Qualter et al., 2013b). The results from the current study indicate that self-reporting of poor health and depressive symptoms are also evident in early adolescents who follow a high, but falling loneliness trajectory.

Sleep dysfunction was evident in the lonely group following a relatively high, reducing loneliness trajectory. Previous research (Cacioppo et al., 2002; Hawkley et al., 2010; Steptoe et al., 2004) has shown an increased likelihood of sleep

dysfunction in lonely adults. Further, earlier cross-sectional research on early and middle lonely adolescents found greater sleep disturbances (Mahon, 1994). What is unique about the results of this study is that sleep dysfunction was demonstrated in children following the relatively high reducing loneliness trajectory; in the current study, relatively high, reducing lonely adolescents had more trouble sleeping, took longer to get to sleep, and had more disturbed sleep. These findings suggest that sleep is disrupted when loneliness is experienced over several years of childhood. Thus, relatively high loneliness makes a significant contribution to sleep dysfunction that is independent of the effects of depression and earlier health problems.

The current study finds poor self-reported health and sleep dysfunction in a group of children following a trajectory of high loneliness, and it may be that the functional mechanisms of the association between loneliness and health are the same for children as those identified in adults. Cacioppo and Hawkley's (2009) model proposes that increased activation of the HPA axis is a functional mechanism of the association between loneliness and health. The study outlined in the next Chapter examines whether the children following a relatively high reducing loneliness trajectory in the current study also have an increased activation of HPA axis to examine whether this is a potential functional mechanism for the association between loneliness and poor health.

#### *Strengths and limitations of the current study*

The current study is the first to examine health, sleep patterns, and loneliness in a prospective sample of children and early adolescents. It provides new insights into how loneliness develops during middle childhood and pre-adolescence and how it impacts on health, independent of depression. One of the major strengths of the current study is that earlier reports of poor health, current loneliness, and depression symptoms were controlled. Sleep dysfunction and health differences in pre-adolescents who experience high loneliness are irrespective of levels of depressive symptoms, suggesting that long-term loneliness should be considered independently in future intervention work.

One limitation is that data on pre-existing health were not collected so children with chronic health conditions were not able to be distinguished in the analyses.

## *Conclusion*

The current study has shown that children who experience relatively high, reducing loneliness in middle childhood report poorer perceived physical health in early adolescence, and greater sleep disturbance than children who follow a low, stable trajectory of loneliness in adolescence. What is yet to be examined is the functional mechanisms of the association between loneliness and health in childhood. Chapter 8 outlines a study that examines whether there are atypical cortisol diurnal patterns implicating the hypothalamic-pituitary-adrenal axis as a functional mechanism, as has been suggested by Cacioppo and Hawkley (2009) in their model for loneliness and health. Cognitive biases that focus on negativity in social situations have also been implicated in the proposed model (Cacioppo & Hawkley, 2009) and in literature on adulthood loneliness (Cacioppo et al., 2000, Duck, Pond, & Leatham, 1994; Jones, Freemon, & Goswick, 1981; Jones, Sansone & Heim, 1983). There is currently no research to date that has examined these cognitive biases in childhood. Chapter 9 outlines a series of studies that examine cognitive biases and deficits in lonely children in comparison to their non-lonely peers. Finally, the current study demonstrates that some external factors may influence the loneliness trajectories in childhood as loneliness reduces in the high lonely group; for example, transition to secondary school, as it may offer an opportunity to form new friendships. Chapter 10 outlines a study that examines loneliness and health across the transition from primary school to secondary school.

## Chapter 8 - Study 4 – Cortisol diurnal rhythm in relation to long term experiences of loneliness and current loneliness state in pre/early adolescence

### Introduction

Chronic activation of the hypothalamic-pituitary-adrenal (HPA) axis has been implicated in the theoretical model for loneliness and poor health (Cacioppo & Hawkley, 2009). Research has identified atypical cortisol diurnal patterns in lonely older adults (Cacioppo et al., 2000; Steptoe, Owen, Kunz-Ebrecht, & Brydon, 2004) and young adults (Doane & Adam, 2010), but cortisol levels in lonely children are yet to be examined. This chapter outlines a diary study of children aged 9-14 years<sup>12</sup> that examined daily cortisol level, self-reported health and sleep patterns on a school and non-school day. Children were recruited from the sample in Study 3 (Chapter 7), thus, enabling the cortisol diurnal pattern to be compared for children who experience relatively high loneliness over a number of years and those who experience low, stable loneliness. As the relatively high lonely group had reduced loneliness at the final time point, the impact of current state loneliness on the cortisol diurnal pattern was also examined to establish whether it is long-term loneliness or current state of loneliness that affects HPA axis.

### *Typical cortisol diurnal rhythm*

Cortisol is the end-product of the hypothalamic-pituitary-adrenal (HPA) axis and acts to release energy stores and elevate blood glucose to provide fuel for the body (Alwin, 2007). It also regulates the immune system (Sapovsky, 2007). In addition, cortisol has an important role in sleep and awakening and displays a circadian rhythm (Clow, Hucklebridge, Stadler, Evans & Thorn, 2010). Adults and children have a stable cortisol diurnal rhythm (displayed in Figure 2.4, in Chapter 2), where cortisol is at its highest levels in the morning, increasing dramatically on

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<sup>12</sup> The age range is slightly different to the age range for Study 4 because children who were only 8-10 years at the commencement of the longitudinal study were included in Study 4 to ensure a strict age range. In Study 5 all children who took part in the study were included in the state loneliness groupings.

awakening and decreasing rapidly through to late morning. Levels then tend to stabilise and flatten throughout the afternoon and evening, reaching the lowest levels in the late evening and early morning hours. Cortisol levels remain low throughout the night and start to rise just before awakening; reaching the highest peak between 15-45 minutes of awakening. This cortisol peaking following awakening is known as the cortisol awakening response (CAR). Both a higher CAR and a flattening of the cortisol diurnal slope have been suggested to be indicative of poor health (Clow, Thorn, Evans & Hucklebridge, 2004) and more recently atypical cortisol diurnal patterns have been linked to poor health (Stone et al., 2001).

Research exploring factors influencing variations in cortisol levels have implicated the anticipation of upcoming events (Fries, Dettenborn, & Kirschbaum, 2009), including the stressful day ahead (Clow, Hucklebridge, Stadler, Evans, & Thorn, 2010; Kudielka & Kirschbaum, 2003). Recent studies suggest that this flexibility of cortisol release in response to a challenging day is important for healthy functioning (Mikolajczak et al., 2010). An important example of cortisol flexibility is the increased levels on work days in comparison to rest days. This has been demonstrated in adults (Kunz-Ebrenct, Kirschbaum, Marmot, & Steptoe, 2004), preschoolers (Watamura, Kryzer, & Robertson, 2009) and young school-aged children (Long, Ungpakorn, & Harrison, 1993).

### *Loneliness in adulthood and HPA functioning*

Chronic activation of the HPA axis has been implicated as a potential mechanism in the theoretical model for loneliness and poor health (Cacioppo and Hawkely, 2009). Loneliness is proposed to result in a hyper-vigilance for social threats (HSTH) in everyday life, which leads to attention, memory and confirmatory biases altering the likelihood of social interaction. These dispositions impact on behaviour resulting in confirmation of a necessity for heightened vigilance for social threat. In turn, they also activate neurobiological mechanisms increasing activation of the HPA axis. This theoretical model indicates that as lonely people experience increased threat activations of the HPA axis, they would display atypical patterns of cortisol release. For example, they should show increased levels of cortisol production and/or a flattening of the cortisol slope. Studies have shown that lonely

adults have a higher cortisol awakening response (Steptoe et al., 2004) and increased mean levels of cortisol (Cacioppo et al., 2000).

Research shows the chronicity of loneliness is associated with poor health (Shiotiz-Ezra & Ayalon, 2010), but what is missing from the literature is an examination of loneliness and cortisol functioning distinguishing between those who experience high loneliness chronically and those who have consistently low levels of loneliness over time. Trajectory studies examining the growth of loneliness over time offer a methodology to address this gap in the literature enabling an examination of persistent high loneliness over time and HPA functioning. These studies enable an examination of whether a particular growth pattern of loneliness (i.e. chronic relatively high loneliness) is associated with atypical cortisol diurnal patterns. Although studies in adulthood have examined high loneliness and HPA functioning, none have examined longitudinal patterns of loneliness and HPA functioning. The current study is the first to examine longitudinal loneliness in a child population and HPA axis functioning. Future studies should examine HPA functioning in adults who experience long term loneliness.

#### *Loneliness in childhood and HPA functioning*

Loneliness has been associated with a flattening of the cortisol diurnal rhythm and momentary changes in state loneliness were linked to increases in cortisol levels in late adolescence to early adulthood (17-20 year olds, Doane and Adam, 2010). Atypical cortisol diurnal rhythms are associated with poor health (Stone et al., 2001). As poor self-reported health is found in children who experience a relatively high level of loneliness from childhood to adolescence in comparison to peers who experience low, stable loneliness from childhood to adolescence (Qualter et al., 2013b; and also see Study 3, Chapter 7), it is important to establish whether atypical cortisol diurnal rhythms are also evident in childhood. As health differences have been identified in children who have experienced high loneliness consistently over a number of years (Qualter et al., 2013b, also see Study 3, Chapter 7) it is important to examine relationships between loneliness and HPA functioning in longitudinal studies. If atypical cortisol diurnal rhythms are evident in lonely children, but not in non-lonely children, it would indicate that the HPA activation is a functional mechanism explaining the link between loneliness and poor health in childhood.

The study in this chapter examines diurnal cortisol rhythm between groups of children displaying discrete growth patterns of loneliness identified using latent growth mixture modelling (identified in Study 3, Chapter 7). In addition, to examine longitudinal loneliness and HPA functioning current state of loneliness is also examined to explore whether it is the long term experience of loneliness that affects HPA axis functioning or the current state of loneliness. As recent research implicates cortisol flexibility as a functional mechanism leading to poor health (Mikolajczak et al., 2010) it is important that this is also examined alongside atypical diurnal rhythms in lonely people. Therefore, to measure cortisol flexibility, cortisol levels in lonely and non-lonely children were compared on a school day and a non-school day.

#### *The current study*

The current study examines differences in the typical circadian rhythm between children who have experienced relatively high long term loneliness and those who have experienced low stable loneliness over a number of years. To examine the diurnal cortisol rhythm between the lonely groups the cortisol slope is also calculated. If the health differences in lonely and non-lonely (see Study 3, Chapter 7) children are due to chronic activation of the HPA axis higher mean levels and/or differences in cortisol slopes will be identified in a group of children experiencing relatively, high loneliness in comparison to a group experiencing low stable loneliness. A comparison of cortisol levels on a school and non-school day is also made to establish if health differences between high and low lonely groups can be explained by a lack of cortisol flexibility to increased demands of the day in lonely people. A lack of cortisol flexibility would be evident if there is little or no differentiation between the cortisol levels and/or cortisol slopes on a school and non-school day in lonely children in comparison to non-lonely children. Differences in cortisol are compared between the trajectory groups identified in Study 3 (see Chapter 7) and groups based on children's current state of loneliness to examine whether differences in cortisol diurnal rhythms are due to long term loneliness or current state of loneliness.

## Method

### *Participants*

Participants were recruited from the sample of children recruited for Study 3 (see Chapter 7): the Lancashire Longitudinal Study of Social and Emotional Development (LLSSED). The current study took place at time point 3 when the children were on average 11 years old. Forty-one children from the LLSSED consented to take part in the current study. Written parental consent was obtained from the children's primary care giver and children gave verbal consent to take part in the study. All testing was completed in accordance with the national and local ethical guidelines according to the Declaration of Helsinki.

Parents completed a confidential screening questionnaire and reported that their children were in good health, had no active infections, were not taking any contra-indicating medications, and had a body mass index (BMI) within a healthy range. Children were screened for depression symptoms and two participants with high depression scores (2 SD+ above the mean) on the Child Depression Inventory (CDI, short version, Kovas, 1980) were removed from the study. A further three participants were removed for self-reported non-adherence to protocol (saliva collected at the incorrect time). The remaining 36 children were included in all the analyses.

To enable a thorough analysis of the data, children were grouped in two independent ways for the data analysis 1) using trajectory groups from Study 3 (see Chapter 7) and 2) using current loneliness state (loneliness measured at time 3 loneliness in Study 3)<sup>13</sup>. Details for each of the groupings are as follows:

- 1) *Trajectory grouping*: From the 36 children (18 male and 18 female) recruited from the LLSSED, 18 met the criteria to be included in the trajectory analysis (e.g. were 8-10 years at time 1 and had data for at least 2 of the three data collection waves) in Study 3 outlined in Chapter 7. Data for these 18 children (10 relatively high reducing lonely group and 8 low lonely group) were used in the analyses in this Chapter.

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<sup>13</sup> It was intended that momentary and daily changes in loneliness and increases/decreases in cortisol would be examined (as Doane & Adam, 2010) but there were no significant momentary or daily changes in loneliness in diary entries so these analyses were not possible

- 2) *Current loneliness*: All 36 children<sup>14</sup> recruited for this study were split into high and low lonely based on a mean split of their current loneliness scores.

### *Procedure*

It was only possible for samples to be collected whilst children were at home (it was an ethical requirement of the university that children were supervised to collect the saliva samples and this was not possible during school time) so sampling was done in the morning, afternoon, and evening to ensure sufficient measurement of the diurnal pattern across the day. Research indicates that this sampling pattern can provide a reliable measurement when only minimal sampling is viable (Adam & Kumari, 2009; Harville et al., 2007). Sampling at three time points (i.e. morning, afternoon, and evening) has been used in other similar studies (e.g. Bruce, Davis, & Gunnar, 2002).

Parents of participating children were visited by the researcher at their homes and given a study packet containing diary booklets, salivettes, and stop watches. Parents and children were given full written and verbal instructions of the study protocol including demonstrations of how to collect saliva samples. Parents were asked that their children refrain from eating, drinking and brushing their teeth prior to sample collection and were given a sheet to record the accurate times of saliva sampling to check for compliance. The researcher stressed the importance of compliance and encouraged parents to miss a sample rather than collect a sample at the incorrect time, and report difficulties with adherence within the diaries. Parents were asked to collect samples on two days: one on a non-school day (Sunday) and the other on a school day (Monday). On each of the days parents were asked to collect three samples: 30 minutes after wakening, after school (at 4pm on weekends) and 30 minutes before bedtime. Participants were asked to avoid atypical days such as birthdays or outings. Participants returned diaries and cortisol samples to the university by post. All data were collected in the summer term to ensure results were not influenced by transition to new school year/high school.

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<sup>14</sup> This data is under review for publication elsewhere and is included at Appendix 1. The publication examines differences in cortisol levels on a school and non-school day in all participants regardless of their loneliness levels.

## *Measures*

*Loneliness.* Loneliness in relation to peers was measured using the peer subscale of the Loneliness and Aloneness Scale for Children and Adolescents (LACA; Marcoen & Brumage, 1985). This was measured in three data collection waves and two discrete groups were identified using Latent Growth Mixture Modelling: relatively high lonely and low lonely group (a more detailed examination of this data analysis is outlined in Chapter 7) for the trajectory group analysis in this study. This measure was also used to create current state loneliness groupings: high and low lonely based on a mean split of current loneliness score.

*Diaries.* Participants were asked to complete diaries at various points of the day. The measures in the diary comprised the following two items:

- 1) *Sleep quality* At the commencement of the day participants were asked to report on the quality of their sleep the night before using a 4-point scale: “very good”, “fairly good”, “fairly bad”, and “very bad”. Possible scores ranged from 0 to 4. Higher scores indicate poorer sleep quality. This item represents one of the items from the Pittsburg Sleep Quality Index (Buysee, Reynolds, Monk, Berman, & Kupfer, 1989, see method section of Chapter 7 for further details).
- 2) *Perceived health* Before bed time participants reported on how well they felt their health had been during the day on a scale of 0 (good health) to 10 (bad health). It was intentionally reversed as the scale was placed beside a picture of a thermometer, i.e. high levels on the thermometer indicate poor health. Possible scores ranged from 0 to 10. Higher scores were indicative of poorer health.

*Cortisol.* Saliva samples were obtained using a salivette saliva sampling device specifically designed for use with children. (Sarstedt Ltd, Leicester, UK). Samples were stored in a domestic refrigerator before being mailed to the university, where they were stored at -20°C until analysis. Mailing samples prior to freezing has been shown to be an appropriate method and does not influence the salivary cortisol results (Clements & Parker, 1998).

For analysis saliva was recovered by thawing at room temperature for 15 minutes then centrifuging (1500 rpm) for 15 minutes. Cortisol concentration (nmol/l) in saliva was then determined by a high sensitivity salivary cortisol enzyme immunoassay kit (Salimetrics, USA) as manufacturer's instructions. Intra-assay variation was below 10%. All children provided saliva samples for all saliva sampling collection times. Any cortisol samples that were 3 standard deviations from mean were removed from all analyses. This resulted in removal of one afternoon and one evening sample from the non-school day and two afternoon and two evening samples from the non-school day. The other samples from these children remain in the analyses<sup>15</sup>. Cortisol data were screened for skewness and only the bedtime sample on the school day was positively skewed so data were not transformed.

Descriptive information about the mean cortisol for each day and actual sampling times can be found in Table 8.1. Consistent with previous research (Davis, Donzellas, Krueger, & Gunnar, 1999) the morning samples were later on the weekend day than the school day ( $t(26) = 6.36, p < .001$ ). Given the circadian rhythm in the production of cortisol (Clow et al., 2004), the difference in sampling times in the morning could result in higher morning cortisol on the school day. As the morning sampling time was later on the non-school day than the school day, the impact of the difference in time of sampling on the morning sample was determined. A time difference score (between time of sampling on non-school day and school day) was calculated and this was correlated with the difference in morning cortisol values. Results indicate that time-difference scores were not correlated with the difference in morning cortisol between the school and non-school day  $r(23) = .361, ns$ . Therefore, these results suggest the differences in cortisol levels on the school day compared to the non-school day are not due to differences in sampling times. There were no significant differences in actual time the sample was taken for the afternoon and evening cortisol samples.

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<sup>15</sup> Although all children provided samples at all time points, some of these samples had insufficient saliva for analysis, all samples were retained in the statistical analysis

Table 8.1 Descriptive statistics for mean cortisol and time of sampling (and SDs)

	Cortisol n/mol				Sampling time			
	Non-school day		School Day (Mon)		Non-school day		School day (Mon)	
	M	SD	M	SD	M	SD	M	SD
Morning	7.29	4.94	10.59	8.21	9:16	63 mins	7:42	26 mins
Afternoon	2.03	1.44	2.89	1.97	16:20	59 mins	16:07	24 mins
Evening	1.78	2.18	2.72	3.83	21:05	32 mins	20:58	42 mins

Gender differences in cortisol data were examined using 2 (day) x 3 (time) x gender (male, female) and there was no main effect of gender ( $F(1,19) = 1.19, p = .289, \eta p^2 = .06$ ) on cortisol levels or interaction between gender and day ( $F(1,19) = 0.35, p = .563, \eta p^2 = .02$ ) or gender and time ( $F(2,38) = 0.67, p = .518, \eta p^2 = .03$ ), thus, it was not deemed necessary to control for gender in the cortisol data analysis.

#### *Data analysis plan*

Cortisol data was analysed, first, using a factorial ANOVA to compare cortisol levels at the 3 time points (morning, afternoon and evening) on the school and non-school day by lonely group. Second, the cortisol slope was compared between the school and non-school day by lonely group. The cortisol slope was calculated by subtracting the evening cortisol value from the morning cortisol value, hence, more negative values indicate a steeper slope of cortisol across the day. Factorial ANOVAs were then used to examine sleep quality and perceived health by lonely group. This analysis was carried out for each of the loneliness groupings: trajectory groups and current loneliness state groups. Where post hoc comparison were conducted the alpha was reduced by the number of comparisons using Bonferroni's correction.

## Results

### 1) Trajectory Groups

The following analyses are based on grouping participants on the relatively high reducing (peer loneliness score = 1.83, SD = 0.44) and low stable (peer loneliness score = 1.96, SD = 0.59) trajectory groupings established through the analyses in Study 3 (see Chapter 7). The high reducing lonely group (N = 10) had a mean age of 10.71 (SD = 0.82) and 40% were female. The low, stable lonely group (N = 8) had a mean age of 11 (SD = 1.07) and 62.5% were female.

### *Cortisol*

Descriptive data for the cortisol values by loneliness group for each day are shown in Table 8.2. A 2 (Day: school day and non-school day) x 3 (Time: morning and evening, afternoon) x 2 (Lonely group: relatively high reducing and low stable) mixed ANOVA, using the Greenhouse Geisser adjustment, revealed no significant effects of day ( $F(1,7) = 3.25, p = .114, \eta p^2 = .32$ ) or lonely group ( $F(1,17) = 0.16, p = .704, \eta p^2 = .02$ ) on cortisol.

There was a significant main effect of time ( $F(1.19,14) = 9.25, p = .003, \eta p^2 = .57$ ) on cortisol levels. Post hoc test using paired samples t-tests revealed that the morning cortisol sample was significantly higher than the afternoon ( $t(23) = 6.85, p < .001$ ) and the evening ( $t(25) = 5.67, p < .001$ ), but the afternoon sample was no greater than the evening sample ( $t(22) 0.98, p = .034$ ). Cortisol levels were averaged across days and results are displayed in Figure 8.1 and show the typical cortisol circadian rhythm, with cortisol being at the highest in the morning and tailing off to low levels by the afternoon and evening (King & Hegadoren, 2002).

Table 8.2: Descriptive statistics for mean cortisol by loneliness trajectory

	Relatively high reducing lonely				Low stable lonely				All participants (N = 18) <sup>16</sup>			
	Non-school day		School Day (Mon)		Non-school day		School day (Mon)		Non-school day		School day (Mon)	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Morning	7.75	6.28	14.49	11.52	9.62	4.10	7.65	7.72	10.01	1.97	13.86	4.00
Afternoon	2.03	1.53	3.41	2.80	1.69	1.19	3.09	1.42	2.36	0.41	3.43	0.79
Evening	2.09	3.17	3.44	4.71	0.75	0.61	2.43	3.08	1.78	1.08	1.94	1.32

<sup>16</sup> Note these values are based on analysis using the trajectories grouping i.e. only involving the 18 children that were in the trajectory analysis for Study 3 (see Chapter 7) so values for all participants will be different to those in Table 8.3.

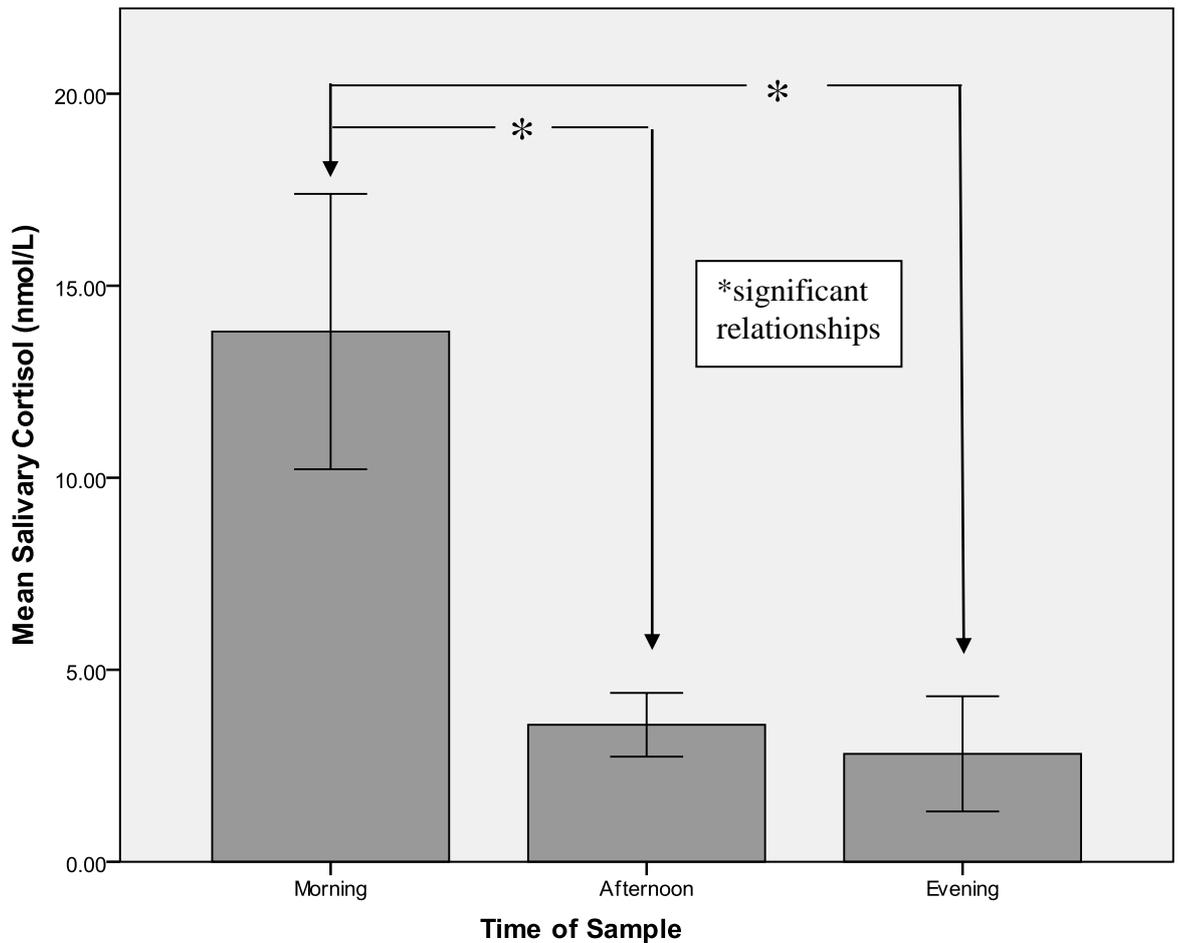


Figure 8.1 Cortisol levels averaged across days for each time point for all children (with 95% CI error bars)

There were no significant interactions between time and day ( $F(2,14) = 1.36$ ,  $p = .290$ ,  $\eta p^2 = .16$ ), day and lonely group ( $F(1,7) = 0.14$ ,  $p = .717$ ,  $\eta p^2 = .02$ ), time and lonely group ( $F(2,14) = 0.10$ ,  $p = .903$ ,  $\eta p^2 = .01$ ) and time, day, and lonely group ( $F(2,14) = 0.22$ ,  $p = .806$ ,  $\eta p^2 = .03$ ).

Cortisol slopes for each day were examined and a 2 (school day, non-school day) x 2 (lonely group: relatively high reducing, low stable) mixed ANOVA revealed no significant effects of day ( $F(1,9) = 0.09$ ,  $p = .777$ ,  $\eta p^2 < .01$ ) or lonely group ( $F(1,9) = 0.01$ ,  $p = .903$ ,  $\eta p^2 < .01$ ) on cortisol slope. There was not a significant interaction between day and lonely group ( $F(1,9) = 1.01$ ,  $p = .322$ ,  $\eta p^2 = .101$ ). These results indicate that there were no differences in the cortisol slope between the days of the week or the lonely groups.

### *Self-reported health*

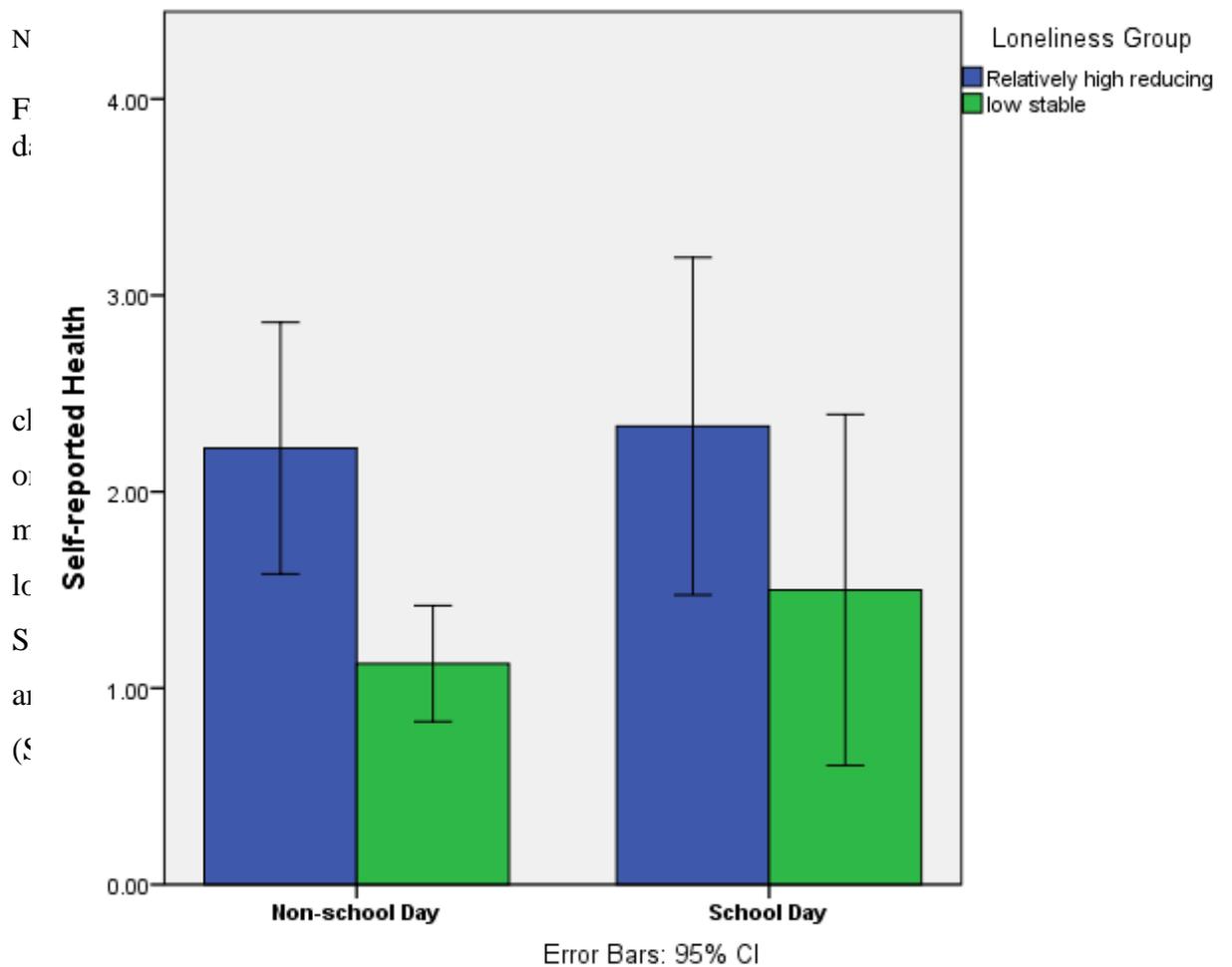
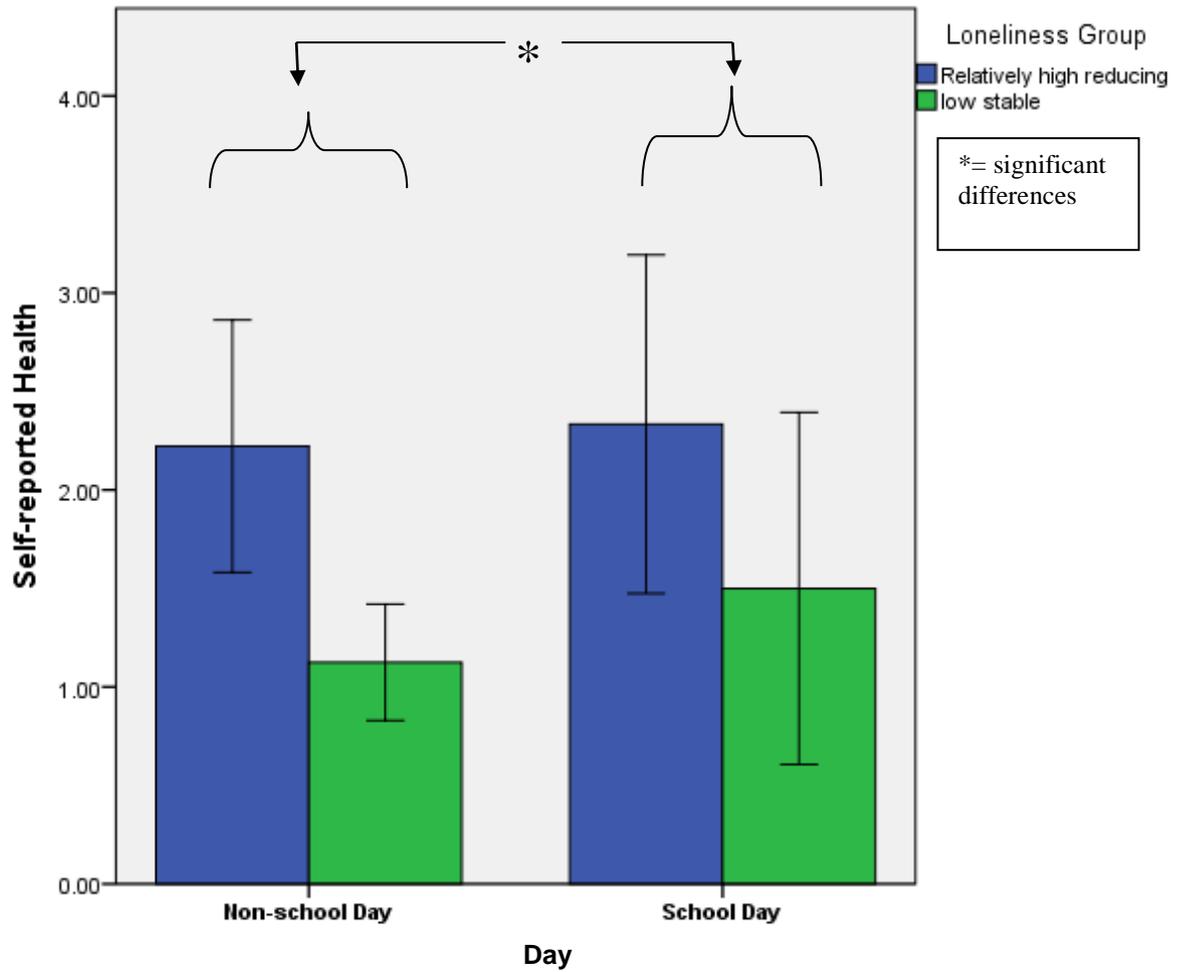
To examine the differences between self-reported health by lonely group on school and non-school day a 2 (Lonely group: relatively high lonely and low stable lonely) x 2 (Day: school day and non-school day) mixed ANOVA was carried out. There was no significant main effect of day ( $F(1,15) = 0.72, p = .409, \eta p^2 = .05$ ). But there was a significant main effect of lonely group ( $F(1,15) = 8.43, p = .011, \eta p^2 = .36$ ). There was not a significant interaction between day and lonely group ( $F(1,15) = 0.21, p = .651, \eta p^2 = .01$ ) on self-reported health. Figure 8.2 displays the means for self-reported health by lonely group for school day and non-school day and shows that the relatively high reducing lonely group are reporting poorer levels of self-reported health<sup>17</sup> in their day-to-day reporting in their diaries than the low, stable lonely group.

### *Sleep Quality*

To examine the differences between sleep quality by lonely group on the school and non-school day a 2 (Lonely group: relatively high lonely and low stable lonely) x 2 (Day: school day and non-school day) mixed ANOVA was performed. Results showed no significant main effect of lonely group ( $F(1,16) = 0.09, p = .775, \eta p^2 = .01$ ), no significant main effect of day ( $F(1,15) = 4.09, p = .409, \eta p^2 = .05$ ), and no significant interaction of day and lonely group ( $F(1,15) = 8.43, p = .011, \eta p^2 = .36$ ) on sleep quality. This indicates that there is no difference between sleep quality between school and non-school day and that the relatively, high lonely group do not report any differences in sleep quality than the low stable lonely group in their day-to-day diary reporting.

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<sup>17</sup> Poor levels of self-reported health are indicated by higher levels on this scale



## Cortisol

Descriptive data for the cortisol values by loneliness group for each day are shown in Table 8.3. A 2 (Day: school day and non-school day) x 3 (Time: morning, evening, afternoon) x 2 (lonely group: high and low lonely) factorial ANOVA, using the Greenhouse Geisser adjustment, revealed a significant main effect of day ( $F(1,19) = 8.73, p = .008, \eta p^2 = .32$ ). An examination of means reveals that cortisol levels were higher on the school day (Mean = 5.36, SD = 0.16) than the non-school day (Mean = 4.02, SD = 0.61), demonstrating cortisol flexibility (Mikolajczak, 2010). There was a significant main effect of time ( $F(1.26,22.66) = 30.41, p < .001, \eta p^2 = .62$ ) and there was a significant interaction between time and day ( $F(1.192, 22.66) = 3.96, p = .027, \eta p^2 = .17$ ) on cortisol levels. The interaction between day and time on cortisol levels is displayed in Figure 8.3.

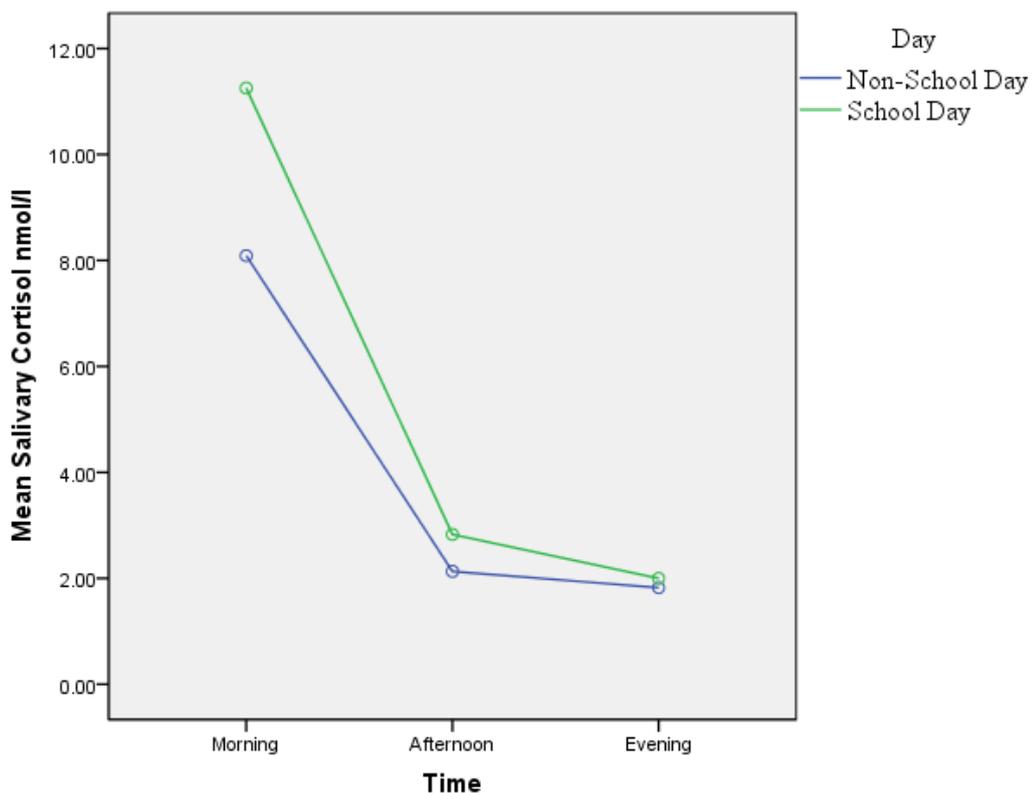


Figure 8.3 Mean salivary cortisol (in nmol/L) at each time point for school and non-school day

Table 8.3: Descriptive statistics for mean cortisol by current state loneliness group

	High Lonely				Low lonely				All participants (N = 36)			
	Non-school day		School Day (Mon)		Non-school day		School day (Mon)		Non-school day		School day (Mon)	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Morning	7.59	1.52	8.46	2.44	8.58	1.45	14.05	2.33	7.29	4.94	10.59	8.21
Afternoon	2.00	0.39	2.13	0.58	2.26	0.38	3.52	0.55	2.03	1.44	2.89	1.97
Evening	1.97	0.65	2.24	0.86	1.68	0.62	1.75	0.82	1.77	2.18	2.73	3.83

Post hoc tests using paired samples t-tests (displayed in Table 8.4) revealed that on day one and day two the morning sample was significantly higher than the afternoon and the evening, but the afternoon sample was not significantly higher than the evening. This indicates that cortisol reduced consistently over the day, but the reduction in levels of cortisol was more rapid from the morning to afternoon; this follows the typical cortisol diurnal rhythm (King & Hegadoren, 2002). When the levels are compared by day, post hoc tests (displayed in Table 9.4) reveal that morning and afternoon levels were higher in the morning and afternoon, but not by the evening, indicating that it is only the morning and afternoon cortisol levels are increased on a school day in comparison to a non-school day.

There was not a significant main effect of lonely group ( $F(1,19) = 1.76, p = .200, \eta p^2 = .09$ ) on cortisol, but there was a trend towards a significant interaction between lonely group and day ( $F(1,19) = 4.09, p = .057, \eta p^2 = .18$ ). There was not a significant interaction between lonely group and time ( $F(2,38) = 1.43, p = .252, \eta p^2 = .08$ ) and lonely group, time, and day ( $F(2,38) = 2.37, p = .107, \eta p^2 = .11$ ). The interaction between day and lonely group was near significant, so a priori comparison tests were conducted. Mean cortisol levels for each day were calculated.

Independent samples t-tests revealed that there were no significant differences between the lonely groups and cortisol levels on each day. However, paired samples t-tests revealed that for the high lonely group there was no significant difference between cortisol levels on the non-school day and school day ( $t(9) = 0.89, p = .396$ ); for the low lonely group cortisol levels were significantly higher on the school day than the non-school day ( $t(10) = 3.02, p = .013$ ). This relationship between lonely group and cortisol levels on the school and non-school day is displayed in Figure 8.4. The results indicate that the low lonely group are flexibly responding to the increased demands of the school day and have higher cortisol levels than on the non-school day, whereas the high lonely group do not adapt cortisol levels on the school day.

Table 8.4 Mean Cortisol (and Standard Deviation) for the school and non-school day by each time point (and related post hoc tests)

	Morning (M)	Afternoon (A)	Evening (E)	Pos hoc tests
Non-School day (D1)	7.36 (5.15)	2.13 (1.42)	1.86 (2.22)	M>A t(28) = 5.76, p < .001* M>E t(29) = 6.52, p < .001* A>E t(28) = 0.39, p = .701
School day 2 (D2)	11.30 (8.04)	2.96 (1.98)	2.77 (3.88)	M>A t(27) 6.26, p < .001* M>E t(30) 4.98, p < .001* A>E t(27) = 0.98, p = .381
Post hoc tests	D1>D2 t(29) = 2.68, p = .012    D1>D2 t(25) = 2.44, p = .022    D1>D2 t(28) = 1.86, p = .074			

\*significant at p < .001 Note: alpha level is adjusted to p < .008 using the boneferoni correction (i.e.  $\alpha/6 = 0.008$ )

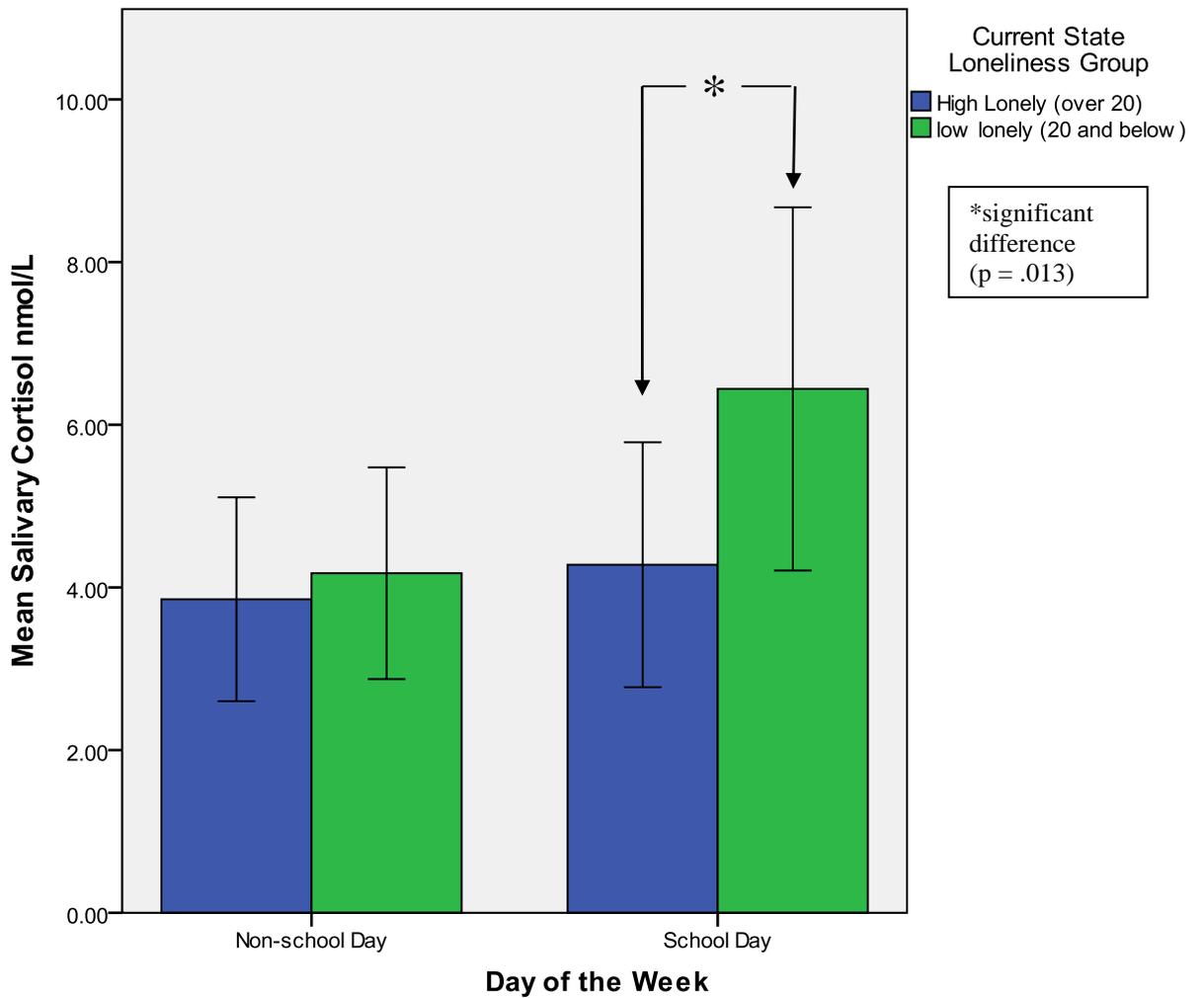


Figure 8.4 Mean cortisol levels (in nmol/L) averaged across time points for each day by lonely group (with 95% CI error bars)

Cortisol slopes for each day were examined and a 2 (Day: school day and non-school day) x 2 (Lonely group: high and low lonely) mixed ANOVA revealed no significant effects of day ( $F(1,24) = 2.13, p = .157, \eta p^2 = .08$ ) or lonely group ( $F(1,24) = 0.18, p = .679, \eta p^2 < .01$ ) on cortisol slope. There was no interaction between day and lonely group ( $F(1,24) = 0.05, p = .819, \eta p^2 < .01$ ). These results indicate that there were no differences in the cortisol slope between the days of the week or the lonely groups.

### *Self-reported health*

To examine the differences between self-reported health by lonely group on school and non-school day a 2 (Lonely group: high and low lonely) x 2 (Day: school day, non-school day) mixed ANOVA was used to examine self-reported health. In comparison to the loneliness trajectory group analysis that found a significant main effect of lonely group, this analysis based on current loneliness state did not reveal a significant main effect of lonely group ( $F(1,32) = 0.01, p = .934, \eta p^2 = < .01$ ) on self-reported health. This indicates that there were no differences in the health reporting on a day-to-day basis between the lonely groups. There was also no significant main effect of day ( $F(1,32) = 17.72, p = .199, \eta p^2 = .05$ ) on self-reported health, and no significant interaction between day and lonely group ( $F(1,32) = 1.20, p = .282, \eta p^2 = .04$ ).

### *Sleep Quality*

To examine the differences between sleep quality by lonely group on school and non-school day a 2 (Lonely group: high and low lonely) x 2 (Day; school day and non-school day) mixed ANOVA was performed on sleep quality. The results were similar to those obtained using the loneliness trajectory groups. There were no significant main effects of lonely group ( $F(1,34) = 0.50, p = .483, \eta p^2 = .02$ ), or day ( $F(1,34) = 0.01, p = .925, \eta p^2 = < .01$ ). There was also not a significant interaction of day and lonely group ( $F(1,34) = 2.83, p = .101, \eta p^2 = .08$ ) on sleep quality. This indicates that there is no difference between sleep quality between school and non-school days and that the high lonely group do not report any differences in sleep quality than the low lonely group in their day-to-day diary reporting.

### Discussion

The aim of the current study was to examine whether, as proposed by Cacioppo and Hawkley (2009), there are differences in the HPA functioning of children who have experienced relatively high long term loneliness and children who have experienced low stable loneliness over a number of years. If health differences in these two groups of children (see Study 3, Chapter 7) are due to chronic activation

of the HPA axis, as Cacioppo & Hawkley (2009) propose, higher mean levels and/or differences in cortisol slopes will be evident in the relatively high lonely group in comparison to the low stable lonely group. Cortisol flexibility was also examined in relation to loneliness by comparing cortisol levels between a school day and non-school day in high and low lonely groups.

### *Cortisol*

The results demonstrate a typical circadian rhythm of high morning cortisol decreasing over the day towards low levels of cortisol release in the afternoon and evening in all children (King & Hegadoren, 2002), indicating that the saliva sampling methodology used in this study was sufficiently rigorous to capture the typical cortisol diurnal rhythm. Cortisol levels were significantly higher on a school day than a non-school day in this sample of 9-14 year olds. The current study complements findings in the current literature that pre-schoolers have different cortisol patterns on childcare days compared to home days (Watmura et al., 2009) and is similar to adult populations who display increased morning cortisol levels on work days (Kunz-Ebrecht et al., 2004; Scholotz et al., 2004). The current study also find higher cortisol on a school day than non-school day in a pre-/early adolescent population demonstrating that increased cortisol on school days is consistent in childhood<sup>18</sup>. This increase in cortisol on school/work days in comparison to non-school days is likely to be a reflection of the increased demands on work/school days demonstrating cortisol flexibility (Mikolajczak, et al., 2010).

The results do not show any differences in cortisol release between the relatively high lonely and the low stable lonely group, indicating that the long term experience of loneliness was not associated with atypical diurnal patterns. This may be due to the fact that in this sample of children loneliness had reduced at the current time point (at age 11, see Chapter 7). However, when current state loneliness is examined there are also no differences between total cortisol output (i.e. mean cortisol). The results indicate that HPA functioning in lonely children is no different to that of non-lonely children, which is contrary to the results obtained in lonely mature adolescents and young adults who depict an atypical pattern (Cacioppo et al.,

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<sup>18</sup> This finding in the current data set is discussed in a paper currently under review (see Appendix 1)

2000; Doane & Adam, 2010; Steptoe et al., 2004). It may be that atypical cortisol diurnal patterns are not evident in childhood and that it is not until later adolescence years/adulthood that this is evident (i.e. loneliness may not have persisted for long enough to result in HPA axis dysfunction).

One should be cautious in interpreting of the results in the current study, because the numbers of children in each of the loneliness trajectories are low (10 children were in the relatively high loneliness group and 8 were in the low stable loneliness group); even in the current loneliness state analysis, group sizes were small. It is important that further replication studies with a larger sample are carried out as the result in the current study could be due to the sample size. What is important is that there is a difference between the lonely groups and cortisol flexibility on the school day. The low lonely group have increased levels of cortisol on the school day, but the high lonely group do not, indicating that the high lonely group are lacking cortisol flexibility (i.e. they do not adapt to the demands of the school day with increased cortisol). Mikolajczak, et al. (2010) have proposed that cortisol flexibility is an adaptive mechanism and is important in health maintenance. They argue that a lack of cortisol flexibility would result in poor health (Mikolajczak et al., 2010). Thus, it may be the case that the lack of cortisol flexibility demonstrated in the high lonely group is a potential functional mechanism for the association between loneliness and health in childhood. This is a contrast to the idea that increased activation of the HPA axis explains the association between loneliness and health that is proposed by Cacioppo and Hawkley (2009) and found in adulthood (Cacioppo et al., 2000; Doane & Adam, 2010; Steptoe, Owen, Kunz-Ebrecht, Brydon, 2004).

### *Self-reported health*

An important finding from this study is that, despite there being no differences in the cortisol diurnal pattern for relatively, high lonely versus low, stable lonely, these children who have experienced relatively high loneliness for a number of years report higher levels of poor health on a day to day basis. The results also replicate those obtained with the same children in Study 3 (see Chapter 7) using a different health measure that measured health over a given period (in the last month) where children in the relatively high lonely group reported poorer health than the low

stable lonely group. It appears, then, that despite the lack of differences in HPA functioning children who experience high loneliness for a number of years are consistently reporting poor health. These results may indicate that there are different functional mechanisms for the association between loneliness and health in childhood. The results of this study implicate a lack of cortisol flexibility in the relationship between loneliness and health in childhood, so this may be an important functional mechanism linking loneliness to poor health.

Researchers have suggested that children have a biological sensitivity to their environment (Boyce & Ellis, 2005). This indicates that children who are experiencing high stress will have less adaptive HPA axis functioning (Del Giudice, Ellis, & Shirtcliff, 2011), given that, they would lack cortisol flexibility. In comparison, children who experience low stress or a high supportive environment will have a high stress reactive system and will display cortisol flexibility, increasing cortisol on more demanding days. Loneliness has been associated with stress in adulthood (Hawkey, Thisted, & Cacioppo, 2009; Pressman et al., 2005), so it may be that lonely children experience chronic stress which in turn leads to a lack of cortisol flexibility. Studies 1 and 2 in the adult section of this thesis have implicated chronic stress as a functional mechanism that links loneliness to poor health in adulthood by chronic activation of multiple physiological systems (McEwen & Stellar, 1993). Study 6 (see Chapter 10) examines whether chronic stress is also evident in a child population.

What is different about the current study and the previous study in this thesis (Study 3) is that children were asked to report on their current state of health, but in Study 3 they recalled their health over a specific time period (i.e. over the last month). This is important because the findings in the current study indicate that children who experience high loneliness report consistently poorer levels of health on a daily basis compared to children experiencing low loneliness. This demonstrates that the association between loneliness and poor health is robust in childhood.

Loneliness trajectory studies with children tend to report a number of different growth trajectories that include a stable high lonely group, stable low lonely group, and a reducing lonely group (Qualter et al., 2013b; Jobe-Shields, Cohen, & Parra, 2011). The trajectories in the LLSED are different to these other studies: the high loneliness group reduced in loneliness between nine and eleven years (see Chapter 7), so the results indicating differences in health between children

experiencing high and low loneliness persist despite levels of loneliness reducing are important. These self-report health differences were not found when the current loneliness state was examined so this may indicate that it is the experience of long term loneliness that results in poor self-reporting of health. It is important, then, that future studies with child populations examine loneliness longitudinally as it is the long term experience of loneliness that contributes to poor health.

### *Sleep Quality*

In comparison to Study 3 of this thesis (see Chapter 7) the differences in sleep quality are not evident when examined using a diary methodology in this study, indicating that the differences in sleep quality in lonely children may be more generalised to a particular time period, rather than being consistently poor on a day-to-day basis. The scale used in the current study is similar to the sleep quality measure used in Study 3 (the Pittsburgh Sleep Quality Index, Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) so the results are quite unexpected. What is different about the measure in the current study is that children were asked to report on their previous night's sleep rather report on their typical sleep patterns as they were asked to do in Study 3. The results indicate that children who experience long term loneliness may report general sleep dysfunction, but not sleep differences on a day to day basis.

### *Strengths, limitations and future research*

Saliva sampling itself is a relatively new field of research and sampling saliva within the home environment with children has only been carried out by a few researchers. Therefore, this study acts as a pilot study of the saliva sampling methodology within a child population and in the home environment. It demonstrates that the protocol was rigorous enough to capture the typical cortisol diurnal rhythm. The numbers of participants were small due to a necessity to recruit from a population where children's loneliness had been followed for a number of years and opt-in was requested at each data collection wave due to ethical requirements of the university. Although recruitment was low, compliance was good in this sample: 100 per cent of the saliva sampling packs were returned to the

university. One weakness, however, is that this resulted in the a small group of relatively high loneliness group who were less lonely than the low stable lonely group, which is not necessarily representative of the child population and is likely to have impacted on the results, and may explain the lack of increased HPA axis activation in this sample. It is important to note that analyses also examined current state loneliness and this was also not associated with increased HPA axis activation in lonely children, but a lack of cortisol flexibility was. Therefore, the results may indicate that functional mechanisms associated with loneliness and health may be different in childhood than adulthood which will be important in future understanding of the developmental course of loneliness and health.

A strength of this study is that loneliness is examined over time rather than as a snap shot of what is happening for children and results indicate that different patterns of cortisol and stress responding may be evident for children who experience loneliness over a number of years and children who are currently lonely. It will be important in future research examining loneliness and health to distinguish between chronic and transient loneliness. Future research should continue to compare current state loneliness and long term experience of loneliness as the current study indicates that these may have different impacts on health.

#### *Conclusion and links to other chapters*

To summarise, no differences were found in cortisol diurnal patterns in relation to loneliness. However, when cortisol levels are compared on a school and non-school day children with a current high loneliness state had less cortisol flexibility (i.e. did not have increased levels on the school day) in comparison to low lonely children. This lack of cortisol flexibility has important implications on lonely children's health (Mikolajczak, et al., 2010) and may be a potential functional mechanism of the association between loneliness and health in childhood.

There were no differences in sleep quality between the lonely groups. However, health reporting was poorer for the children that had relatively high loneliness for a number of years, but not for those whose current state of loneliness was high. These results indicate that children who have experienced high loneliness from middle childhood to pre-adolescence continue to report poorer health on a daily basis in pre/early adolescence despite their levels of loneliness reducing. This

complements findings in Study 3 (Chapter 7) that the relatively, high lonely group reported poorer general health (i.e. over a longer time period) than the low, stable group. This finding indicates that there is a robust link between long term loneliness and poor self-reported health in childhood. The results also indicate that there may be some differences between the health reporting of children who have experienced loneliness for a number of years and those who are currently lonely highlighting the importance of examining loneliness and health longitudinally.

The results of the current study and Study 3 show that loneliness in childhood, similar to studies in an adult sample, has an impact on detrimental impact on health. Loneliness in adulthood do only affects health, but has also been shown to affect cognitive processing. The next chapter in the thesis examines the cognitive functioning of lonely children to establish if lonely children display the cognitive biases and impairments that lonely adults do. Chapter 10 examines lonely children's responses to a social challenge (the transition from primary school to secondary school) to provide an investigation of HSTH within a real life context, offering ecological validity for Cacioppo and Hawkley's (2009) model for loneliness and health in child population. This final study is comparable to Studies 1 (see Chapter 3) and 2 (and Chapter 4) in this thesis that examined HSTH in real life social contexts in adult populations. The last chapter (Chapter 11) examines evidence in this thesis for both adult and child populations together to explore Cacioppo and Hawkley's (2009) model for loneliness and health using a developmental focus.

## Chapter 9 – Study 5 Cognitive processing of lonely children

### *Introduction*

In their theoretical model explaining mechanisms involved in the link between loneliness and health, Cacioppo and Hawkley (2009) propose that lonely people have a hypervigilance for social threat (HSTH). They argue that this HSTH leads lonely people to attend to negative social information and remember more negative social events than non-lonely people. Eye tracker studies display evidence of the HSTH in lonely children and when asked to respond to social vignettes lonely children are more likely to attribute hostile intentions and report greater retaliatory aggression than their non-lonely peers (Qualter et al., 2013a). However, no studies have examined whether lonely children display cognitive biases, such as an increased memory for social information. Studies in adulthood have also demonstrated that lonely adults display difficulties with voluntary attentional control that are not evident in non-lonely adults (Cacioppo et al., 2000). Currently, there are no studies with a child population that examine whether this attention deficit (i.e. difficulties with attentional control) is demonstrated in childhood. This chapter outlines Study 5 which involves a series of cognitive tasks that examine whether biases for negative social information and difficulties with attention control exist in lonely children in comparison to non-lonely children.

### *Lonely adults and cognition*

Research into the cognitive processing of lonely people was outlined in Chapter 2. Cacioppo and Hawkley (2009) have suggested that loneliness leads to HSTH which results in attention, memory, and behavioural biases. They argue that HSTH would lead lonely adults to attend more to negative social information and remember more negative social events than non-lonely, and the lonely person would behave in a way that would limit social contact, for example, by withdrawing from social contexts.

A number of studies have demonstrated cognitive biases in adulthood. In a modified emotional Stroop task lonely adults showed more Stroop interference for social words than non-social words (Shintel, Nusbaum, & Cacioppo, 2006), indicating that they find the social words more distracting. Social words showed the greatest interference when they were negative social words in comparison to positive social words in lonely adults. Studies using eye tracker methodology have found that lonely adults are more likely to fixate first on socially threatening stimuli than non-lonely adults (Bangee, Harris, Bridges, Rotenberg, & Qualter, under review). It has also been demonstrated that lonely adults have a greater memory recall of social events (Gardner, Pickett, Jeffries, & Knowles, 2005) than their non-lonely peers. Those with fewer close friends are more accurate at identifying emotional expressions and are more attuned to positive and negative vocal cues, indicating that they have enhanced social monitoring (Gardner, Pickett & Brewer, 2000). Taken together, this evidence shows that lonely adults have a bias towards social information that results in difficulty to disengage from social information and an enhanced memory for social events. Further, when presented with both positive and negative social information lonely adults are more likely to be drawn to the negative social information.

The bias for negative social information evident in lonely adults will have important implications in social interactions, because the attention capture by the negative social information may affect the way that social information and interactions are perceived and interpreted. This appears to be the case as lonely adults interpret their own and their social partners behaviour negatively in social encounters and they expect others to rate them negatively (Duck, Pond & Leatham, 1994; Jones, Freemon, & Goswick, 1981; Jones, Sansone, & Heim, 1983). Diary studies also confirm this, as that lonely adults report social interactions as more negative and less satisfying than non-lonely (Cacioppo et al., 2000). Lonely adults also show weaker activation to pleasant pictures of people than to equally pleasant pictures of objects. In contrast, non-lonely adults show a stronger activation in reward and learning brain areas to pleasant pictures of people than to objects (Cacioppo, Norris, Decety, Monteleone, & Nusbaum, 2007), indicating that lonely adults experience less reward from social interaction.

In addition to specific cognitive biases for social information, there is some evidence to suggest that there are general attention deficits and cognitive decline in

lonely people. Cacioppo et al. (2000) demonstrated, in a dichotic listening task involving spoken consonant-vowel pairs, that lonely adults in comparison to their non-lonely peers showed an attention deficit when voluntary attentional control conflicted with automatic attention processes. In older adults, loneliness has been linked to increased cognitive decline (Tilvis et al., 2004; Wilson et al., 2007). Cacioppo and Hawkley (2009) argue that HSTH directly results in cognitive biases, but this more general cognitive deficit/decline is not fully explained in their model. It could be that the cognitive impairments are the result of prolonged activation of the HPA axis (as proposed in Cacioppo & Hawkley's 2009 model) which has been associated with memory impairments (Lupien et al., 2005; Wolf, 2003). An alternative explanation could also be that the state of loneliness loads a person's cognitive functioning leading to general impairments on task performance. This impairment could include difficulties with executive functioning, such as inhibition of undesired/inappropriate task responses. Current research has yet to examine the specific mechanisms involved in reduced cognitive functioning.

#### *Lonely children and cognition*

In comparison to the literature on loneliness and cognition in adulthood, there is little research that has examined cognitive processing in lonely children. It is important that research is carried out that examines cognitive bias in children because there may be developmental differences in cognitive processing, as cognitive processes develop throughout childhood and adolescence based on neurological changes during this time (Anderson, 2002). Such research would confirm whether these cognitive biases associated with loneliness are evident in childhood. It may be that it is these cognitive biases that contribute to the persistence of loneliness from childhood to adulthood. Evidence of these biases would also support the application of appropriate intervention strategies when working with lonely children.

There is very limited research on children that examines cognitive biases, Qualter et al. (2013a) have displayed, in a series of studies, that lonely children (as young as 8 years old) display biases towards social information. First, lonely children are more likely than non-lonely children to attribute hostile intentions to ambiguously motivated social exclusion, indicating that they are displaying similar negative biases in perception and interpretation of social interaction. Second,

loneliness is associated with rejection sensitivity in childhood, indicating that lonely children have a tendency to expect, perceive, and overreact to possible social rejection. Third, using eye tracker methodology, Qualter et al. (2013a) showed that lonely children have difficulty in disengaging from socially threatening stimuli in comparison to non-lonely children. These findings are similar to early work that found that lonely children are more likely than non-lonely children to make internal attributions for negative outcomes; they had a negative self-bias (Qualter & Munn, 2002).

The findings from this eye tracker study with children (Qualter et al., 2013a), differs from the findings from adult eye tracker research (Bangee, Harris, Bridges, Rotenberg, & Qualter, under review). Lonely adults display an initial vigilance (evidenced by attention fixation) not evidenced in non-lonely adults, followed by avoidance of the stimuli (Bangee, Harris, Bridges, Rotenberg, & Qualter, under review). In contrast, lonely children display similar initial fixation to non-lonely children, but find it difficult to disengage from the socially threatening information. Lonely adults initially fix their attention on social threat stimuli, but they are able to disengage much quicker than lonely children. These initial biases towards social threat may be more pronounced in lonely adults because they have had longer exposure to their negative expectations. Changes in cognitive ability, particularly the ability to relocate attention, are likely to be implicated in these changes in information processing (Anderson, 2002). Therefore, it is important to examine cognitive processing of lonely children and not make assumptions based on the adult literature.

### *The current series of studies*

This chapter reports the findings of a series of studies examining cognitive processing of lonely children. These studies aim to extend the current literature to examine whether there are similar or different patterns of cognitive processing in childhood, as there are in adulthood. The studies aim to replicate results obtained in adult literature, first, to examine whether there are memory biases for negative social information in childhood, and second, examine whether there is a general attention deficit in childhood. Study 5a is an adaptation of Gardner, Pickett, Jeffries, and Knowles's study (2005) which examines whether a similar bias for recall of social

events is also present in lonely children. Study 5b aims to replicate findings of Cacioppo et al. (2000), but uses slightly different methodology given the limitations involved in data collection in schools. This study aims to examine whether if children, like adults, have a general attention deficit.

## STUDY 5a

The goal of Study 5a was to replicate the study carried out by Gardner, Pickett, Jeffries, and Knowles (2005) in a child sample. Gardner et al. (2005) found that lonely adults had better memory recall for social events than non-lonely adults. The current study examines whether lonely children also have enhanced memory for social information. According to Cacioppo and Hawkley's (2009) model it would be expected that lonely people would have an increased memory for social information as they have HSTH and attend to social information more.

## Method

### *Participants*

Children were recruited from the NWCTS at time 2, in October, at children's primary schools (see discussion of child populations in Chapter 6). A sample of 65 children were present at time 2 and took part in this study. Thirty-two of the children were female (49.2%) and all children were aged 11 years old at the time of the study. Parents gave written consent for their children to take part at the commencement of the study and children gave verbal consent to take part in the study at data collection. Recruitment procedures and testing was in accordance with the national and local ethics guidelines according to the Declaration of Helsinki.

## Measures

*Loneliness.* Loneliness was measured using peer loneliness sub-scale of the Louvain Loneliness Scale for Children and Adolescents (Marcoen & Brumage, 1985, see Study 3, Chapter 7). In the current study, this scale demonstrated acceptable internal consistency, Cronbach's alpha = .90.

*Social anxiety.* The Social Avoidance and Distress – General sub-scale (SAD-G)<sup>19</sup> of the revised social anxiety scale for children (LaGreca & Stone, 1993) was used to measure social anxiety. The scale involves three sub-scales of social avoidance and distress: general, in relation to new people, and fear of negative evaluation. The full scale comprises 22 items including 4 filler items. Children are asked to indicate how often the items apply to them on a 5-point scale: “Not at all”, “hardly ever”, “sometimes”, “most of the time”, and “all of the time”. The social avoidance and distress - general sub-scale comprises 4 items. Examples of items are on this sub-scale are, “I am quiet when I am with a group of kids”, and “I feel shy with kids I know well”. Possible scores on this sub-scale range from 4 to 20, with higher scores indicating greater social anxiety. The social anxiety scale for children (LaGreca & Stone, 1993) has been found to display acceptable internal consistency, reliability, and validity (Ginsberg, LaGreca, & Sliverman, 1998). In the current study, this scale demonstrated acceptable internal consistency, Cronbach’s alpha = .92.

*Social memory task.* Children were told they were to read through a series of events that a child like them had experienced. Children were given the following instructions:

*You are going to be asked to read extracts from a diary of a child who is the same age as you. The pages describe events that happened to them for 4 days. Read each page carefully – the power point slides will move on for you; **you do not need to click to move on.***

Children were then presented with diary pages from a child on the computer (no name for the child was given). Each of 4 diary pages presented to children consisted of a title (Monday, Tuesday, Wednesday, or Thursday) and then four diary events, one for each of the social conditions: individual, interpersonal, and collective, and one each of the affective conditions: positive and negative events (see appendix

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<sup>19</sup> The Social Avoidance and Distress: General (SAD-G) has been used in this study to enable a comparison to studies with adult samples that have used Leary’s (1983) Interaction Anxiousness Scale i.e. Bangee, Harris, Bridges, Rotenberg, & Qualter, under review).

2 for specific diary events used in the task). The diary events were adapted from Gardner et al. (2005) to be appropriate for British children. Each page stayed on the computer screen for 2 minutes and then automatically moved on to the next page.

After reading all of the diary children completed a verbal fluency task (as Gardner, et al., 2005), in which they formed as many words as possible from the letters in the word “librarian” for 2 minutes, and then the word “crustacean” for another 2 minutes. These tasks were included merely to provide a time delay between reading the diary and the surprise recall task. After the verbal fluency tasks, participants were presented with a new screen asking them to recall as many of the events as possible from the diary, using the following instructions:

*Please think about the diary entries you read earlier in the session. In these entries you learned about 4 days in a person’s life and the events they experienced. Please list as many of these events as you can remember on a separate sheet of paper. It is important that you try to recall as many events as possible and that you list these events as close to word for word as possible. Let the researcher know you have recalled as many events as you can by raising your hand.*

Children then recalled the events from the diaries recording them on paper. Children were able to take as long as they needed to recall the events, but were not given longer than 5 minutes.

#### *Procedure*

Data were collected within secondary schools. Children were placed in small groups of 5 or 6, but completed the task independently. Half of the children completed the loneliness and social anxiety questionnaire first and half the children completed the memory task first.

## Results

In line with other research in this area (Cacioppo et al., 2002; Qualter et al., 2013a) children were grouped as high lonely based on the upper quartile of loneliness scores. The resulting high lonely group ( $n = 12$ , 75% female) had a mean peer loneliness score of 2.66 ( $SD = 0.44$ ) and the low lonely group ( $n = 53$ , 43% female) had a mean peer loneliness score of 1.44 ( $SD = 0.28$ ).

Two trained research assistant blind to the loneliness conditions tallied the number of positive and negative, collective, interpersonal and individual events recalled by each participant. In accordance with Gardner et al. (2005), events were scored 1 if the participant had reported the gist of the diary entry. Coders agreed on more than 60% of the recall sets<sup>20</sup>; when coders disagreed on the number of accurate events for a participant, the dispute was resolved by a third party (the author of this thesis).

Memory recall for each condition was analysed using a 2 (Lonely group: high and low lonely)  $\times$  2 (affective: positive and negative)  $\times$  3 (social: individual, interpersonal, and collective) mixed ANOVA, adjusted by social anxiety. There was no significant main effect of the affective nature of the diary events on recall ( $F(1,62) = 0.36$ ,  $p = .850$ ,  $\eta p^2 = < .01$ ) or a significant main effect of social content of the diary events on recall ( $F(2,124) = 0.10$ ,  $p = .908$ ,  $\eta p^2 < .01$ ). There was a significant interaction between the affective and social content of the diary events on recall ( $F(2,124) = 4.50$ ,  $p = .013$ ,  $\eta p^2 = .07$ ).

There was no significant main effect of lonely group on recall of diary events ( $F(1,62) = 1.72$ ,  $p = .195$ ,  $\eta p^2 = .03$ ). There were no significant interactions between lonely group and social content of the diary events ( $F(2,124) = 0.03$ ,  $p = .973$ ,  $\eta p^2 = < .01$ ) or lonely group and affective nature of the diary events ( $F(1,62) = 0.32$ ,  $p = .576$ ,  $\eta p^2 = < .01$ ). There was a significant interaction between social content, affective nature of the diary events, and lonely group ( $F(2,124) = 3.67$ ,  $p = .029$ ,  $\eta p^2 = .06$ ). The relationships between the recall of lonely groups dependent on the social content and affective nature of the diary events are displayed in Figure 9.1 for the high lonely group and in Figure 9.2 for the low lonely group.

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<sup>20</sup> This reliability is lower than the Gardner et al. (2005) paper, children in the study wrote very few words so it was difficult to judge whether they had the "gist" of the entry.

An examination of the interaction graphs (Figure 9.1 and 9.2) reveals different patterns of recall for the lonely groups based on the social content of the diary entries: the high lonely appear to recall more negative than positive individual events and more positive than negative social events; the low lonely group appear to have the opposite pattern to the high lonely group: they appear to recall more positive than negative individual events and more negative than positive social events. To examine the results further recall for interpersonal and collective events was averaged to create recall for social events. The difference between recall for negative and positive content for social and non-social events were examined for each lonely group using paired t-tests. For the low lonely group there was no significant differences between recall for negative and positive non-social diary entries ( $t(52) = 0.20, p = .842$ ), but there was a trend towards low lonely people recalling significantly more negative than positive social diary entries ( $t(52) = 1.99, p = .052$ ). One must be cautious in the interpretation of these results as Bonferroni's correction for multiple comparisons would reduce the alpha to  $p < .013$  ( $\alpha/4 = 0.0125$ ). Although the sample size is sufficient for this type of study the high lonely group is small and these results may be nearer significance in a larger population (with a larger high lonely group).

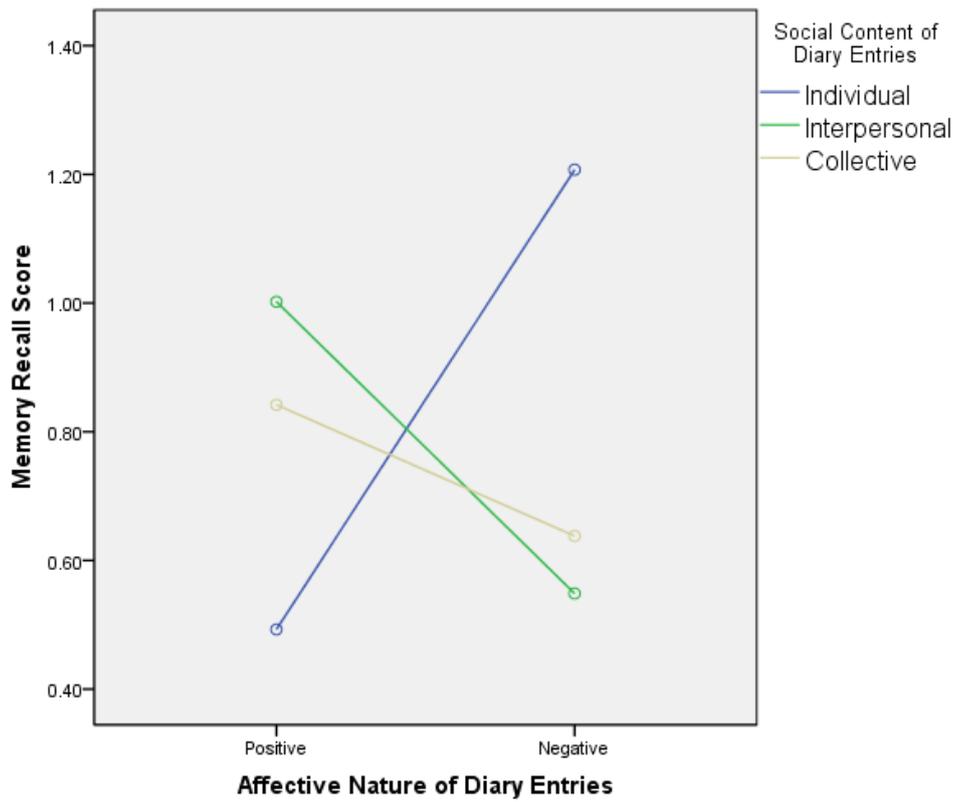


Figure 9.1 Memory recall for the high lonely group by affective nature of diary entries for each of the social condition

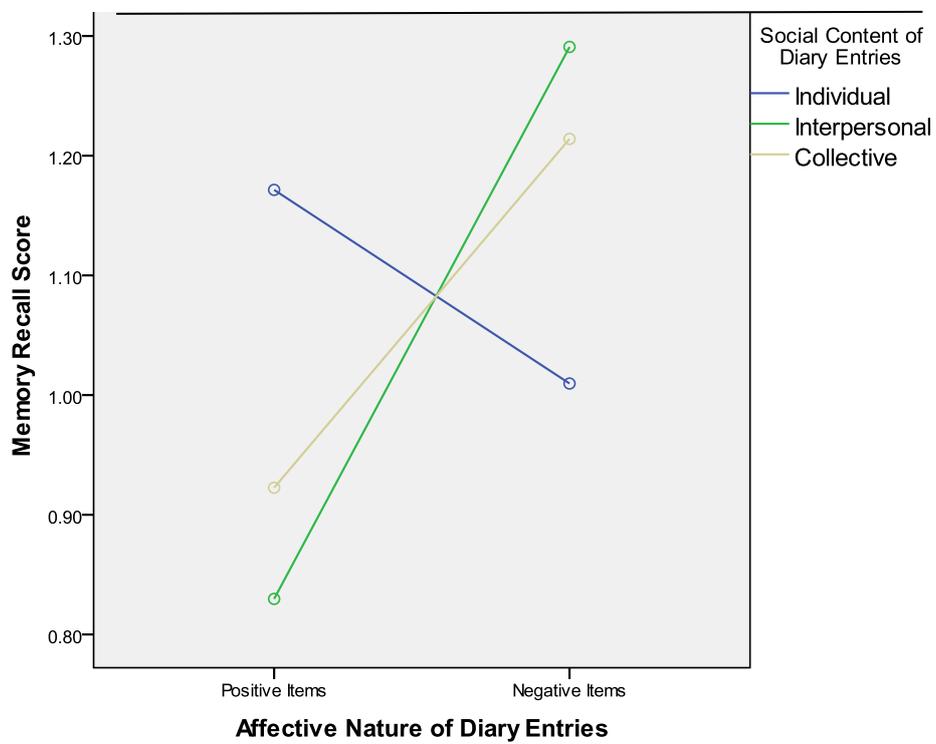


Figure 9.2 Memory recall for the low lonely group by affective nature of diary entries for each of the social condition

## Discussion

The current study aimed to replicate Gardner et al. (2005) study in a child sample to examine whether the cognitive biases that are found in lonely adults are evident in childhood. Gardner et al. (2005) found that lonely adults recalled more social events than non-lonely adults in their memory recall task. In the current study, replicating Gardner et al. (2005) memory task, high lonely children did not recall more social events than non-lonely children. This indicates, that lonely children, in contrast to adults, do not have a bias for social information in a memory recall task. Given that eye tracker studies have shown that lonely children process social information differently to lonely adults (Bangee et al., under review; Qualter et al., 2013a) the results in the current study may reflect developmental differences in cognitive processing (Anderson, 2002). It may also be that children have not been lonely for long enough to have the same cognitive biases to social information as adults.

An interesting finding in the current study is that there was an interaction between the affective nature and the social content of diary entries on memory recall that was different between the lonely groups. High lonely children appeared to recall more negative than positive non-social events, and more positive than negative social events. In contrast, low lonely children appeared to recall more positive than negative non-social events and more negative than positive social events. However, when further analysis was carried out these relationships did not remain, so it is important that there is a cautious interpretation of the results. The findings indicate that lonely children may have a different focus in their attention for social information than non-lonely children, which is supported by eye tracker studies (Qualter et al., 2013a).

## STUDY 5b

The aim of Study 5b was to examine whether, similar to adults, lonely children have difficulties with attentional control in comparison to non-lonely children. Cacioppo et al. (2000) demonstrated that lonely adults have increased difficulties with attentional control in a dichotic listening task. Study 5b involves two tasks both of which use task irrelevant information as distracters: one examines

attentional control using auditory distraction (as Cacioppo et al., 2000) and the other task uses visual distraction. Impaired performance on distractibility tasks in relation to loneliness has only been examined in using auditory distractibility, so the visual attention task in the current study makes an important contribution to the field, enabling a comparison of results for a visual attention task with the results from the auditory attention task. Thus, enabling an examination of whether impaired performance on tasks involving attentional control in lonely people is replicable in tasks involving the visual modality or whether the impairment is specific to the auditory modality.

The first task involves a serial digit span task in four auditory conditions: quiet, neutral words, positive social words, and negative social words. The task aims to replicate the findings of Cacioppo et al. (2000) to examine whether, similar to adults, lonely children have greater difficulties in attentional control. It also includes positive and negative social words to examine whether the social content of speech impacts on the distractibility in lonely children. The second task uses a flanker visual attention task using a methodology designed by Stoet (2010). This task differs from the first task as it does not involve a speech distraction and has no social content (i.e. social threatening) of the distracting/task irrelevant information.

## Method

### *Participants*

Children were recruited from the NWCTS (see details of child population in Chapter 2) to complete the cognitive tasks for this study. A sample of 55 children (52.7% were female) aged between 11-12 years (mean age = 11.84, SD = 0.37) were recruited and completed the two tasks at an additional visit to their schools in the July at their secondary schools (i.e. time 4). Parents gave written consent for their children to take part at the commencement of the study and children gave verbal consent to take part in the study at each data collection time point. Recruitment procedures and testing was in accordance with the national and local ethics guidelines according to the Declaration of Helsinki.

## *Apparatus and materials*

*Questionnaire Measures* Loneliness and social anxiety were used as in study 1a. In the current study, both measures had an acceptable level of reliability: Loneliness - Cronbach's alpha = .94 and Social Avoidance and Distress - General (i.e. social anxiety) - Cronbach's alpha = .93.

*Serial recall with task irrelevant speech* The auditory stimuli for the irrelevant speech task were presented one at a time in a female voice and consisted either of neutral words, positive social, or negative social (for words see Appendix 3). The positive social words were from Anderson (1968) and the negative social words were from MacLeod, Matthews, and Tata (1986). Children were asked to ignore the words presented to them in headphones. The spoken stimuli were digitised and combined with silence using a sound-editing program to create a one-item-per-second presentation rate. Sound onsets were simultaneous with the onset of the visual stimuli. All sounds were presented over digital headphones. The digit span task involved presentation of 6 numbers presented one by one in the centre of the screen. The children saw a small fixation cross in the centre of the screen for 750 msec and then the visual stimuli were presented. Children were instructed to ignore any sounds heard through the headphones and to concentrate on remembering the numbers. There were eight trials of each auditory condition one of each auditory condition (quiet, neutral, positive social and negative social), a total of 24 trials (4 auditory conditions x 8 number strings). Number strings were generated using a number generator. Number strings starting with the digit 1 or involving more than 2 sequential numbers (i.e. 2, 3, 4) were not used. The auditory conditions were randomly presented. Children were asked to type their recall of numbers in order using numbers on the keyboard.

*Flanker task* The flanker task in this study used the methodology devised by Stoet (2010). A 3 x 3 (10 x 10 cm) grid of black lines (1 mm in width) was presented at the centre of a white screen which was visible throughout the experiment. Red or green circles (15 mm in diameter) were presented in the centre grid and children were asked to press the space bar only if the stimulus presented was a green circle. When the circle in the centre of the screen was red, children were asked not to press

the space bar. The red and green circle in the centre of the screen represents the go trial (where a response is expected) and no-go trial (where a response is not expected). Whilst the red or green centre circles were presented, these were flanked by green, red and/or blue circles in the rest of the grid.

On each trial, a flanker (red, green, or blue) appeared in one of the eight grid positions (but not the centre). There were three trial types: compatible (the flanker is the same as the target, i.e. red or green), incompatible (the flanker is different to the target, i.e. red or green), neutral (the flanker is different to the target, but not a colour that the target could be, i.e. blue). Children were asked to ignore the circles presented in the rest of the grid. After 200 ms, a red or green circle was presented in the central grid position (while the flanker remained on the screen). Children were asked to respond (i.e. press the space bar) if the circle in the central grid was green but withhold a response (i.e. do not press the space bar) if the circle was red. The circles disappeared after a response was given or after 500 ms if response not given. A lack of response in a go trial was followed by a response of “too slow” and a response in a no-go trial was followed by a response of “error”. Error messages were presented for 2 seconds. The experiment started with at least 10 training trials, children needed to get 10 trials correct in order to commence the experimental trials. Children performed 240 trials in two blocks. Between the blocks children were given a break of 10 seconds.

### *Procedure*

Data were collected when the children were at secondary schools. Children were placed in small groups of between 2 and 5 (dependent on numbers of children taking part in the study at each school). Half of the children completed the loneliness and social anxiety questionnaire first and half the children completed the tasks first. The tasks were also randomised so half of the children did the serial recall task first and half did the flanker task first. Children completed the questionnaire measures in a questionnaire booklet and tasks were performed on a 15 inch laptop.

## Results

In line with other research in this area (Cacioppo et al., 2002; Qualter et al., 2013a) children were grouped as high lonely based on the upper quartile of loneliness scores. The resulting high lonely group (n = 11, 70% female) had a mean peer loneliness score of 2.69 (SD = 0.66) and the low lonely group (n = 44, 49.2% female) had a mean peer loneliness score of 1.35 (SD = 0.26).

### *Serial recall with task irrelevant sounds*

Proportions correct for serial recall performance in each irrelevant speech condition (adjusted by social anxiety) are found in Table 5.1.

Table 9.1 Proportions correct for serial recall in each irrelevant speech condition by lonely group (adjusted by social anxiety)

	Quiet	Neutral	Positive Social	Negative Social	Total
High Lonely	0.55 (0.07)	0.31 (0.05)	0.38 (0.06)	0.35 (0.06)	0.40 (0.05)
Low Lonely	0.62 (0.03)	0.44 (0.02)	0.47 (0.02)	0.47 (0.03)	0.50 (0.02)
Total	0.58 (0.04)	0.38 (0.02)	0.42 (0.03)	0.41 (0.03)	

Independent t-tests were used to examine differences between the lonely groups on mean proportion of correct words recalled. The proportion correct by lonely group for each condition is displayed in Figure 9.2. Independent t-tests (using one-tailed predictions as recall was expected to be poorer in the high lonely group based on previous research (e.g. Cacioppo et al., 2000) revealed that the low lonely group had higher recall in all the word conditions: neutral ( $t(52) = 2.73, p < .001$ ), positive social ( $t(52) = 1.64, p = .053$ )<sup>21</sup>, and negative social ( $t(52) = 1.99, p = .026$ ). There were no significant differences between the proportions correct between low and high lonely groups in the quiet condition ( $t(52) = 0.83, p = .411$ ). This indicates

<sup>21</sup> Note: that the differences between lonely and non-lonely for positive social and negative social words reflect a trend when the Bonferroni correction is applied based on number of comparisons reducing alpha to  $p < .01$  ( $\alpha/4 = .01$ )

that there is no difference in serial recall between the lonely groups when there is no distracting information, but, when there is a task irrelevant speech distractor, the high lonely group have poorer task performance. This shows that the high lonely group find it more difficult than the low lonely group to ignore irrelevant distracting speech whilst performing a task.

To compare performance in the speech condition to the quiet (non-speech) condition, difference scores were calculated by subtracting the proportion correct for the quiet condition by an average of all 3 speech conditions. This difference score was compared between the two lonely groups to examine whether there was a greater cost to performance to the high lonely group in the speech condition. There was not a significant difference between the lonely groups ( $t(52) = 1.04, p = .150$ , one-tailed).

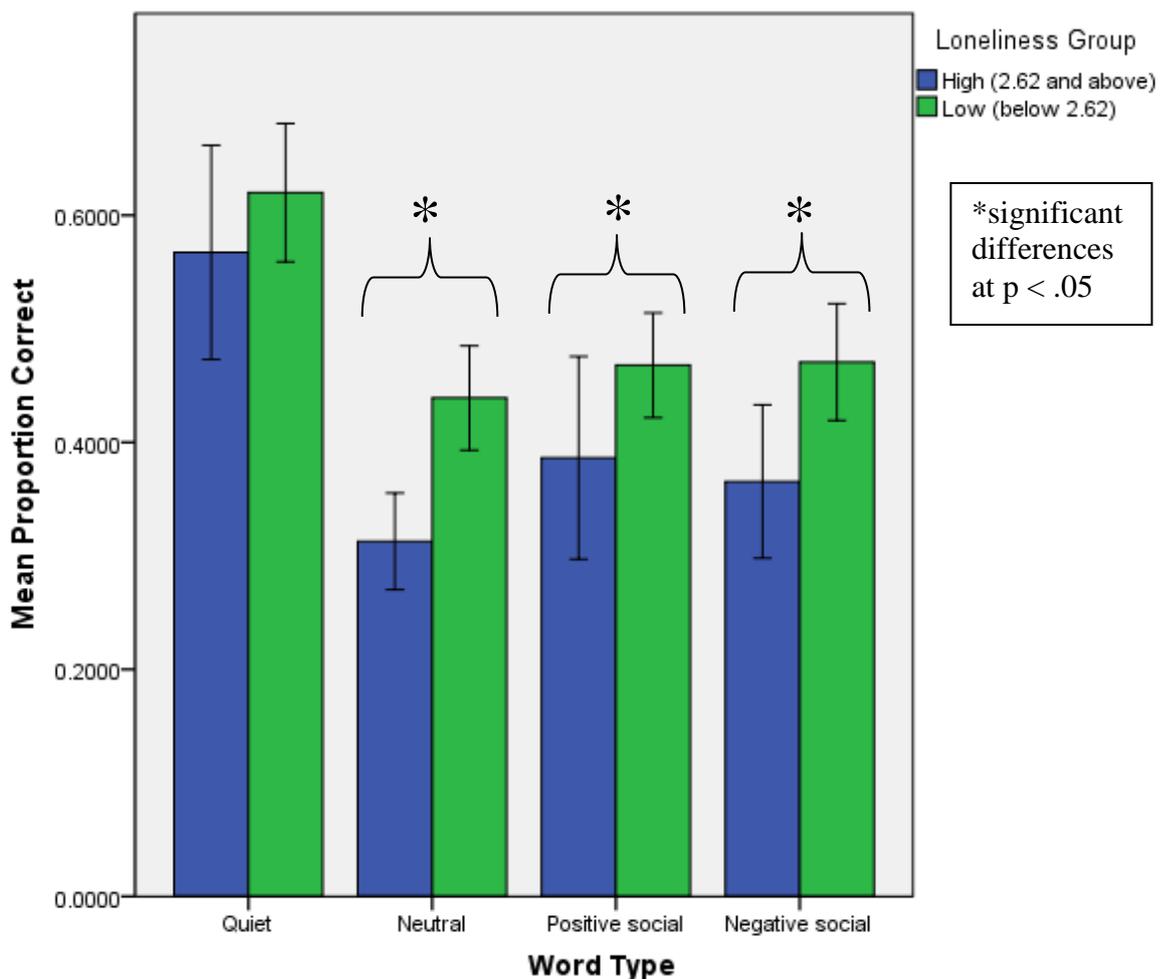


Figure 9.2 Proportion correct digits by lonely group for each speech condition (with 95% CI error bars)

### *Flanker task*

There were three children who had a percentage error rate of above 60%, because this could be an indication that they were not following the protocol correctly, these three children were removed from all the analyses.

*Training trials.* At a group level children performed 4 (SD = 3.32) sets of practice trials. The high lonely group performed on average 4.10 (SD = 2.42) sets of practice trials and the low lonely group performed a mean of 3.98 (SD = 3.52) sets of practice trials. Comparison between the high and low lonely groups showed that there was no significant difference between number of set of trials performed between the lonely groups ( $t(49) = 0.11, p = .217$ ).

*Reaction time.* Reaction time for each flanker condition for the go-trials (reaction time for no-go trials was not recorded) by lonely group (adjusted by social anxiety) is displayed in Table 5.2. A repeated 2 (Lonely group: high and low lonely) x 3 (Flanker type: compatible, incompatible, and neutral) repeated measures ANOVA, with social anxiety as a co-variant, was conducted for reaction times for the go-trials. There was a significant main effect of flanker type ( $F(2,94) = 14.33, p < .001, \eta p^2 = .23$ ). Post hoc comparisons revealed that reaction time for compatible trials was faster than incompatible ( $t(50) = 15.70, p < .001$ ) and neutral trials ( $t(50) = 15.40, p < .001$ ). There was no difference in reaction times for incompatible and neutral trials ( $t(50) = 0.19, p = .852$ ). There was no significant main effect of lonely group ( $F(1,47) < .01, p = .990, \eta p^2 = < .01$ ) and there was no significant interaction between flanker type and lonely group ( $F(2,94) = 0.27, p = .269, \eta p^2 = .02$ ).

Table 9.2 Mean reaction time (and standard error) for each flanker condition for go-trials by lonely group (adjusted by social anxiety)

	Compatible	Incompatible	Neutral	Total
High Lonely	328.67 (9.64)	361.37 (8.38)	365.36 (8.81)	351.80 (8.13)
Low Lonely	326.58 (4.10)	364.65 (3.56)	364.54 (3.74)	351.92 (3.45)
Total	327.62 (4.81)	363.01 (4.18)	364.95 (4.40)	

Table 9.3 Error percentages (and standard errors) for go and no-go trials for each trial type by lonely group (adjusted social anxiety)

	Go-Trials			No-go Trials			Total
	Compatible	Incompatible	Neutral	Compatible	Incompatible	Neutral	
High Lonely	4.12 (1.43)	9.73 (3.09)	6.02 (1.96)	3.00 (1.18)	19.78 (3.18)	5.17 (2.27)	7.97 (1.48)
Low Lonely	3.95 (0.61)	6.87 (1.31)	6.55 (0.83)	3.05 (0.50)	14.96 (1.36)	5.68 (0.96)	6.84 (0.63)
Total	4.03 (0.71)	8.30 (1.54)	6.28 (0.98)	3.03 (0.59)	17.37 (1.59)	5.42 (1.13)	

*Errors.* Percentage of errors for each flanker condition for the go-trials and no-go trials by lonely group (adjusted by social anxiety) is shown in Table 9.3. A repeated 2 (Lonely group: high and low lonely) x 2 (Trial type: go-trials and no-go trials) x 3 (Flanker type: compatible, incompatible, and neutral) repeated measures ANOVA, with social anxiety as a co-variant, was carried out on errors. There was a significant main effect of flanker type ( $F(2,94) = 6.46, p = .002, \eta p^2 = .12$ ). Post hoc comparisons reveal that there were more errors in the incompatible trials than compatible ( $t(50) = 10.69, p < .001$ ) and neutral trials ( $t(50) = 4.09, p < .001$ ). There were more errors on the neutral trials than the compatible trials ( $t(50) = 7.42, p < .001$ ). There was no significant main effect of trial type ( $F(1,47) = 0.75, p = .392, \eta p^2 = .02$ ) or lonely group ( $F(1,47) = 0.42, p = .47, \eta p^2 < .01$ ). The interactions between lonely group and flanker type ( $F(2,94) = 2.10, p = .128, \eta p^2 = .04$ ) and lonely group and trial type ( $F(1,47) = 0.07, p = .800, \eta p^2 < .01$ ) were not significant.

## Discussion

The current study aimed to replicate, in a child sample, the findings of Cacioppo et al. (2000) that showed lonely adults display impaired performance on an auditory distraction task in comparison to non-lonely adults. Results of the current study show that, in the serial recall task with irrelevant speech, there was no difference in serial recall between the lonely groups when there was no distracting information, but when there was an task irrelevant speech distractor, the high lonely group had poorer task performance. This shows that the high lonely children found it more difficult than the low lonely children to ignore irrelevant distracting speech whilst performing an unrelated task. This is similar to Cacioppo et al.'s (2000) study that found lonely adults were more distracted by irrelevant speech when the attentional demands were high. This indicates that lonely children have similar difficulties with attention control as non-lonely adults.

Cacioppo and Hawkley (2009) argue that the HSTH in lonely people directly results in cognitive biases, but the cognitive deficit/decline shown in the current study and in previous studies (Cacioppo et al, 2000), is not fully explained in their model. It could be that the cognitive impairments are the result of prolonged activation of the HPA axis (as proposed in Cacioppo & Hawkley's 2009 model) which has been associated with memory impairments (Lupien et al., 2005; Wolf,

2003). An alternative explanation could also be that the state of loneliness loads a person's cognitive functioning leading to general impairments on task performance and difficulties with executive functioning, such as inhibition of undesired/inappropriate task responses. Loneliness has been associated with increased anxiety (Johnson, LaVoie, Spenceri, & Mahoney-Werni, 2001; Jones, Rose, & Russell, 1990) and rumination (Vanhalst, Luyckx, Raes, & Goossens, 2012), and these processes would load the lonely person's cognitive capacity, reducing working memory. The reduction in working memory span would lead to increased distractibility on cognitive tasks involving irrelevant distractors. It would be important in further research to examine working memory and executive functioning in lonely people to establish the functional mechanism that leads to cognitive deficits/impairments in lonely adults and children.

What was interesting about the findings in the current study, is that there were no differences in recall for the high lonely children in relation to the content of speech. This was unexpected as Qualter et al. (2013a) demonstrated that children have similar biases for negative social information to adults. It may be that in this task and in Cacioppo et al.'s study (2000), the speech is distracting, not the content of the speech. The results for the flanker task differ to the serial recall task as there were no differences in task performance between the lonely groups. If children have a general difficulty with attentional control it would be expected that differences between the lonely groups would also be evident on the flanker task. What is different about this task and the serial recall task is that it involves speech. It may be, that difficulties with attentional control in lonely people only relate to a particular sensitivity for speech. Speech is social in nature and given lonely people's HSTH (Qualter et al., 2013a; Cacioppo & Hawley, 2009), it would be expected that distractibility would be at its greatest in lonely people when the distracting information could be considered a potential social threat. Lonely people are on a heightened state of alert for social threat in everyday life (Cacioppo & Hawley, 2009; Qualter et al., 2013a; see also studies 1 and 2 in this thesis), so they may find it more necessary than non-lonely people to screen speech, and hence, are more distracted by spoken auditory information in these tasks. Future research should examine differences in auditory tasks that involve speech as a distraction and those which do not.

## Conclusion

The tasks in the current study are the first to examine cognitive biases and attention control in lonely children. Evidence from existing studies with adults indicate that lonely adults have an increased memory for social information (Gardner et al, 2000) and display difficulties with attentional control (Cacioppo et al., 2000). In the current study lonely children did not have better memory recall for social information than non-lonely children. This may reflect developmental differences in loneliness and social information processing.

Findings from the current study indicate that, similar to adults, lonely children have difficulties with attentional control, but only in an attention task that involves speech. As it has been demonstrated that lonely people, both children and adults, have a HSTH (Cacioppo & Hawkley, 2009; Qualter et al., 2013a) and as a result are on a heightened state of alert, it is likely that the sensitivity to distraction by speech is the result of an increased necessity to screen speech information for social threat. To date, the impact of loneliness on attentional control in adults has only been examined using a task with a speech distractor (Cacioppo et al., 2000). Future adult studies should examine whether attentional control differences are also evident in visual attention tasks or whether, similar to children, they are only present in speech distractor tasks.

## Chapter 10: Study 6 – Responding to a Social Challenge: Transition to High School in Lonely Children

### Introduction

Studies 1 and 2 (outlined in Chapter 3 and 4) in the adult section of this thesis examined real life, naturally occurring social stressors in adulthood and the associated stress response and perception of social threat in high lonely adults in comparison to low lonely adults. This chapter outlines the final child study which brings the adult and child strands of research in this thesis together by examining stress and perception of social threat in relation to a real life, naturally occurring social stressor in childhood: the transition from primary to secondary school. Self-reports of poor health are also examined in this cohort of children to offer further evidence of the association between long term loneliness and poor health in childhood (see Study 3 outlined in Chapter 7). Because this social stressor involves a transition period, adjustment is also measured to examine whether lonely children have greater difficulties with the adjustment to secondary school.

### *Summary of adult studies in a real life context*

The current theoretical model proposed by Cacioppo and Hawkley (2009) for loneliness and health (outlined in Chapter 2) suggests that loneliness leads to a hypervigilance for social threat (HSTH) which in turn results in increased activation of threat surveillance mechanisms (such as the hypothalamic-pituitary-adrenal (HPA) axis). They propose that it is the chronic activation of the HPA axis in lonely people that results in poor health. The model indicates that in a socially stressful situation lonely people are likely to experience an increased HPA axis stress response as they are on a heightened alert for social threats and will report higher levels of social threat than non-lonely people.

Studies 1 and 2 in this thesis (in Chapters 3 and 4) examined the HPA axis stress response, self-reporting of stress, and HSTH (using a measure of perception of social threat) in two separate everyday real life social contexts in adult populations.

In Study 1 participants gave a presentation to their peers, but comparison between lonely groups was not possible as the activity did not elicit a HPA axis stress response. In comparison, meeting strangers during an ice breaker session in Study 2 was sufficiently stressful to elicit a HPA stress response, but there were no differences between high and low lonely groups. In both studies the high lonely groups reported higher levels of perception of social threat than the low lonely groups, indicating that HSTH is found in real life social contexts in lonely people offering ecological validity for Cacioppo and Hawkley's (2009) model.

Self-reported stress was higher for lonely people in both Studies 1 and 2 on all days regardless of participation in the stressful social activity, indicating that lonely adults generally feel more stressed in everyday life rather than having increased stress due to a specific social activity. These results are similar to those obtained in other empirical studies using diary methodology where lonely people have not reported more stressful events in everyday life, but generally report higher stress levels than non-lonely people (Hawkley, Thisted, & Cacioppo, 2009; Pressman et al., 2005).

The study outlined in this chapter (Study 6) aims to bring the adult and child studies within this thesis together by investigating a real life, naturally occurring social stressor for children: the transition from primary to secondary school. Study 6 is the first to examine the impact of loneliness on the stress response and perception of social threat to a real life, naturally occurring social stressor in children.

### *Loneliness and health in childhood*

Study 3 (outlined in Chapter 7) is the first study to examine longitudinal loneliness and health outcomes in childhood. Study 3 demonstrated children who experience long term loneliness, despite reduction in loneliness level at 11 years, report poorer health, higher levels of depressive symptoms, and greater sleep dysfunction than those experiencing low stable loneliness. The reduction in childhood loneliness at 11 years was an unexpected finding because loneliness has previously been shown to increase during adolescence (Goossens, 2008a). Other recent trajectory studies have also shown a reducing loneliness group, alongside a high, stable loneliness group (Jobe-Shields, Cohen, & Parra, 2011; Qualter et al., 2013b; Vanhalst, Goossens, Luyckx, Scholte, & Engels, 2012). One suggestion for

this reducing loneliness at 11 years is that children in the cohort in Study 6 were at a transitory stage, moving from primary school to secondary school. It is possible that this move offers lonely children the opportunity to form new friendships and address their difficulties with social interaction (Bohert, Aikens, Wargo, & Arola, 2013; Güroglu, Cillessen, Haselager, & van Lieshout, 2012). It is also a time within UK schools that intervention occurs to support the transition for all children, but particularly those who have had previous difficulties with loneliness, social anxiety, and friendships in their primary schools. Study 6, outlined in this chapter, examines the growth of loneliness across the transition period, and provides an opportunity to investigate the proposition that loneliness may reduce over this period due to increased opportunities for re-connection with others.

Cacioppo and Hawkley (2009) implicate chronic activation of the hypothalamic-pituitary-adrenal (HPA) axis as a functional mechanism in their theoretical model for loneliness and health. However, the studies within this PhD have noted that lonely adults typically experience chronic stress (see Studies 1 and 2 in Chapters 3 and 4) but do not have an attenuated HPA axis stress response to social stressors in everyday life. Increased stress in everyday life places cumulative wear and tear on multiple physiological systems resulting in poor health (McEwen & Stellar, 1993). It is possible that chronic stress is an important mechanism linking loneliness to poor health. It is important that chronic stress is measured in additional populations to build evidence for this proposition; hence, there is a measure of stress in the current study. Additionally, to build a developmental perspective it is important to examine whether increased stress related to loneliness is also evident in child populations. Study 6 outlined in this chapter is the first to examine stress in lonely children.

#### *Loneliness and the transition from primary to secondary school*

The growth of loneliness across the transition from primary to secondary school has not been examined in the loneliness literature. Although there have been some studies examining the transition from primary school to secondary school that have measured loneliness, they have used loneliness as an adjustment measure (e.g. Ladd, Kochenderfer, & Coleman, 1996). Peer acceptance and friendships have been linked to adjustment across the transition period and pre-transition peer relationships

predict post-transition adjustment (Kingerly, Erdley, & Marshall, 2011; Swenson, Nordstrom, & Hiester, 2008). Peer acceptance and friendship play an important role in adjustment in the transition from primary to secondary school so children who have high levels of loneliness may find the transition period particularly difficult and display lower levels of adjustment.

However, Study 3 (see Chapter 7) showed a decrease in loneliness at 11 years of age in children who had experienced relatively high loneliness for a number of years. In the UK, transfer from primary school to secondary school occurs at 11 years of age. Recent studies have demonstrated that organised activities across the transition are linked to increased friendships (Bohert et al., 2013) and the transition itself has been shown to offer opportunities for change in friendship patterns (Güroglu et al., 2012). Therefore, it may be that the transition to secondary school offers opportunities for re-connection, and for children who have experienced loneliness pre-transition, their levels of loneliness may reduce.

In the current study, it is predicted that loneliness and adjustment to secondary school specifically, at a group level loneliness would reduce across the transition. However, for some children who experience high chronic loneliness across the transition loneliness level will remain the same. In addition, as the move to secondary school offers opportunities for re-connection with others for some children who experience high loneliness prior to transition may having decreasing levels of loneliness.

### *The current study*

The aims of the current study were to (1) examine the course of loneliness across the transition from primary to secondary school in a UK population, (2) examine the association between loneliness and stress, perception of social threat, and adjustment to the transition, and (3) examine the association between loneliness and self-reported health and sleep dysfunction across the transition. Measures were taken before the transition in children's primary school (in July), during transition (in October) and after transition (in January) in their secondary schools. First, the levels of loneliness were examined at the group level (i.e. in the full sample of children). Second, children were grouped by loneliness based on a mean split at each time

point. Third, each of the measures (health, stress and adjustment) was compared by lonely group.

## Method

### *Participants and Procedure*

The participants were from the North West Child Transition Study (NWCTS), which is a prospective study of 80 children recruited from 12 primary schools in Lancashire, UK. This study is on-going and the data discussed in this chapter reflects the results of the first round of data collection. Data were collected across the transition from primary to secondary school which takes place in year 6-7 in schools in the UK. Children were aged 11 years (mean age 11 years and 4 months) at time 1 (in July before the transition to secondary school). Self-reports of loneliness, health, stress, and adjustment to secondary school were collected at three time points that took place in July (before transition) in the child's primary school, at the child's secondary school in October (during transition), and January (after transition). Data were collected in the July and October in 19 secondary schools. Only children who provided data at two or more data collection time points (including time 1) were included in the final sample, resulting in the inclusion of 70 children in the current study. Of this sample 54.3% were male. The children's primary care-giver gave written consent at the commencement of the study and child assent was requested at each time point. All participants were tested in accordance with the national and local ethics guidelines according to the Declaration of Helsinki.

### *Measures*

*Peer-related loneliness.* Loneliness in relation to peers was measured using the peer subscale of the Loneliness and Aloneness Scale for Children and Adolescents (LACA: Marcoe & Brumage, 1985) as Study 3 (see Chapter 7). In the current study, this sub-scale demonstrated good internal consistency across the three time points ( $\alpha = .84, .90$ , and  $.93$  for T1, T2, and T3 respectively).

*School belonging.* The Psychological Sense of School Membership scale (PSSM, Goodenow, 1993) was used to measure school belonging. The PSSM has been found to display acceptable internal consistency, reliability, and validity (Goodenow, 1993). This measure involves a series of statements and children are asked to rate how true each statement is for them on a Likert scale ranging from 1 for not true at all to 5 for completely true. Examples of items include “I feel like a real part of my school”, “People here notice when I’m good at something” and “Other students in the school take my opinions seriously”. Possible scores range from 18 to 90 with higher scores relating to higher levels of school belonging. Children were asked to respond to the statements in relation to the school they were currently attending so at time 1 their responses related to their primary school. Later at time 2 and 3 children rated their responses related to their new secondary school. In the current study, the PSSM demonstrated good internal consistency across the three time points ( $\alpha = .89, .89$  and  $.93$  for T1, T2, and T3 respectively).

*School concerns.* The School Concerns Questionnaire (SCQ; Thomasson, Field, O’Donnell, & Woods, 2006) was used to measure the level of anxiety about secondary school. The SCQ has been found to display acceptable internal consistency, reliability, and validity (Rice, Frederickson, & Seymour, 2010). The measure has been designed for UK children. At all time points the measurement related to anxiety about the move to secondary school. This measure involves a list of 17 potential concerns about moving to secondary school (e.g. the size of the school, following a timetable, being bullied). Participants are asked to rate their level of concern for each item on a 10-point Likert scale (0 for not worried; 10 for extremely worried). Possible scores range from 0 to 170, with higher score indicating higher levels of concerns about the move to secondary school. In the current study, the SCQ demonstrated good internal consistency across the 3 time points ( $\alpha = .92, .94$  and  $.93$  for T1, T2, and T3 respectively).

*Health.* Self-reported health was measured using the Pediatric Quality of Life Inventory (PedsQL; Varni, Seid, & Rode, 1999) as in Study 4 (see Chapter 8). In the current study, the physical functioning sub-scale demonstrated acceptable internal consistency across the 3 time points ( $\alpha = .72, .79$  and  $.71$  for T1, T2, and T3 respectively).

*Stress.* The Perceived Stress Scale (PSS: Cohen, Kamarck, & Mermelstein, 1983) was used to measure stress. The PSS is an American measure of perceived stress, which has been successfully used in the UK (e.g. Pall & Croucher, 2003). The PSS has acceptable internal consistency, reliability, and validity (Cohen & Williamson, 1988). The PSS measure was designed for adults with at least a junior high school education, but is widely used with pre/early adolescent populations (e.g. Cartwright et al., 2003). The PSS asks participants about their thoughts and feelings in the last months. It involves a list of 10 items about particular thoughts and feelings one could have. Participants are asked to indicate how often they have had thoughts and feelings similar to the item. Example questions include “How often have you felt things were going your way?” and “How often have you felt difficulties were piling up so high that you couldn’t deal with them?” After reverse scoring the relevant items, responses for each item are summed to create a total PSS score. Possible scores range from 0 to 40. Higher scores on the PSS scale indicate higher levels of everyday self-reported stress. In the current study, the PSS demonstrated acceptable internal consistency across the 3 time points ( $\alpha = .78, .85$  and  $.82$  for T1, T2, and T3 respectively).

*Perception of Social Threat.* This measure was developed by the author and involves a series of five vignettes relating to social situations that may occur that are specific to the transition to secondary school. For example, joining in a game in the playground or asking for help to find a classroom (see Appendix 4 for the vignettes used in the measure). After each vignette participants are asked to rate the likelihood of cooperation (this is reverse coded), how anxious they would feel about the situation, and how much of a problem it would be for them. There are three sub-scales of social threat expectancy, anxiety, and coping. Participants are asked to rate from 1-5; higher scores indicate higher threat expectancy (once reverse coded), threat anxiety, and threat coping. These are summed for each item; possible scores for each sub-scale range from 5 to 25. The scores for each sub-scale are summed to calculate a perception of social threat score. Possible scores for the perception of social threat range from 15-75, with higher scores indicating higher levels of perception of social threat. In the current study, the perception of social threat measure demonstrated acceptable internal consistency across the 3 time points ( $\alpha = .85, .89$  and  $.86$  for T1,

T2, and T3 respectively; and for the sub-scales, threat expectancy  $\alpha = .40, .54, .66$ ; threat anxiety  $\alpha = .75, .83, .78$ ; threat coping  $\alpha = .71, .79, .78$ ).

### *Data Analysis Plan*

Data analyses proceeded in three stages. First, the mean trend in loneliness was examined at the group level to determine the general trend. Second, the growth patterns of loneliness for specific groups of individuals were determined using a mean split of loneliness at each time point. Those high in loneliness (as determined by the mean split) at all three time points were categorised as “high lonely” and those low in loneliness at all three time points were categorised as “low lonely”. Children who were high in loneliness at time 1, but were not at time 2 and/or time 3 were categorised as “high transient” and children who were low in loneliness at time 1 but were not at time 2 and/or time 3 were categorised as “low transient”. The growth of loneliness for these four groups over the transition period was examined using a factorial ANOVA. Trajectories were not examined because the sample is too small to analysis using Growth Mixture Modelling<sup>22</sup>. Third, differences between the lonely groups in health, stress, and adjustment to the transition were examined across the three time points using a series of Factorial ANOVAs.

## Results

### *Missing Data Analyses*

To minimize the bias associated with attrition and missing data, the expectation maximization (EM) algorithm was used to impute missing data (Schafer & Graham, 2002). This algorithm assumes that the data are missing completely at random (Little & Rubin, 1987; Schafer & Graham, 2002), but where these assumptions are not met, EM parameter estimates are still typically less biased than those estimated using ad hoc procedures such as pairwise or listwise deletion of missing data (Collins, Schafer, & Kam, 2001; Schafer & Graham, 2002). EM is appropriate when a moderate amount of missing data is noted as < 30% missing

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<sup>22</sup> To increase the sample size, data is being collected in 2013-14 and 2014-15 to ensure appropriate sample size to perform an analysis that will result in grouping by trajectories.

(Little & Schneker, 1995). In the current study, only children who participated in at least two of the three data collection time points (one of which had time point 1: before the transition) were included in the present study. A total of 70 (M = 38, 54.3%) children met these criteria, with 8.57% of data missing at the second and third time points (i.e. 6 children at each time point). Little's (1988) Missing Completely At Random (MCAR) test was non-significant [ $\chi^2 = 1.235, p = .996$ ], suggesting that missing values could be reliably estimated for this sample. To ensure integrity of the data EM was only applied to the loneliness data; for all other measures EM was not applied.

*Development of loneliness at the group level*

Differences between mean loneliness scores at each of the time points were examined using paired samples t-tests and are displayed in Table 10.1. Paired samples t-tests revealed that loneliness scores are significantly lower after transition ( $t(69) = 4.59, p < .001$ ) and during transition ( $t(69) = 4.59, p < .001$ ) than before transition. The comparison between loneliness levels after transition and during transition suggest a trend toward lower lonely during transition ( $t(69) = 1.93, p = .058$ ). These results show that loneliness at the group level is reducing over the transition period.

Table 10.1 Mean loneliness (and standard deviations) scores for all participants at each time point

	Time 1: Before Transition	Time 2: During Transition	Time 3: After Transition
Mean Loneliness score	1.85 (0.56)	1.66 (0.56)	1.58 (0.63)

*Loneliness Groups*

To examine differences in loneliness growth patterns over the transition period, children were grouped in to high and low lonely group using a mean split at each time point. It would be more appropriate to use Growth Mixture Modelling to

distinguish lonely trajectories but the sample size is too small.<sup>23</sup> Children were then grouped into loneliness groups based on the pattern of loneliness levels over the transition period. Children were categorised as “high stable” if they were high lonely at all three time points (n = 14, 20%), “low stable” if they were low lonely at all three time points (n = 29, 41.4%), “high transient” if they were high lonely at time 1 but low lonely at time 2 and/or time 3 (n = 16, 22.9%), and “low transient” if they were low lonely at time 1 but high lonely at time 2 and/or time 3 (n = 11, 15.7%).

To examine the loneliness growth patterns for each of the loneliness groups the mean loneliness scores for each group at each time point were compared. These results are displayed in Figure 10.1. A 3 (Time: before, during and after transition) x 4 (Lonely group: high stable, high transient, low stable, low transient) mixed ANOVA on loneliness scores was undertaken. A Greenhouse-Geisser adjustment was used as Mauchley’s test was significant. The lonely groups were created using a mean split of loneliness scores at each time point so a significant main effect of time and lonely group would be expected. The results reveal a significant main effect of time ( $F(1.80,118.82) = 13.95, p < .001, \eta p^2 = .17$ ) and a significant main effect of lonely group ( $F(1,66) = 78.82, p < .001, \eta p^2 = .78$ ) on loneliness scores. There was a significant interaction between time and lonely group ( $F(5.401,118.82) = 7.23, p < .001, \eta p^2 = .25$ ) on loneliness scores. Paired samples tests between each time point were carried out by lonely group to examine growth of loneliness across the transition period for each lonely group. Patterns of reduction/increase in loneliness over the transition period are displayed in Figure 10.1.

Paired samples t-tests revealed that for the *high stable lonely group* there were no significant differences between loneliness scores at each of the time points over the transition period, showing that for this group, loneliness levels were remaining the same across the transition period. In comparison, for the *low stable lonely group* the loneliness score was lower during transition ( $t(28) = 3.11, p = .004$ ) and after transition ( $t(28) = 4.49, p < .001$ ) than before transition. There was a trend for the loneliness score in the low stable group to be lower after transition than during transition ( $t(28) = 1.86, p = .073$ ). This shows that loneliness scores for the low stable group were reducing over the transition period.

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<sup>23</sup> In the full-scale larger study (after data has been collected in 2013-14 and 2014-15) data analysis will involve piecewise modelling as this will incorporate the reduction in loneliness at the group level.

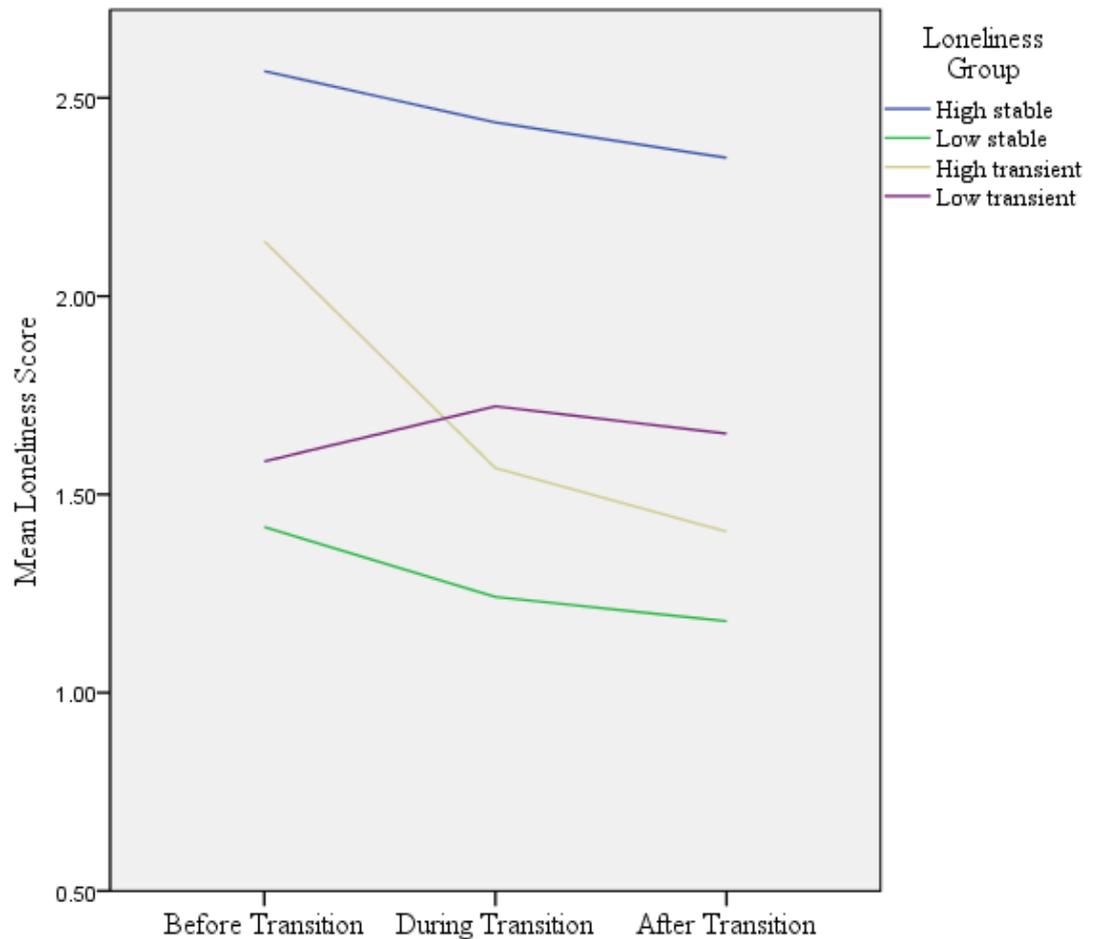


Figure 10.1 Mean loneliness score at each time point for all loneliness groups

For the *high transient lonely group* loneliness scores were lower during transition ( $t(15) = 7.01, p < .001$ ) and after transition ( $t(15) = 7.57, p < .001$ ) than before transition. There was a trend for loneliness to be lower after transition than during transition ( $t(15) = 1.79, p = .094$ ). This pattern of results indicates that loneliness scores for the high transient group were decreasing over the transition period. For the *low transient lonely group* there was no significant differences between loneliness at each of the time points, although there was a trend for a higher loneliness score during transition than before transition ( $t(10) = 1.97, p = .077$ ). It should be noted here that based on the results of the t-tests it may appear that the low transient group and high transient group had similar scores at all three time points, this would not be correct as the mean loneliness scores on which the criteria for grouping is based decreases over the time points (see Table 10.1).

### *Differences in loneliness between lonely groups*

A series of one-way ANOVAs were carried out to examine differences in loneliness scores between the lonely groups at each time point. ANOVA results are displayed in Table 10.2 and revealed significant differences between the lonely groups at each time point. The mean loneliness scores for each lonely group at each time point and results of post hoc comparisons (using Tukey's multiple comparisons) are shown in Table 10.2.

*Before transition*, there was a significant difference in loneliness scores between all lonely groups, with the exception of low stable and low transient which were not significantly different. Importantly, the high stable lonely group had higher loneliness scores than the high transient, indicating that children who increase in loneliness over the transient have lower levels of loneliness prior to transient than those who remain high lonely throughout the transition. *During transition* all lonely groups were significantly different in levels of loneliness, with exception of the high transient and low transient groups which now have similar loneliness levels. *After transition* the high transient group which has reduced in loneliness levels is now not significantly lonelier than the low stable and the low transient groups. This indicates that after the transition period the group that started high and reduced in loneliness now has similar levels of loneliness to both of the low lonely groups.

### *Health, stress and adjustment measures and lonely groups*

A series of 3 (Time: before, after, and during transition) x 4 (Lonely group: high stable, low stable, high transient and low transient) mixed ANOVAs were carried out for each of the health and adjustment to transition measures. Given that the data analysis involved a number of multiple comparisons, using the Bonferroni correction the alpha was adjusted to .006 ( $\alpha/n$ , where  $n = 8$  comparisons). To summarise the results there was a general pattern of a main effect of time and lonely group, but no interaction was found. To aid clarity in the text means for time at the group level for each measure that displays a main effect of time is included in Table 10.3 and means for each measure by lonely group and post-hoc comparisons between

lonely groups are displayed in Table 10.4. The main effects of time and lonely group are examined in detail in the following text.

Table 10.2 Mean loneliness score (and standard deviation) and post hoc comparisons for loneliness groups at each time point

Transient Period	High Stable (HS)	High Transient (HT)	Low Stable (LS)	Low Transient (LS)	ANOVA result	Post Hoc Comparisons
Before	2.62 (0.48)	2.16 (0.18)	1.43 (0.26)	1.57 (0.24)	$F(3,66) = 57.89, p < .001$	HS > HT $p < .001$ HS > LS $p < .001$ HT > LS $p < .001$ HT > LT $p < .001$ LS < LT NS
During	2.55 (0.49)	1.58 (0.27)	1.26 (0.20)	1.72 (0.20)	$F(3,66) = 61.82, p < .001$	HS > HT $p < .001$ HS > LS $p < .001$ HS > LT $p < .001$ HT > LS $p = .005$ HT < LT NS LS < LT $p < .001$
After	2.49 (0.67)	1.41 (0.33)	1.19 (0.18)	1.67 (0.50)	$F(3,66) = 34.77, p < .001$	HS > HT $p < .001$ HS > LS $p < .001$ HS > LT $p < .001$ HT > LS NS HT < LT NS LS < LT $p = .006$

NS = not significant

Table 10.3 Means (and standard deviations) for each measure at the group level by time

	Before transition (T1)	During transition (T2)	After Transition (T3)	Post Hoc Comparisons
<i>Adjustment to Transition:</i>				
School concerns	66.36 (27.15)	48.68 (28.88)	39.64 (23.47)	T1-T2 $t(62) = 6.45, p < .001$ , T1-T3 $t(63) = 8.68, p < .001$ , T2-T3 $t(61) = 2.48, p = .016$
School Belonging	71.27 (11.50)	73.53 (11.04)	73.57 (13.25)	NS
Stress	15.12 (6.52)	11.23 (6.67)	12.64 (7.62)	T1-T3 $t(49) = 3.94, p < .001$ , T1-T2 $t(57) = 3.93, p < .001$ , T2-T3 $t(48) = 0.14, p = .890$
<i>Health:</i>				
Health*	4.52 (3.66)	3.82 (3.74)	3.25 (3.22)	T1-T2 $t(67) = 2.50, p = .017$ , T1-T3 $t(64) = 3.40, p = .001$ , T2-T3 $t(62) = 1.26, p = .212$
<i>Perception of Social Threat:</i>				
Threat expectancy	11.11 (2.60)	10.30 (2.67)	10.50 (3.50)	NS
Threat anxiety	13.76 (4.11)	11.62(4.58)	10.48 (4.18)	T1-T2 $t(67) = 4.43, p < .001$ , T1-T3 $t(65) = 7.06, p < .001$ , T2-T3 $t(63) = 2.52, p = .014$
Threat Coping	12.16 (3.48)	10.72 (4.13)	9.59 (3.88)	T1-T2 $t(67) = 3.17, p = .002$ , T1-T3 $t(65) = 5.72, p < .001$ , T2-T3 $t(63) = 2.26, p = .006$
Perception of social threat	49.19 (12.66)	32.62 (10.27)	30.58 (9.68)	T1-T2 $t(67) = 13.85, p < .001$ , T1-T3 $t(65) = 13.74, p < .001$ , T2-T3 $t(63) = 1.98, p = .052$

Notes: NS = not significant \*higher scores on the health measure indicates poorer health quality of life #higher scores on the sleep measure indicate more difficulty sleeping

Table 10.4 Means (and standard deviations) for each measure by lonely group

	High Stable (HS)	High Transient (HT)	Low Transient (LT)	Low Stable (LS)	Post Hoc Comparisons
<i>Adjustment to Transition:</i>					
School concerns	75.74 (5.34)	49.00 (4.73)	54.52 (5.60)	37.53 (3.54)	HS > HT p = .002, HS > LT p = .039, HS >LS p < .001, HT >LS NS, HT < LT NS, LS < LT NS
School Belonging	63.25 (3.10)	73.00 (2.28)	70.25 (3.01)	79.80 (1.78)	HS < HT NS, HS < LS p < .001, HS > LT NS, HT < LS NS, HT > LT NS, LS > LT p = .042
Stress	19.07 (1.42)	11.19 (1.50)	15.33 (1.84)	8.59 (0.98)	HS > HT p = .002, HS > LT NS, HS >LS p < .001, HT > LS NS, HT < LT NS, LS < LT P = .012
<i>Health:</i>					
Health*	7.36 (0.75)	4.31 (0.72)	3.55 (0.78)	2.09 (0.50)	HS > HT p = .023, HS > LT p = .004, HS >LS p < .001, HT > LS NS, HT > LT NS, LS < LT NS
<i>Perception of Social Threat:</i>					
Threat expectancy	12.50 (0.58)	10.91 (0.54)	11.15 (0.61)	9.52 (0.39)	HS > HT NS, HS > LT NS, HS >LS p < .001, HT > LS NS, HT < LT NS, LS < LT NS
Threat anxiety	15.57 (0.98)	11.24 (0.91)	12.03 (1.03)	10.80 (0.66)	HS > HT p = .011, HS > LT NS, HS >LS p = .001, HT > LS NS, HT < LT NS, LS < LT NS
Threat Coping	14.44 (0.84)	9.98 (0.78)	11.00 (0.87)	9.75 (0.56)	HS > HT p = .001, HS > LT p = .030, HS >LS p < .001, HT > LS NS, HT < LT NS, LS < LT NS
Perception of social threat	47.69 (2.37)	35.91 (2.20)	38.18 (2.48)	33.79 (1.58)	HS > HT p = .001, HS > LT p = .036, HS >LS p < .001, HT > LS NS, HT < LT NS, LS < LT NS

Notes: NS = not significant \*higher scores on the health measure indicates poorer health quality of life #higher scores on the sleep measure indicate more difficulty

### *Adjustment to school transition*

*School Belonging* ANOVA results revealed there was no significant main effect of time ( $F(2,98) = 0.38, p = .687, \eta p^2 < .01$ ) on school belonging. It is important to note that school belonging before transition was based on child's perception of their belonging to the current school (i.e. the primary school). These results indicate that school belonging is static across the transition and similar levels of school belonging are found for both in primary and secondary schools. There was a significant main effect of lonely group ( $F(3,49) = 8.38, p < .001, \eta p^2 = .34$ ) on school belonging, but no interaction between time and lonely group ( $F(6,98) = 1.56, p = .168, \eta p^2 = .09$ ). Post hoc comparisons and means for lonely group (displayed in Table 10.4) reveal that the high stable lonely group have lower levels of school belonging than the low stable group, but these levels are not significantly higher than the other lonely groups. The low stable group report higher levels of school belonging than the low transient group.

*School concerns* ANOVA results revealed there was a significant main effect of time ( $F(2,112) = 33.10, p < .001, \eta p^2 = .37$ ) on school concerns. and a significant main effect of lonely group ( $F(3,56) = 12.13, p < .001, \eta p^2 = .39$ ), but no interaction between time and lonely group ( $F(2,112) = 1.47, p = .193, \eta p^2 = .07$ ) on school concerns. Post hoc comparisons and means for time at the group level (displayed in Table 10.3) reveal that school concerns reduce across the transition period. Post hoc comparisons and means for lonely group (displayed in Table 10.4) reveal that the high stable lonely group reports higher levels of school concerns than all other lonely groups.

### *Health*

ANOVA results revealed there was a significant main effect of time ( $F(2,118) = 6.24, p = .003, \eta p^2 = .10$ ) and a significant main effect of lonely group ( $F(3,59) = 11.78, p < .001, \eta p^2 = .36$ ) but no interaction between time and lonely group ( $F(6,118) = 1.34, p = .245, \eta p^2 = .06$ ) on perceived health. Post hoc comparisons and means for time at the group level (displayed in Table 10.3) show that perceived health reduced across the transition period. Post hoc comparisons and

means for lonely group (displayed in Table 10.4) reveal that the high stable lonely group reported poorer health than the other lonely groups.

### *Stress*

ANOVA results revealed there was a significant main effect of time ( $F(2,84) = 6.36, p = .003, \eta p^2 = .13$ ) on perceived stress. Post hoc comparisons and means for time at the group level (displayed in Table 10.3) showed that stress reduces across the transition period. There was a significant main effect of lonely group ( $F(3,42) = 13.41, p < .001, \eta p^2 = .49$ ) but no interaction between time and lonely group ( $F(6,84) = 0.75, \eta p^2 = .05$ ) on self-reported stress. Post hoc comparisons and means for lonely group (displayed in Table 10.4) reveal that the high stable lonely group reported higher levels of stress than all other lonely groups. The low transient lonely group reported higher levels of stress than the low stable lonely group.

### *Perception of Social Threat*

*Threat Expectancy* ANOVA results revealed there was not a significant main effect of time ( $F(2,120) = 0.59, p = .554, \eta p^2 = .10$ ) on threat expectancy, indicating that threat expectancy does not change across the transition period. There was no significant interaction between time and lonely group ( $F(6,120) = 1.16, p = .330, \eta p^2 = .05$ ). There was a significant main effect of lonely group ( $F(1,60) = 6.50, p = .001, \eta p^2 = .25$ ). Post hoc comparisons and means for lonely group (displayed in Table 10.4) showed that the high stable lonely group reported higher levels of threat expectancy than the low stable lonely group, but not significantly more than the other lonely groups.

*Threat anxiety* ANOVA results revealed there was a significant main effect of time ( $F(2,120) = 19.67, p < .001, \eta p^2 = .25$ ) on threat anxiety. Post hoc comparisons and means for time at the group level (displayed in Table 10.3) reveal that threat anxiety reduces across the transition period. There was a significant main effect of lonely group ( $F(3,60) = 5.71, p = .002, \eta p^2 = .22$ ), but no significant interaction between time and lonely group ( $F(6,60) = 0.58, \eta p^2 = .03$ ) on threat anxiety. Post hoc comparisons and means for lonely group (displayed in Table 10.4) reveal that the high stable lonely group reported higher levels of social threat anxiety than the high

transient and low stable lonely groups, but not significantly more than the low transient group.

*Threat coping* ANOVA results revealed there was a significant main effect of time ( $F(2,120) = 13.38, p < .001, \eta p^2 = .18$ ) on threat coping. Post hoc comparisons and means for time at the group level (displayed in Table 10.3) reveal that threat coping reduces across the transition period. There was a significant main effect of lonely group ( $F(3,60) = 7.87, p < .001, \eta p^2 = .28$ ) but no significant interaction between time and lonely group ( $F(6,120) = 0.58, \eta p^2 = .02$ ) on threat coping. Post hoc comparisons and means for lonely group (displayed in Table 10.4) reveal that the high stable lonely group reported higher levels of coping with social threat than all the other lonely groups.

*Perception of social threat* ANOVA results revealed there was a significant main effect of time ( $F(2,120) = 112.55, p < .001, \eta p^2 = .65$ ) on perception of social threat. Post hoc comparisons and means for time at the group level (displayed in Table 10.3) reveal that perception of social threat reduces across the transition period. There was a significant main effect of lonely group ( $F(3,60) = 8.19, p < .001, \eta p^2 = .29$ ), but no significant interaction between time and lonely group ( $F(6,120) = 0.52, p = < .001, \eta p^2 = .03$ ). Post hoc comparisons and means for lonely group (displayed in Table 10.4) reveal that the high stable lonely group reported higher levels of coping with social threat than all the other lonely groups.

## Discussion

The current study aimed to examine the growth of loneliness across the transition from primary to secondary school and examine health, stress, HSTH and adjustment outcomes dependent in children who experience high loneliness.

### *Loneliness and Transition from primary to secondary school*

At the group level loneliness reduced across the transition from primary to secondary school. These findings help explain the results obtained in Study 3 (see Chapter 7), where children who had experienced high stable loneliness decreased in their levels of loneliness at 11 years of age (the age in the UK when children move from primary to secondary school). Recent studies have demonstrated that organised

activities across the transition are linked to increased friendships (Bohert, Aikens, Wargo, & Arola, 2013) and the transition itself offers opportunities for change in friendship patterns (Güroglu, Cillessen, Haselager, & van Lieshout, 2012). Therefore, it is likely that the reduced levels of loneliness at a group level in the current study are due to the transition offering opportunities for re-connection.

Grouping, using a mean split at each time point, revealed four groups: 1) a high stable lonely group for which loneliness levels remain the same across the transition, 2) a high transient group who have high levels of loneliness pre-transition which reduce over the transition period, 3) a low stable lonely group whose loneliness levels also reduce, and 4) a low transient group who have a slight increase in their loneliness levels. Pre-transition, the high transient and high stable lonely groups have significantly different loneliness levels indicating that there may be other distinguishing features between them. What is particularly interesting about the patterns of change in loneliness is that the high lonely group that reduces in loneliness levels after transition (i.e. the high transient group) have similar loneliness levels to the other low lonely groups following transition. This is important because it indicates something has occurred in order to reduce the loneliness levels in these children. This may be due to a particular intervention or support from teachers and parents with social interaction or it may be due to the increased number of potential children to connect with. It will be important for future studies to examine the specific mechanisms that cause this reduction in loneliness at this particular transition stage.

#### *Adjustment to secondary school*

School belonging was static across the transition period and levels of school belonging were the same in primary and secondary schools. The high stable lonely group had the lowest levels of school belonging. Interestingly, the low transient group had lower levels of school belonging than the low stable group, indicating that a lack of feeling of belonging in the secondary school may be involved in increases in loneliness levels in the low transient group. Cacioppo and Hawkley's (2009) model mentions little about how the lonely person interacts with the social world, but they do indicate that the negativity and passivity typical of a lonely person results in either attraction (to support/help the lonely person) or repulsion from others. The

finding in this study that a lack of school belonging is associated with an increase in loneliness supports Cacioppo and Hawkley's suggestion of an interplay of the social world and the lonely person. The findings also indicate that intervention strategies would be useful that targeted increasing whole school belonging which would impact in decreasing loneliness feeling in high lonely children.

In comparison, school concerns at the group level reduced across the transition period, with the high stable lonely group reporting the highest levels of school concerns. This indicates that for most children school concerns reduced due to school intervention across the transition (Bohert, Aikens, Wargo, & Arola, 2013) or the experience of transition itself (Güroglu, Cillessen, Haselager, & van Lieshout, 2012). For the high stable lonely group these concerns remained after the transition, despite intervention and support given by schools at transition.

### *Health*

At the group level perceived health reduced over time. The high stable lonely group reported poorer health than all other groups than the low stable group. This result is similar to the results in Study 3 (see Chapter 7), which found poor health outcomes and sleep dysfunction in children who had experienced high stable loneliness, despite it reducing at pre-adolescence, in comparison to children who had experienced low stable loneliness. Other studies within the loneliness and health research field with children have only examined loneliness using a cross-sectional design, so the studies 3 and 4 in this thesis are the first to examine the long term implications of loneliness on physical health in childhood. The results indicate that similar to adults (Shiotiz-Ezra & Ayalon, 2010), it is the long term experience of loneliness that is associated with poor health outcomes in childhood.

### *Stress*

Self-reported stress was highest in the high stable lonely group at all time points across the transition period. These results are similar to the results obtained in the adult studies in this thesis (Studies 1 & 2; see Chapter 3 & 4) that examined stress in a real life social context. Those adult studies found higher levels of self-reported stress in lonely adults were not observed specifically in relation to a social stressor,

but were generally higher in everyday life. Perceived stress in the high stable lonely group in the current study was not related to the transition period, but remained high throughout the study. These results indicate that the high stable lonely group typically experiences chronic stress in every day life. Other literature using diary methodology shows that lonely adults do not report more stressful events in everyday life, but generally report higher stress levels than non-lonely people (Hawkley, Thisted, & Cacioppo, 2009; Pressman et al., 2005). Increased stress in everyday life places cumulative wear and tear on a number of physiological systems which results in poor health (Justin, McEwen, & Lupien, 2010; McEwen & Stellar, 1993). It appears, then, in both adulthood and childhood that chronic stress may be a potential functional mechanism that links loneliness to poor health.

What is particularly interesting is that the low transient group reported higher levels of stress than the low stable group, indicating that this may be an important contributor for why this group differs to the low stable group. The low transient group, despite having low loneliness finds the transition to secondary school more stressful than the other group that started with similar low levels of loneliness. This may be linked to their lack of school belonging, resulting in more stress about the move to secondary school. It may be that this group includes children who are moving schools alone, for example, without siblings and friends from their primary school (Weller, 2007). Future research will want to establish what is different about this group of children that results in the slight increasing of loneliness across the transition period.

#### *Perception of social threat*

Threat anxiety and threat coping reduced over the transition period, indicating that at the group level, the transition to secondary school may be a period when perception of social threat increases. As children experience the move to the new school and their school concerns reduce, it seems that in turn, their confidence about coping in a socially threatening situation increases. However, threat expectancy does not reduce over the transition period, indicating that children are not reducing their threat anxiety because they believe threat situations are less likely to occur. This is an important finding because it indicates that threat anxiety decreases as threat

coping increases, suggesting that cognitive behavioural intervention strategies may be useful to support children with threat anxiety.

Similar to the adult studies (see Studies 1 and 2), the high stable lonely group retain higher levels of perception of social threat than the other groups throughout the study. This indicates that this group have typically high levels of perception of social threat in everyday life that is not specific to the social context or stressful situation. Although, the results may also suggest it may take longer for their threat sensitivity to reduce after a transition. In Studies 1 and 2 high lonely adults typically showed higher levels of perception of social threat in everyday life that was not specific to the social context. It may be that in childhood lonely children also experience a general alertness for social threat as defined Cacioppo and Hawkley's (2009) model.

### *Strengths and limitations*

The current study is the first to examine the growth patterns of loneliness across the transition from primary to secondary school. It is also the first to examine the impact of loneliness on adjustment to moving to secondary school. It offers further evidence for the association between long term loneliness and health in childhood, and is the first to examine self-reported stress in lonely children in comparison to non-lonely children. The current study is an important one because it identifies a group of children for whom loneliness is high, but reduces across the transition, indicating that for at least some lonely children, targeted intervention at transitions may support re-connection and reduce levels of loneliness. Future studies should examine what defines this lonely group ("high transient") from the lonely group that remains the same across the transition ("high stable"). Such work would inform intervention strategies for lonely children across this period.

It will be important in future studies to examine loneliness for a longer period to explore the changes in loneliness for the high transient and low transient lonely groups post-transition. For example, to examine whether loneliness levels of the high transient lonely group return to similar loneliness levels following the transition or whether they remain low. It would also be important to examine other social factors, such as whether friends from primary school are moving with children to the new school because mutual friendships buffer the impact of peer rejection on loneliness (Nagle et al., 2003; Sanderson & Siegel, 1995; Renshaw & Brown, 1993;

Parker & Asher, 1993). These factors may influence the increasing loneliness in the group of children who had low loneliness pre-transition (“low transient”) and this may be a temporary state of loneliness for these children.

### *Conclusion*

The current study is the first to examine the impact of loneliness across the transition from primary to secondary school. The current study shows that at a group level, loneliness reduces across the transition to secondary school, indicating that the move offers children the opportunity for re-connection with others. Children who experience high stable loneliness across the transition have lower levels of adjustment to transition, report higher levels of stress, and poorer health. The study shows that there is a group of children for whom loneliness is high prior to transition and for which loneliness levels reduce across the transition period. Future research should examine characteristics or interventions with these children that mean that their loneliness levels reduce across this period.

The current study showed that children who experience high stable loneliness across the transition period to secondary school had higher levels of perception of social threat that were consistently high across the transition period. This is similar to adult studies in this thesis (Studies 1 and 2) that also show higher levels of perception of social threat in everyday life rather than increased HSTH to social stressors. This indicates that lonely people (both children and adults) are typically on a heightened state of alert for social threat despite the social context and offers ecological validity for Cacioppo and Hawkley’s (2009) model.

The current study also shows that, similar to the adult studies in this thesis (Studies 1 and 2), lonely children experience stress in everyday life suggesting that chronic stress may be an important mechanism linking loneliness and health. Cacioppo and Hawkley’s (2009) model for loneliness and health should be re-examined in relation to this evidence that chronic stress has a role in the impact of loneliness on health.

The next chapter (Chapter 11) summarises the results of the child studies and discusses them in relation to current literature and theoretical models for loneliness and health. The final chapter (Chapter 12) of the thesis brings the results of both the

adult and child studies together and highlights important findings from the thesis and re-examines Cacioppo and Hawkley's (2009) model in light of these findings.

## Chapter 11: Overview of child studies

### *Summary of studies*

The current literature relating loneliness and health in childhood was examined in Chapter 6 and three areas were outlined that warranted further investigation: 1) an examination of whether it is the long term experience of loneliness in childhood that is associated with poor health, 2) an examination of whether there are cognitive biases for social information and a general attention deficit in lonely children, and 3) an examination of social threat evaluation in real life social challenges for lonely children. Four studies were conducted in the child section of this thesis to address these aims. The first study (Study 3) examined growth patterns of loneliness over a 4.5 year period in 8-11 year old children and the associated physical health outcomes. The second study (Study 4) used a sub-group of the same sample to examine cortisol diurnal patterns in children who experience long term loneliness. The third study (Study 5) examined cognitive functioning in lonely children in comparison to non-lonely children. Finally, the fourth study (Study 6) examined general patterns of loneliness across the transition from primary to secondary school and the impact of loneliness on health, stress response, and evaluation of social threat in relation to the transition.

Study 3 demonstrated two distinct growth patterns of loneliness: a relatively, high reducing loneliness and a low stable loneliness group. The results demonstrated that children who experienced relatively high, reducing loneliness in middle childhood reported poorer perceived physical health in pre/early adolescence and greater sleep disturbance than children who followed a low, stable trajectory of loneliness, despite levels of loneliness reducing in the high lonely group at 11 years. The potential functional mechanism for the association between high loneliness and poor health was examined in Study 4. Cacioppo and Hawkley (2009) have proposed that lonely people are on a heightened state of alert for social threat which results in increased activation of the hypothalamic-pituitary-adrenal axis. They argue that it is the chronic activation of the HPA axis leads to poor health in lonely people. The results of Study 4 did not show any differences in HPA axis functioning in the relatively, high lonely group in comparison to the low, stable group. However, those

children who were high in loneliness at the time of testing did not display cortisol flexibility (increased cortisol levels on a work day in comparison to a rest day), whereas children reporting low levels of loneliness did. A lack of cortisol flexibility has been associated with poor health (Mikolajczak, et al., 2010) so this may be a functional mechanism for the association between loneliness and health in childhood.

Study 5 examined cognitive biases and attentional control in lonely children. Evidence found in empirical studies with adults indicates that lonely adults have an increased memory for social information (Gardner, Pickett, Jeffries, & Knowles, 2005) and display difficulties with attentional control (Cacioppo et al., 2000). In Study 5 lonely children did not have better memory recall for social information than non-lonely children. Findings from study 5 indicated that, similar to adults, lonely children have difficulties with attentional control, but only in an attention task that involves speech. It is likely this speech distraction evident in lonely people is the result of an increased necessity to screen speech information for social threat because of the HSTH that is present in lonely people (Cacioppo & Hawkley, 2009; Qualter et al., 2013a).

Study 6 examined the growth of the loneliness for children transferring from primary to secondary school and the associated adjustment, health, stress, and perception of social threat. This study demonstrated that at a group level loneliness reduced across the transition to secondary school, indicating that the move to secondary school enables children the opportunity for re-connection with social others. The reduction of loneliness across the transition period in this study supports the reducing loneliness levels at 11 years old demonstrated in Study 3. Study 6 found that children who experienced high stable loneliness across the transition had lower levels of adjustment, reported greater stress, and had poorer health, than those who had low stable loneliness across the transition period. This is similar evidence to that obtained in Study 3 which found poor health in those children who experienced long-term loneliness. Similar to adults (Shioitz-Ezra & Ayalon, 2010), it is the long term experience of loneliness that leads to poor health in childhood.

Importantly, Study 6 shows that there is a group of children for whom loneliness is high prior to transition and reduces across the transition period, indicating that intervention at transition periods may result in a reduction in loneliness levels in some children. Findings from Study 6, are similar to those from the adult studies in this thesis (Studies 1 and 2), that examined social stressors in a

real life context. Findings from Study 6 showed that children who experienced high loneliness reported higher levels of perception of social threat that remained the same across the transition period. This indicates that lonely children are on a heightened state of alert for social threat in everyday life and offers ecological validity for Cacioppo and Hawkley's (2009) model in relation to childhood loneliness. Also, Study 6 showed that, similar to the adult studies in this thesis (Studies 1 and 2), that lonely children experienced chronic stress in everyday life suggesting that chronic stress may be an important mechanism linking loneliness and health in both childhood and adulthood.

#### *Relation to current theoretical models*

##### *a) Long term loneliness in children leads to poor health*

In adulthood, it is the long term experience of loneliness that has been linked to poor health (Shioitz-Ezra & Ayalon, 2010). Studies in this thesis are the first to examine the experience of long term loneliness in childhood and the associated health outcomes. Findings from both Study 3 and 6 demonstrate that, similar to adulthood, it is the long term experience of loneliness that results in poor health in childhood.

##### *b) Cortisol flexibility is implicated in the relationship between loneliness and health in childhood*

Cacioppo and Hawkley's (2009) model implicates increased activation of the HPA axis as a functional mechanism in the association between loneliness and poor health. Study 4 is the first to examine HPA axis functioning in childhood and did not show differences in the overall cortisol levels between high and low lonely children. However, when cortisol levels were compared on a school and non-school day, children with a current high loneliness state did not display cortisol flexibility (i.e. did not have increased cortisol levels on the school day). In contrast, children with a low current loneliness state had higher levels of cortisol on a school day than a non-school day, indicating cortisol flexibility (Mikolajczak, et al., 2010). This implicates cortisol flexibility is a functional mechanism for loneliness and health in

childhood specifically. Adult studies that have examined the cortisol diurnal rhythm did not compare work and rest days (Doane & Adam, 2010; Cacioppo et al., 2000; Steptoe, Owen, Kunz-Ebrecht, & Brydon et al., 2004) so lack of cortisol flexibility may also be an important mechanism within adulthood that links loneliness to poor health. Future studies examining the impact of loneliness on HPA axis functioning in adult populations should measure cortisol levels on both work and rest days to investigate this proposition.

Recently the HPA axis has been implicated in developmental psychopathology. Researchers argue that children have a biological sensitivity to their environment (Boyce & Ellis, 2005). This indicates that children who are experiencing high stress (i.e. lonely children) will have less flexible stress system resulting in low stress reactivity. This may explain why lonely children have a less adaptive HPA axis functioning (Del Giudice, Ellis, & Shirtcliff, 2011), that is, one that lacks cortisol flexibility. In comparison, children who experience low stress or a high supportive environment will have a high stress reactive system and will display cortisol flexibility, increasing cortisol on more demanding days.

*c) Childhood loneliness is linked to chronic stress*

Cacioppo and Hawkey's (2009) model only implicates increased HPA axis activation as a functional mechanism in the links between loneliness and poor health. In this thesis chronic stress is found in lonely adults (Studies 1 and 2) and children (Study 6). Chronic stress is linked to poor health through its effect on multiple physiological systems (including HPA axis, Justin, McEwen, & Lupien, 2010; McEwen & Stellar, 1993). Cacioppo and Hawkey (2009) do not mention chronic stress as a functional mechanism in their model for loneliness and health. Chronic stress has been associated with HPA axis dysfunction (Miller, Chen, & Zhou, 2007; Wüst, Federenko, Hellhammer, & Kirschbaum, 2000) central nervous system (CNS) dysfunction (Dallman et al., 2003; McEwen, 2001), increased activation of the autonomic nervous system (ANS) (Vitaliano et al., 2002), and decreased immune system functioning (Glaser & Kiecolt-Glaser, 2005; Segstrom & Miller, 2004). It may be that chronic stress has an indirect pathway to poor health in lonely people through its impact on multiple physiological systems. Cacioppo and Hawkey's

(2009) model should be re-examined to incorporate the impact of chronic stress on health in lonely people.

*d) Cognitive processing in lonely children is different to lonely adults*

Cacioppo and Hawkley's (2009) model indicates that HSTH in lonely people leads to cognitive biases, which result in attention to negative social information and increased memory of negative social events than non-lonely people. Evidence for this theory has been demonstrated by Gardner et al.'s (2005) study that demonstrated that lonely adults remembered more social information. However, in a replication of Gardner et al.'s (2005) study with a child sample, Study 5 did not find that lonely children had better recall for social information than non-lonely children. Recently findings from an eye tracker studies with child and adult samples have demonstrated that lonely adults initially fix their attention on social threat stimuli, but they are able to disengage much quicker than lonely children (Bangee, Harris, Bridges, Rotenberg, & Qualter, under review; Qualter et al., 2013a).

Taken together, the findings of Study 5 and Qualter et al.'s (2013a) study indicate that a developmental perspective to the cognitions of lonely people may be necessary. This is of particular importance for devising interventions for lonely people as these may need to be different for adults and children. It may be that children have not been lonely for long enough to have the same cognitive biases to social information as adults or the differences may be the result of developmental factors, such as neurological changes during childhood and adolescence (Anderson, 2002). Therefore, it is important to examine cognitive processing of lonely children and not make assumptions based on adult literature.

*Impact and future research*

The studies in this section of the thesis are important ones because they are the first to examine longitudinal loneliness in childhood and physical health outcomes. The studies demonstrate that, similar to adults, that it is the long-term experience of loneliness that is associated with poor health. Future studies that examine childhood loneliness should use a longitudinal design, but it would be

important to investigate current state of loneliness as this has been shown in studies in this thesis have an impact on HPA functioning.

Cacioppo and Hawkley (2009) have proposed that it is increased activation of the HPA axis in lonely people due to a HSTH. The studies in this thesis implicate chronic stress as a functional mechanism of the association between loneliness and health and indicate that the current theoretical model needs to be re-examined. Also, Study 4 implicated a lack of cortisol flexibility in children with a high current loneliness state, indicating that it may be this lack of cortisol flexibility that plays a role in the health differences in childhood, rather than increased cortisol flexibility.

Study 6 demonstrated sensitivity in lonely children to be distracted by speech information, but not visual stimuli. To date, the impact of loneliness attentional control in adults has only been examined using a task with a speech distractor (Cacioppo et al., 2000). It is important, then, that future studies should examine whether attentional control differences are also evident in visual attention tasks in adulthood or whether, similar to children, they are only present in speech distractor tasks. It is important that there is a developmental perspective on the impact of loneliness on social information processing because the findings in this thesis and the eye tracker studies (Bangee et al., under review; Qualter et al., 2013a) demonstrate that lonely children processing social information different to lonely adults.

Study 6 is the first study to examine the impact of loneliness on transition and shows that for most children loneliness decreases across the transition period. Future research should examine the characteristics or specific factors that distinguish these children from the ones who experience high stable loneliness across the transition to examine mechanisms that lead loneliness levels to reduce across this period. Such research would inform policy makers about appropriate intervention strategies for lonely children during the transition from primary to secondary school.

## Chapter 12: General Discussion and Conclusions

Cacioppo and Hawkley's (2009) model for loneliness and health was outlined in Chapter 2. This model proposes that loneliness results in a hyper-vigilance for social threats (HSTH) which leads to attention, memory, and confirmatory biases altering the likelihood of social interaction. These biases then impact behaviour, resulting in confirmation of a necessity for heightened vigilance for social threat. These biases also activate neurobiological mechanisms increasing activation of the hypothalamic-pituitary-adrenal (HPA) axis and diminish sleep quality. According to Cacioppo and Hawkley (2009), repeated and chronic activation of these threat surveillance systems and diminished anabolic processes heighten cognitive load, diminish executive functioning, dysregulate brain and physiological systems, and lead to broad based morbidity and mortality. The model is displayed in Figure 12.1.

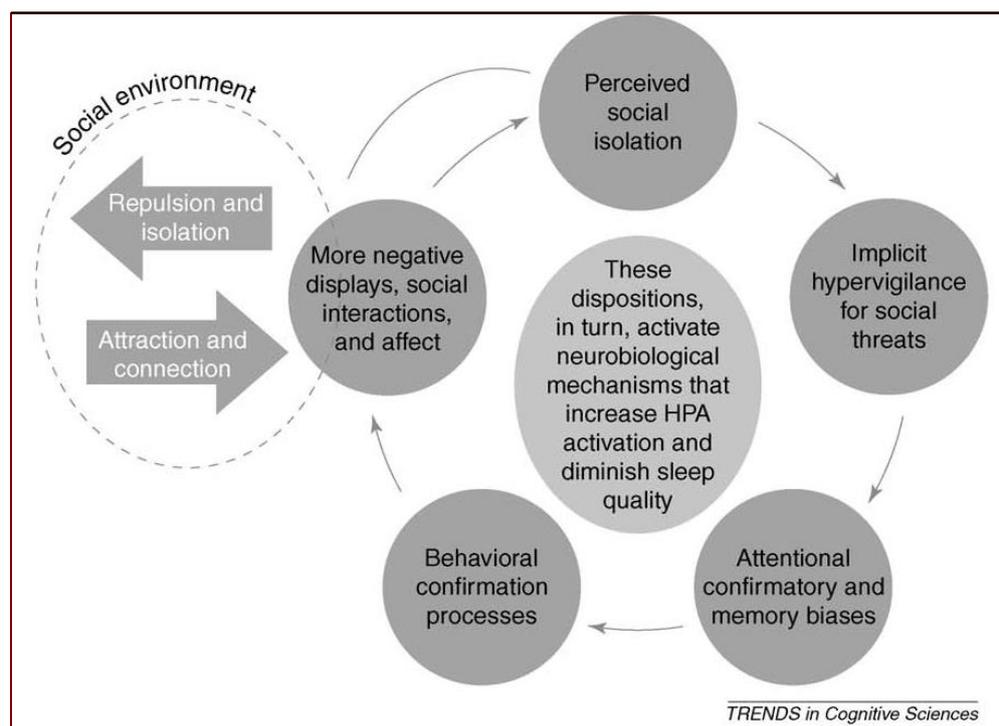


Figure 12.1 Loneliness and Health Model (from Cacioppo & Hawkley, 2009)

The gaps in Cacioppo and Hawkley's (2009) model were outlined in Chapter 2 and two specific areas were identified that warranted further investigation in the adult literature. First, examination of hyper-vigilance to social threat information

using a cognitive paradigm that measures attentional deployment rather response bias was necessary. Second, examination of physiological responding (hypothalamic-pituitary-adrenal (HPA) axis activation) and hypervigilance to social threat (HSTH) in real life social challenges rather than laboratory stress tasks that involve a perception of social evaluation.

In relation to child literature, there was limited research on loneliness and physical health; all the studies were cross sectional and there was no examination of long term loneliness in childhood and its impact on physical health or HPA axis functioning. The first aim, then, in the child studies in this thesis was to examine longitudinal loneliness, physical health, and HPA axis functioning. The child studies in the thesis next examined whether cognitive biases and impairment that Cacioppo and Hawkley (2009) implicate in the maintenance of loneliness that have been found to be evident in adults (Cacioppo et al., 2000; Gardner et al., 2000) are also evident in lonely children. Finally, to bring the adult and child studies together, HSTH within a naturally occurring, real-life social context for children: the transition from primary school to high school was examined.

### *Summary of Studies*

#### *Adult studies*

Studies 1 and 2 are the first to examine HSTH and the HPA stress response to real life, naturally occurring social stressors: public speaking in Study 2 and meeting strangers in Study 3. Results provided evidence for HSTH, but not HPA axis stress reactivity, offering ecological validity for Cacioppo and Hawkley's (2009) proposition of HSTH in lonely people, but not increased HPA stress response to social challenges. The findings of Studies 2 and 3 implicate chronic stress in lonely people as a functional mechanism of the association between loneliness and health. In these studies lonely adults reported higher levels of stress than non-lonely people generally in everyday life, which was not dependent on the stressful situation or HPA axis activation.

### *Child studies*

Study 3 is the first study to examine longitudinal loneliness and its impact on physical health in childhood. Results demonstrate that children who experience relatively high, reducing loneliness in middle childhood report poorer perceived physical health in early adolescence and greater sleep disturbance than children who follow a low, stable trajectory of loneliness, despite levels of loneliness reducing in the high lonely group at 11 years old.

Study 4 is the first to examine HPA axis functioning in lonely children. Results showed no differences in cortisol diurnal patterns in relation to loneliness. However, when cortisol levels were compared on a school and non-school day children with a current high loneliness state did not display cortisol flexibility (i.e. did not have increased levels on the school day). In comparison, children with a low current state of loneliness had higher levels of cortisol on a school day, indicating cortisol flexibility. This lack of cortisol flexibility (Mikolajczak, et al., 2010) evident in lonely children may be a potential functional mechanism of the association between loneliness and health in childhood.

Study 5 examined cognitive biases and attentional control in lonely children. Results showed that lonely children did not have better memory recall for social information than non-lonely children. Findings from Study 6 indicated that, similar to adults, lonely children have difficulties with attentional control, but only in an attention task that involves speech. It has been demonstrated that lonely people, both children and adults, have a HSTH (Cacioppo & Hawkley, 2009; Qualter et al., 2013a) and as a result are on a heightened state of alert, so it is likely that the sensitivity to distraction by speech is the result of an increased necessity to screen speech information for social threat.

Study 6 is the first to examine the impact of loneliness across the transition from primary to secondary school. Results showed that at the group level loneliness decreased across the transition period. Children who experienced high stable loneliness across the transition reported lower levels of adjustment, higher levels of stress, poorer health, and greater sleep dysfunction. These children who had high stable loneliness across the transition had higher levels of perception of social threat which remained high throughout the transition period. Importantly, in Study 6 there was a group of children who had high loneliness prior to transition who reduced in

their loneliness level following transition, indicating that, for at least some lonely children, transition may provide opportunities for re-connection with others (references) and consequently reduction in loneliness.

### *Theoretical Implications*

#### *Adulthood*

Studies 1 and 2, using real life social contexts revealed that lonely people typically report high levels of stress in everyday life than non-lonely people, rather than increased stress reactivity to a social stressor. These findings support other studies that have demonstrated lonely people report increased levels of stress in everyday life (Hawkley, Thisted & Cacioppo, 2009; Pressman et al. 2005). The experience of chronic stress places increased wear and tear on a number of physiological systems in the body that results in poor health (McEwen & Stellar, 1993), so it is possible that chronic stress is an important functional mechanism in the association between loneliness and health. Current theoretical models for loneliness and health may need to be re-examined to include chronic stress as a functional mechanism.

It is known that lonely people behave more passively in social contexts than non-lonely (Cacioppo et al., 2000; Steptoe et al., 2004) and they tend to interpret social interaction differently to non-lonely people, focusing negative information (Cacioppo et al., 2000). Study 3 demonstrated that lonely people may have a different focus for their stress and anxieties in social contexts. Lonely and non-lonely people did not differ in their anxiety about forming friendships, but after three days of social interaction, the high lonely group were more anxious about forming friendships. Given lonely people's negativity (Cacioppo et al., 2000) and passivity (Cacioppo et al., 2000; Steptoe et al., 2004) in social interaction, friendship formation anxiety did not decrease in the high lonely group through interaction with others because this group would be focused on the negative aspects of their communications with others. In comparison, the low lonely group, do not have this negativity basis and their interpretations of interactions with others would be based on the sum of their interactions, thus, result in a reduction of friendship formation anxiety as they get more familiar with others. To date no studies have examined the

interaction between the focus of lonely peoples' anxiety/stress in social interaction, their interpretation of social interaction, and the impact on their behaviour. Future studies should examine how these internal processes lead to differences in behaviour in lonely people, this will help researcher to understand the maintenance of loneliness.

### *Childhood*

The studies in this thesis offer some important insights into existing theoretical understanding of loneliness and health because longitudinal studies were carried out that examined loneliness and physical health. Studies 4, 5 and 7 were the first to examine long term loneliness and physical health in childhood and adolescence. The findings demonstrate that, similar to adults (Shioitz-Ezra & Ayalon, 2010), children who experience long term loneliness report poorer health than children who experience low, stable loneliness. This is important because it demonstrates that it is long term experience of loneliness that is critical in impacting on a person's health. This has important implications for future research because it shows that transient and chronic loneliness have different impacts on physical health. Future research that aims to examine predictors, outcomes, and interventions for lonely people should ensure that transient and chronic loneliness are distinguished by carrying out longitudinal research projects, as these loneliness types have different impacts on health.

Study 4 found that lonely children had a lack of cortisol flexibility (Mikolajczak, et al., 2010). Cortisol flexibility in everyday life (i.e. increasing cortisol levels to reflect the demands of the day) is considered adaptive and important for good health. A lack of cortisol flexibility has been linked to poor health (Mikolajczak, et al., 2010), so this may be an important functional mechanism that links loneliness to poor health in childhood. Although this thesis examined cortisol flexibility in lonely children, no studies have examined this in adulthood. It may be that cortisol flexibility is an important mechanism only in childhood loneliness, but cortisol studies with adults would be necessary to determine that.

Study 6 indicated that at least for some lonely children, factors may influence reductions in loneliness. The literature review examining childhood studies in this thesis (see Chapter 6) implicates particular factors as buffers and risks for loneliness

at different developmental stages. The work in this thesis indicates that transition times may offer opportunities for forming new friendships and addressing difficulties with social interaction and indicate that at these times children who experience high levels of loneliness can reduce in their levels of loneliness if given the appropriate support and assistance relevant to their developmental stage. This has important implications for theoretical understanding within loneliness literature because there is no current research about intervention strategies for lonely children and the current theoretical model for loneliness and health (Cacioppo & Hawkley, 2009) does not examine mechanisms for how loneliness may reduce for some lonely people. Future research should investigate specific factors leading to reductions in loneliness. It may be that the transition itself supports re-connection and reduces loneliness simply by there being more potential others to connect with (Güroglu, Cillessen, Haselager, & van Lieshout, 2012) or it may be that involvement from others (Bohert, Aikens, Wargo, & Arola, 2013), such as teachers or parents, increases positivity about forming new friendships and changes the way that lonely children interact with others. It is also important to note that the reduction in loneliness levels over the transition period may not be long lasting and future studies should examine the impact of transition on loneliness over a longer period (Study 6 only followed children up to five months after transition) to examine if this is the case.

### *Developmental perspective*

The work in this thesis demonstrates that there are some key similarities between loneliness in adulthood and childhood and also some key differences. In adulthood it is the long term experience of loneliness that leads to poor health (Shioitz-Ezra & Ayalon, 2010), this is the same in childhood (see Study 3, chapter 7). The findings in this thesis indicate that both children and adults experience chronic stress as a result of being lonely and report higher levels of HSTH in everyday life than their non-lonely peers. However, there are some key differences in loneliness in childhood. Findings in this thesis indicate that lonely children do not have the same cognitive biases for social information as lonely adults. Although future research will be necessary in this area, it appears that lonely children may not have been lonely for long enough to have developed the same biases that lonely adults have or that there are differences in cognitive processing of social information

that is the result of developmental change (Anderson, 2002). In addition, the findings in this thesis indicate that loneliness may reduce at key time points across a person's life, such as during a social transition. Given this evidence it is important that future research work and theoretical models attempt to develop a developmental perspective to understanding loneliness and health.

### *Reanalysis of Cacioppo and Hawkley's (2009) model of loneliness and health*

The findings of this thesis indicate that there are a number of key areas that need to be re-examined in Cacioppo and Hawkley's (2009) model of loneliness and health: 1) chronic stress as a functional mechanism linking loneliness to poor health, 2) mechanisms that result in a reduction of loneliness levels, and 3) a developmental perspective to understanding processes involved in the maintenance of loneliness. Each of these key areas is discussed in detail.

#### *1) Chronic stress*

Cacioppo and Hawkley's (2009) model only implicates increased HPA axis activation as a functional mechanism in the links between loneliness and poor health. In this thesis chronic stress is found in lonely adults (Studies 1 and 2) and children (Study 6). Chronic stress is linked to poor health through its effect on multiple physiological systems, such as HPA axis, but also the ANS, CNS, and immune system (McEwen, 1998b; McEwen & Stellar, 1993). Cacioppo and Hawkley (2009) do not mention chronic stress as a functional mechanism in their model for loneliness and health. It may be that chronic stress has an indirect effect to poor health in lonely people through its activation of multiple physiological systems. Cacioppo and Hawkley's (2009) model should be re-examined to incorporate the impact of chronic stress on health in lonely people. Figure 12.2 depicts this pathway from loneliness to chronic stress leading to poor health. Future work should examine the variables implicated in this path model to investigate predictors and outcomes involved in the relationship between loneliness and health.

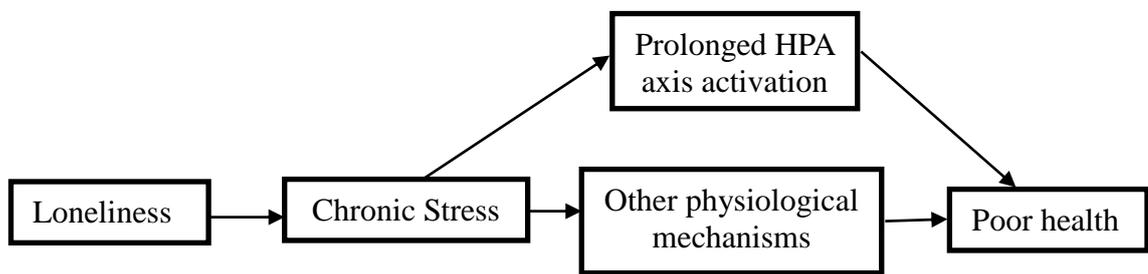


Figure 12.2 The impact of chronic stress in the association between loneliness and poor health

## 2) *Mechanisms involved in reducing loneliness*

Cacioppo and Hawkley (2009) typify loneliness as a cyclic model (see Figure 12.1) and say little about loneliness levels changing due to interaction with other people. They propose that the social world influences a person's loneliness through dynamic attraction, and connection towards others or repulsion and isolation from others in the social world. They do not detail these processes at great length in their model, but the theoretical model implicates that due to the HSTH that lonely people experience, they will be more passive in social interactions and interpret interactions more negatively. As a result of the lonely person's negativity and passivity in social interactions, others will behave passively and/or negatively towards them and this will confirm a lonely person's need to feel socially threatened in social contexts and they will remain lonely.

The findings in this thesis demonstrate that the transition period may offer children opportunities for re-connection with others and consequently for some children loneliness levels reduce. It may be that there are other significant times of transition that lead to reductions in loneliness levels, for example, going to university or starting new employment. It may be that transition times offer increased opportunities for attraction and connection to others by increased potential others to connect with or interventions (such as from teachers and parents) that may act on the attentional and confirmatory biases resulting in lonely people being less negative in their interpretation of other people's behaviour in social interactions. Future research should examine other transitions, such as starting a first job after leaving education,

to investigate whether, similar to the findings in Study 6, that some lonely adults have reductions in their loneliness levels during these transitions. Certainly Cacioppo and Hawkley's (2009) model needs to be revised and factors identified that reduce loneliness at these key stages in a lonely person's life. Interventions that target opportunities for re-connection and cognitive behavioural work that reframes the social situation for lonely people are likely to be most successful in decreasing loneliness; the work in this thesis indicates that such interventions are likely to be most successful if carried out during transition periods.

### *3) Developmental perspective on the maintenance of loneliness*

Not only is there evidence in this thesis to indicate that there are key times when loneliness may reduce across a lonely person's life, the way a lonely person interprets the social situation is different in childhood to adulthood. Cacioppo and Hawkley's (2009) model for loneliness and health has focused on evidence from studies in adulthood. Study 5 in this thesis is the first to examine cognitive biases to social information in childhood and reveals that there may be differences in cognitive processing between lonely children and adults. Although, Gardener et al. (2005) found that lonely adults had better memory recall for social information than their non-lonely peers, Study 5 did not find any differences in recall for social information in lonely and non-lonely children. Results from eye tracker studies also demonstrate visual processing differences in lonely children and adults. Lonely adults display an initial vigilance (evidenced by attention fixation) not evidenced in non-lonely adults, followed by avoidance of the stimuli (Bangee, Harris, Bridges, Rotenberg, & Qualter, under review). In contrast, lonely children display similar initial fixation to non-lonely children, but find it difficult to disengage from the socially threatening information (Qualter et al., 2013). Lonely adults initially fix their attention on social threat stimuli, but they are able to disengage much quicker than lonely children. Taken together the evidence in this thesis and results of eye tracker studies indicate that there should be a developmental perspective to understanding the maintenance of loneliness.

A re-examination of Cacioppo and Hawkley's (2009) model is necessary because certainly the cycle proposed appears to be responsible for the maintenance of loneliness: HSTH leads to cognitive biases, which in turn lead to negative and

passive behaviour in social interactions, which serve to maintain loneliness. But the evidence in this thesis indicates that cognitive biases and processing of social information may be different in lonely children to lonely adults. The current theoretical model (Cacioppo & Hawkley, 2009) does not have a developmental perspective on cognitive processing that leads to maintenance of loneliness. It will be important that future research ensures that cognitions and behaviour of lonely children are compared to those of lonely adults in order to re-examine Cacioppo and Hawkley's (2009) using a developmental perspective.

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## Appendices

1. Paper under review: Harris, R. A., Robinson, S. J., Bradley, B. F., & Qualter, P. (under review). Cortisol levels on a school day compared to a non-school day in 9-14 year old children
2. Diary events used in child memory task (Study 5a)
3. Words used in child serial recall with irrelevant speech task (Study 5b)
4. Social vignettes used in the perception of social threat measure (Study 6)

# Appendix 1

## -PAPER UNDER REVIEW-<sup>24</sup>

Cortisol levels on a school day compared to a non-school day in 9-14 year old children

Authors: \*Rebecca A. Harris, Sarita J. Robinson, Belinda F. Bradley, & Pamela Qualter

*Pre-schoolers have higher cortisol levels in the morning, afternoon and evening on a nursery day compared to a non-nursery day. Similar patterns are seen in adulthood with higher cortisol awakening response on a work day compared to a rest day. The current study extends the literature by examining whether the same pattern of heightened cortisol of a school day is evident in pre-adolescents and adolescents (aged 9-14 years; N=36, 18 male). Participants provided a morning, afternoon and evening saliva sample on a school day and a non-school day. Results show that similar to pre-schoolers and adults, pre-adolescents and adolescents have higher levels of cortisol on a school/work day compared to a non-school day and showed a steeper cortisol decline on the school day than the non-school day. Findings suggest that indicate the pattern of increased cortisol on work days is consistent across the age ranges.*

Adults and children have a stable diurnal cortisol pattern with levels at the highest at awakening, declining over the day, and remaining low until the later hours of sleep when levels increase (King & Hegadoren, 2002). Research exploring factors influencing variations in cortisol levels has implicated the anticipation of upcoming events in increasing of cortisol (Fries, Dettenborn, & Kirschbaum, 2009). Recent studies suggest this flexibility of cortisol release in response to challenge is important

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<sup>24</sup> This paper under review is included in this thesis as it relates to the data set discussed in Chapter 9 (Study 5) and examines cortisol at a group level (i.e. it does not spilt the participants into high and low lonely).

for healthy functioning (Mikolajczak, et al., 2010). An important example of cortisol flexibility is the increased levels on work days in comparison to rest days. Although, this has been demonstrated in adults (Kunz-Ebrenct, Kirschbaum, Marmot, & Steptoe, 2004) and preschoolers (Watamura, Kryzer, & Robertson, 2009), no studies have established whether increased levels of cortisol on school days are also observed in pre-adolescents and early-adolescents. It is important to examine cortisol patterns on school and non-school days for this age group as there are increased academic pressures in late primary school (age 8-10 years) and secondary school (11+ years) in the UK. It is also important to examine cortisol across different ages as salivary cortisol levels in childhood, adolescence and adulthood are age-dependent: cortisol levels increase with age (Kiess et al., 1995, Törnbage, 2002).

In adult populations higher morning cortisol levels on work days are associated with work days being perceived as more stressful, unhappy and less controllable (Kunz-Ebrenct et al., 2004) and with chronic work overload (Schlotz, Hellhammer, Schulz, & Stone, 2004). Research that compares nursery and home days in pre-schoolers shows increases and/or flattening of the cortisol curve across the day in comparison to typical circadian decreases on home days (Watumura et al., 2009). However, conflicting results are found in primary school aged children: Spangler (1995) compared cortisol levels on a home and a school day in 5-6 year olds and found no differences. However Long et al. (1993) found cortisol levels were higher on a home day than a school day in a smaller sample of 6 year olds. Further, studies examining cortisol when children start primary school have noted differences in school day and non-school day levels (Bruce et al. 2002; Davis et al., 1999), but only for the first few days. This suggests that it could be the challenge of transition to school that places increased demands on these children rather than the usual typical school day as has been demonstrated in pre-school children (Watumura, Kryzer, & Robertson, 2009). The results imply that, although increased cortisol is found in pre-schoolers on childcare/school days, this pattern of increased cortisol levels is not consistently found on typical school days in older children.

There may be a different pattern of results in pre-adolescence and adolescence as there is increased pressure on the later primary and secondary school years in relation to level of work and assessment. As examination and testing has been demonstrated to increase cortisol levels in middle childhood (Tennes & Kreye, 1985), it is likely pre-adolescents and adolescents may also have increased cortisol

on school days. Therefore, the current study examines whether pre-adolescents and adolescents show different patterns of salivary cortisol release on school days compared to non-school days. Further as adult studies have suggested that negative mood is reported in adults on a work day, the current study will also examine and whether a decreased mood state is also associated with the school day.

## **Method**

### **Participants**

Participants were drawn from the Lancashire Longitudinal Study of Social and Emotional Development (LLSSED) in North West England, a prospective study of 417 children recruited from schools in Lancashire, UK. Forty-one children from that sample consented to take part in the current study from across 6 secondary schools and 10 primary schools in North West England. Written parental consent was obtained from the children's primary care giver and children gave verbal consent to take part in the study. All testing was completed in accordance with the national and local ethical guidelines according to the Declaration of Helsinki.

Parents completed a confidential screening questionnaire and reported that their children were in good health, had no active infections, were not taking any contra-indicating medications, and had a body mass index (BMI) within a healthy range. Children were screened for depression symptoms using the Child Depression Inventory (CDI, short version, Kovas, 1980) and two participants with high depression scores ( $2 SD+$  above the mean) were removed from the study. A further three participants were removed for self-reported non-adherence to protocol (saliva collected at the incorrect time). Data from the remaining 36 children (18 male) between ages of 9-14 years (mean = 10.42,  $SD = 1.52$ ) were used in the analyses.

### **Procedure**

Parents of participating children were visited by the first author at their homes and given a study packet containing diary booklets, salivettes, and stopwatches. Parents and children were given full written and verbal instructions of the study protocol including demonstrations of how to collect saliva samples. Parents were asked that their children refrain from eating, drinking and brushing their teeth prior to sample collection and were given a sheet to record the accurate times of saliva sampling to check for compliance. The researcher stressed the importance of compliance and encouraged parents to miss a sample rather than collect a sample at the incorrect time, and report difficulties with adherence within the diaries. Parents

were asked to collect three samples on a non-school day (Sunday) and a school day (Monday); 30 minutes after waking, after school (at 4pm on weekends) and 30 minutes before bedtime. Participants were asked to avoid atypical days such as birthdays or outings. All diaries and cortisol samples were returned to the university by post. Mailing samples prior to freezing has been shown to be an appropriate method and does not influence the salivary cortisol results (Clements & Parker, 1998). All data were collected in the summer term to ensure results were not influenced by transition to new school year/high school.

### **Measures**

*Diaries:* Participants were asked to complete diaries at various points of the day to measure sleep, mood state and perceived health. *Sleep quality and duration* At the commencement of the day participants were asked to report on the quality of their sleep the night before using a 4-point scale: “very good”, “fairly good”, “fairly bad”, “very bad”. *Mood states* Participants were asked to indicate in their diaries how happy they felt at three points during the day: morning, afternoon and bedtime, rated on a scale of 0 (not at all) to 5 (very much). *Perceived health* Before bed time participants reported on how well they felt their health had been during the day on a scale of 0 (good health) to 10 (bad health). It was intentionally reversed as the scale was placed beside a picture of a thermometer, i.e. high levels on the thermometer indicate poor health.

*Cortisol:* Saliva samples were obtained using a salivette saliva sampling device specifically designed for use with children (Sarstedt Ltd, Leicester, UK). Samples were stored in a domestic refrigerator before being mailed to the university, where they were stored at -20°C until analysis. For analysis saliva was recovered by thawing at room temperature for 15 minutes then centrifuging (1500 rpm) for 15 minutes. Cortisol concentration (nmol/l) in saliva was then determined by a high sensitivity salivary cortisol enzyme immunoassay kit (Salimetrics, USA) as manufacturer’s instructions. Intra-assay variation was below 10%. All children provided saliva samples for all saliva sampling collection times. Any cortisol samples that were 3 standard deviations from mean were removed from all analyses. This resulted in removal of one afternoon and one evening sample from the non-school day and two afternoon and two evening samples from the non-school day.

The other samples from these children remain in the analyses<sup>25</sup>. Cortisol data was screened for skewness; only the bedtime sample on the school day was positively skewed so data were not transformed.

As previous research has demonstrated that cortisol levels are affected by general health and sleep patterns (Clow, Hucklebridge, Stadler, Evans & Thorn, 2010; Fries et al., 2009), diaries were inspected to ensure children were generally healthy and had good sleep quality on the sampling days. There were no significant differences between children's reports of self-perceived health or sleep quality between the school day and non-school day. Consistent with previous research (Davis et al., 1999) the morning samples were later on the weekend day than the school day ( $t(26) = 6.36, p < .001$ ). There were no significant differences in sampling time for the afternoon and evening cortisol samples. Given the circadian rhythm in the production of cortisol (Clow et al., 2004), the difference in sampling times could result in higher morning cortisol on the school day. This fact was taken into account in interpretation of the cortisol data. Descriptive information about the mean cortisol for each day and sampling times can be found in Table 1.

### **Data analysis plan**

Cortisol data was analysed first using a factorial ANOVA to compare cortisol levels at the 3 time points (morning, afternoon and evening) on the school and non-school day. Secondly, the cortisol slope was compared between the school and non-school day. The cortisol slope was calculated by subtracting the evening cortisol value from the morning cortisol value, hence, more negative values indicate a steeper slope of cortisol across the day. As morning sampling time was later on the non-school day, to examine whether this impacted on the cortisol results at sampling time difference was calculated and this was correlated with 1) the difference between the morning sample on the school day and non-school day, and 2) the difference between the cortisol slope on the school day and the non-school day. Non-significant correlations between the sampling time difference and the cortisol results would indicate that the later sampling time on the non-school day did not influence the results.

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<sup>25</sup> Although all children provided samples at all time points, some of these samples had insufficient saliva for analysis, all samples were retained in the statistical analysis

## Results

### *Salivary cortisol*

Descriptive data for the cortisol values are shown in Table 1. A 2 (school day, non-school day) x 3 (time: morning, evening, afternoon) ANOVA using the Greenhouse Griesser adjustment revealed a significant effect of day ( $F(1,20) = 8.08$ ,  $p = .010$ ,  $\eta p^2 = .29$ ), time ( $F(1.24,24.80) = 30.44$ ,  $p < .001$ ,  $\eta p^2 = .60$ ) and interaction between day and time ( $F(1.19,23.76) = 48.37$ ,  $p = .051$ ,  $\eta p^2 = .16$ ). As the interaction was near significance in relation to *a priori* predictions post hoc tests were carried out. Results showed that cortisol was significantly higher on the school days in the morning ( $t(29) = 2.67$ ,  $p = .012$ ), the afternoon ( $t(25) = 2.44$ ,  $p = .022$ ) and there was a trend for higher levels in the evening ( $t(28) = 1.86$ ,  $p = .074$ ). Figure 1 displays the cortisol values for each sampling time by day.

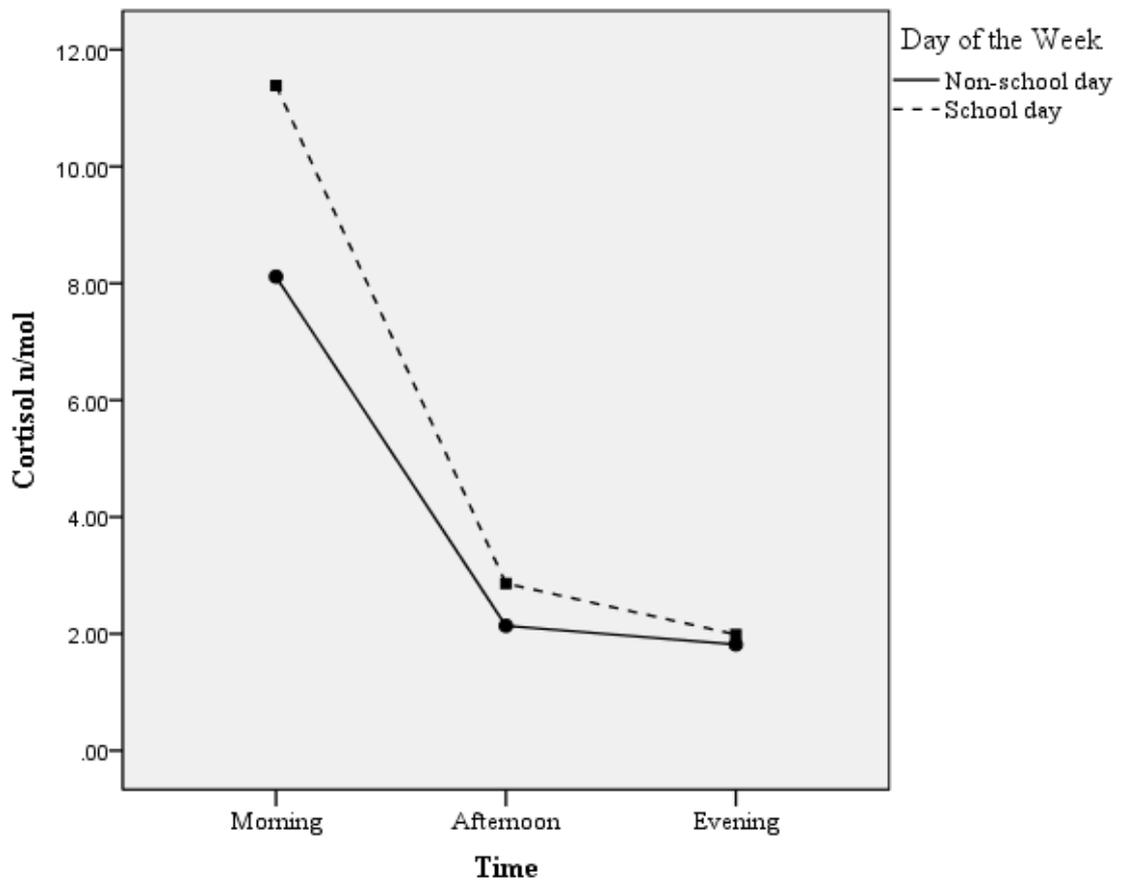


Figure 1 Mean cortisol for each sampling time by sampling day

Table 1 Descriptive statistics for mean cortisol and time of sampling (and SDs)

	Cortisol n/mol				Sampling time			
	Non-school day		School Day (Mon)		Non-school day		School day (Mon)	
	M	SD	M	SD	M	SD	M	SD
Morning	7.29	4.94	10.59	8.21	9:16	63 mins	7:42	26 mins
Afternoon	2.03	1.44	2.89	1.97	16:20	59 mins	16:07	24 mins
Evening	1.78	2.18	2.72	3.83	21:05	32 mins	20:58	42 mins

These results demonstrate that there is not only increased mean cortisol on school days, but if each time point during the day is examined, pre-adolescents and adolescents have increased cortisol on a school day in the morning, afternoon and evening (note: this is a trend in the evening) in comparison to non-school day. This displays a consistent pattern of increased levels of cortisol across the day on a school day in pre-adolescents and adolescents.

Cortisol slope measures were calculated for school and non-school days (by subtracting the evening cortisol value from the morning cortisol value) to examine diurnal patterns. More negative values indicate a steeper slope of cortisol across the day. There was a trend ( $t(25) = 1.54, p = .065$ , one-tailed) for a steeper cortisol slope for school day (Mean = -7.98, SD = 9.40) than the non-school day (Mean = -5.71, SD = 5.01).

To determine the impact of the difference in time of sampling for the morning sample a time difference score (between time of sampling on non-school day and school day) was calculated and this was correlated with the difference in morning cortisol values and cortisol slope between the school and non-school day. Results indicate that time-difference scores were not correlated with the difference in morning cortisol between the school and non-school day  $r(23) = .361$ , ns, or difference in cortisol slope  $r(20) .145$ , ns. Therefore, these results suggest the differences in cortisol levels on the school day compared to the non-school day are not due to differences in sampling times.

#### *Mood*

To examine the differences between mood state on school and non-school day a 2(school day, non-school day) x 3(time: morning, afternoon, evening) ANOVA using the Greenhouse Geisser adjustment revealed no significant effect of day ( $F(1,32) = 0.17, p = .682, \eta p^2 = .01$ ), a significant effect of time ( $F(1.68, 53.84) = 10.88, p < .001, \eta p^2 = .25$ ) and no significant interaction of time and day ( $F(1.73, 55.32) = 1.14, p = .325, \eta p^2 = .03$ ). These results demonstrate pre-adolescents and adolescents do not report any differences between happiness on a school day than a no school day, despite the increased levels of cortisol on school days.

## Discussion

This is the first study to examine cortisol differences between school days and non-school days in children aged 9-14 years. Results show that pre-adolescents and adolescents have higher mean salivary cortisol levels on a school day than a non-school day. Higher mean cortisol levels were observed in the early morning and mid-afternoon saliva samples. Further there was a trend towards a heightened cortisol level in the evening sample on the school day and for a more rapid decline of cortisol levels a school day than a non-school day. The current study complements findings that pre-schoolers had different cortisol patterns on childcare days compared to home days (Watmura et al., 2009) and is similar to adult populations who display increased morning cortisol levels on work days (Kunz-Ebrecht et al, 2004; Scholotz et al., 2004). The current study extends existing research literature demonstrating pre-adolescents and adolescents exhibit similar patterns of heightened cortisol on a school day compared to a home day as other age groups.

An important difference between the children in this sample and adult samples is that, whereas adults report greater unhappiness on work days (Kunz-Ebrecht et al., 2004), pre-adolescents and adolescents in the current study do not. There is no difference in mood reported by pre-adolescents and adolescents between and school-day and a non-school day. The higher levels of cortisol on a school day in the current sample of 9-14 year old children may not be in response to a more negative mood state on school days but simply due to a more demanding schedule. Recent research has suggested that heightened awakening cortisol may be modulated by upcoming events with higher cortisol on awakening when people have a more demanding day ahead (Fries et al., 2008).

Although, increased levels of cortisol have been associated with poor health, it is a flattened cortisol slope and lower morning cortisol levels that is implicated with chronic stress and poor psychosocial functioning (Saxbe, 2008). As pre-adolescents and adolescents have a steeper slope on school days it is most likely that the increased cortisol is adaptative and reflects the increased demands of the school day (Mikolajczak, et al., 2010). Further research should examine individual differences in the cortisol flexibility on the school day for children with psychosocial difficulties, such as loneliness and those with academic difficulties.

In future studies it would also be interesting to monitor more closely factors that can influence cortisol levels in pre-adolescents and adolescents, such as menache (Oskis, Loveday, Hucklebridge, Thorn, & Clow, 2009) and adverse experiences (Gustafsson, Ackarsäter, Lichtenstein, Nelson, & Gustafsson, 2010). It would also be useful to compare mood states, social evaluative stress and work demands between pre-adolescents and adolescents on a school day and adults on a work day (Kunz-Ebrecht et al., 2004). In addition, the impact of individual differences (such as the temperament of child) and environment factors (such as periods of increased school based assessments and examinations) on cortisol patterns should also be explored as there are some differences in the results for similar studies with younger primary school aged children (Bruce et al. 2002; Davis et al., 1999; Spangler, 1995). Cortisol levels at different times of the academic year should also be examined to explore the possibility that increased cortisol may be due to increased challenge of school day and assessment.

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## Appendix 2

Diary events used in memory task

### **Individual positive events**

I entered a competition and won £10.

I received the highest mark in the class on my test.

I played a chess match and won.

I found out I have been picked to get guitar lessons, I get to take a guitar home to practise with.

### **Individual negative events**

A £5 note fell out of my pocket and blew away before I could grab it.

I fell off my bike and hurt my head.

I went to the dentist and had three fillings – Ugh, I can't believe it.

I got a haircut that I absolutely can't stand; it's incredibly ugly.

### **Interpersonal positive events**

I received a parcel in the mail from my cousin (who I am really close to) and it was full of these hilarious pictures from our last holiday together.

It occurred to me today that my relationship with my new friend is going really well.

I learnt a new dance with my new friend.

My best friend and I had a great time thrashing the rest of the class in the Ping Pong championship.

### **Interpersonal negative events**

My best friend let me down; we had made plans to do something at the weekend but I guess it didn't matter.

My sister/brother and I got into a big fight tonight over the room being such a mess – I don't know if we're ever going to stop fighting about the same old stuff.

I forgot all about my older sister's birthday – I think I really let her down and I don't know if she'll accept my apology.

I got told off for talking in class and it was not me.

### **Collective positive events**

My football team won its final game in FA cup.

I was elected as one of just a few people in my year to represent the School Council.

My class has got cinema tickets for good attendance.

My class has been working really hard on the recycling school project, and today we won the price for best work on the project out of all the other classes.

### **Collective negative events**

I forgot to bring the music for a really important practice session for the Student Choir that I sing in (we're going to competition soon) – everyone was mad with me.

My team did really terrible in the talent contest; in fact, we probably came in last.

My group entered a poster competition and we just found out we didn't win the prize.

I managed to forget some important ingredients for a recipe at cooking club; my group were unable to make the cake.

Adapted from Gardner, W. L., Pickett, C. L. & Brewer, M.B. (2000). Social Exclusion and Selective Memory: How the need to belong influences Memory for social events, *Personality and Social Psychology Bulletin*, 26, 486-496

## Appendix 3

Words used in the serial recall with task irrelevant speech (Study 5b).

<b>SOCIAL THREAT WORDS</b>	<b>POSITIVE SOCIAL WORDS</b>
CRITICISED	HONEST
EMBARRASSED	LOYAL
HATED	TRUSTWORTHY
FAILURE	DEPENDABLE
WORTHLESS	CONSIDERATE
HUMILITATED	RELIABLE
LONELY	KIND
IGNORED	FRIENDLY

## Appendix 4

Social vignettes from the perception of social threat measure (Study 7)

1. You walk into the dinner hall and don't see anyone you know.
2. It is break time. You are in your school playground and a group of children are playing a game and you want to join in. You ask them if you can join in.
3. You are in one of your classes. You start to do the work your teacher has asked you to do and your pen is not working and you do not have another one. The person next to you (who you do not know) has a few pens on their desk. You ask them if you can borrow a pen.
4. You need to find the classroom for your next lesson, but you can not find the classroom. You need to ask someone to show you the way.
5. As you walk through the school gates there is a group of children that are a few years older than you standing in your way. You need to get past them.

## List of Publications from this Thesis

**Harris, R. A.** Qualter, P., & Robinson, S. J., (2013). Loneliness trajectories from middle childhood to early adolescence: Impact on perceived health and sleep disturbance. *Journal of Adolescence*. Available on-line.

## List of Other Publications (in date order)

Nightingale, S., Roberts, S., **Harris, R. A.**, Tariq, V., Appleby, Y., Barnes, L., & Qualter, P. (in print). Trajectories of University Adjustment: Predictors and Health Outcomes. *Learning and Individual Differences*

Qualter, P., Brown, S. L., Rotenberg, K. J., Vanhalst, J., **Harris, R. A.**, Goossens, L., Bangee, M. & Munn, P. (2013). Trajectories of Loneliness during Childhood and Adolescence: Predictors and Health Outcomes, *Journal of Adolescence*, Available on-line.

Qualter, P., Rotenberg, K., Barrett, L., Henzi P., Barlow, A., Stylianou, **Harris, R. A.**, (2013). Investigating Hypervigilance for Social Threat of Lonely Children. *Journal of Abnormal Child Psychology*, 41, 325-338.

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**Harris, R.**, & Roper, C., (2011). Psychology Internship: Evaluation using Communities of Practice and Motivational Theory. *Diffusion: The UCLan Journal of Undergraduate Research*, 4, 1, Available on-line.